MEETING PROGRAM AND ABSTRACTS

OCTOBER 17–20, 2018

SVP
SOCIETY OF VERTEBRATE PALEONTOLOGY

78TH ANNUAL MEETING 2018

ALBUQUERQUE CONVENTION CENTER • ALBUQUERQUE, NM

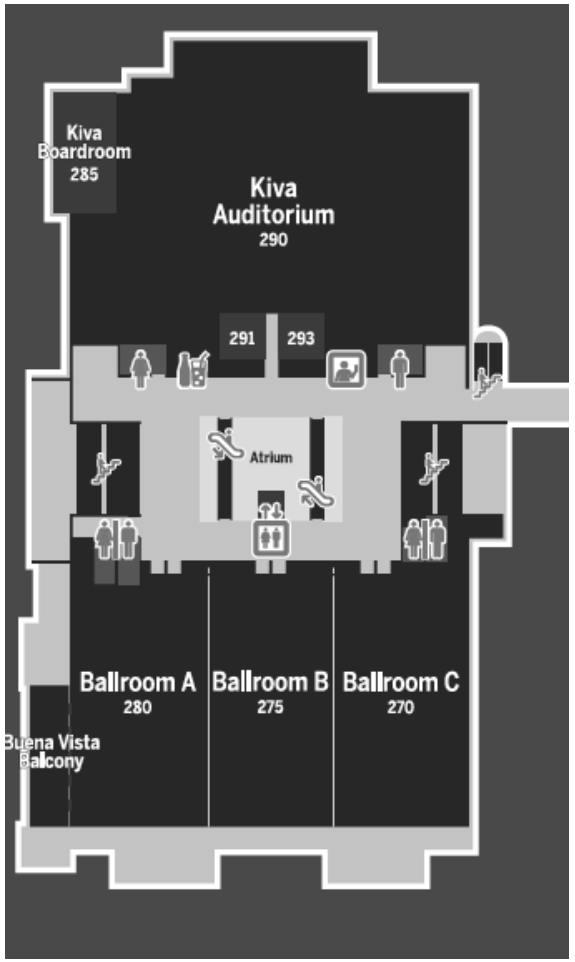
SOCIETY OF VERTEBRATE PALEONTOLOGY
OCTOBER 2018
ABSTRACTS OF PAPERS
78th ANNUAL MEETING

Albuquerque Convention Center
Albuquerque, New Mexico,
U.S.A.

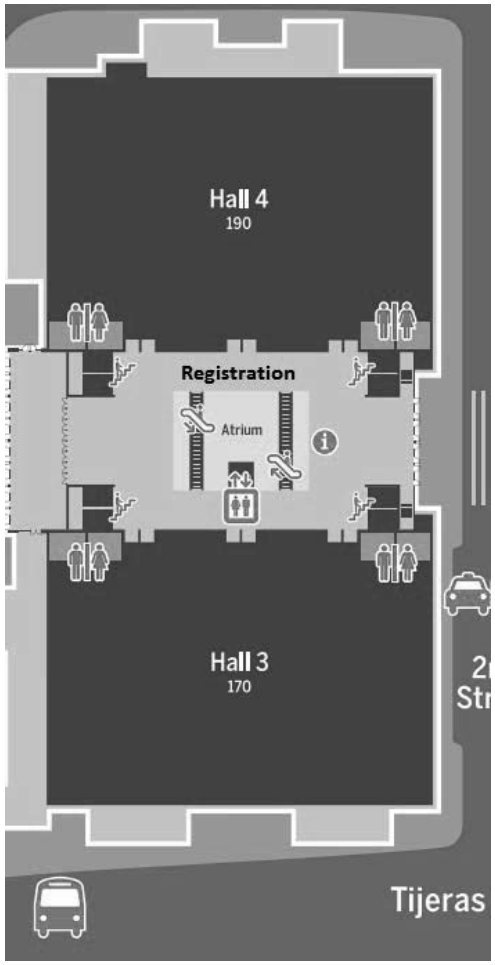
October 17–20, 2018

ALBUQUERQUE CONVENTION CENTER

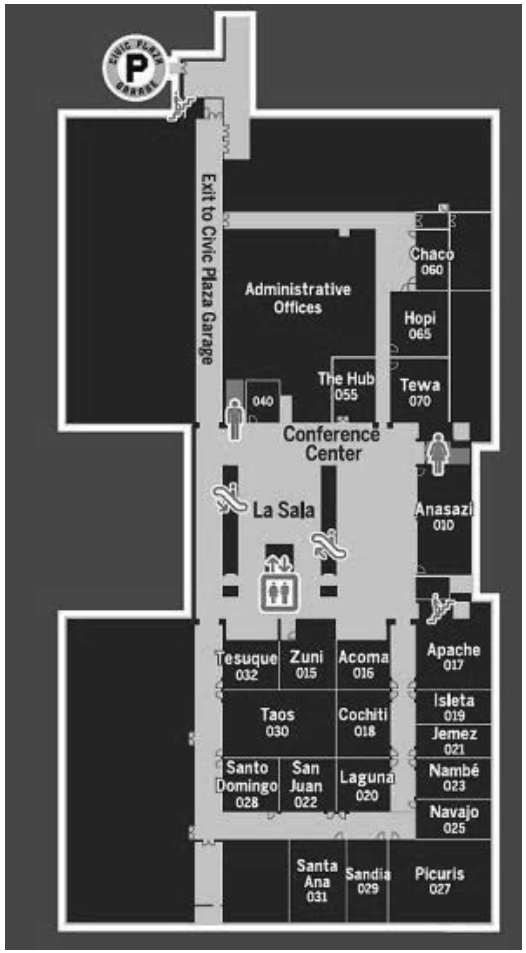
Upper Level



Ground Level



Lower Level



WELCOME TO ALBUQUERQUE!

The Host Committee of the 78th Annual Meeting is delighted to welcome all participants to the Society of Vertebrate Paleontology's 2018 meeting in Albuquerque, New Mexico. The meeting will take place at the Albuquerque Convention Center in downtown Albuquerque, which is a thriving center of dining and cultural opportunities.

It has been 25 years since the Society of Vertebrate Paleontology annual meeting was held in New Mexico. This year's meeting is co-hosted by the New Mexico Museum of Natural History and Science and the University of New Mexico. The Museum recently celebrated its 30th anniversary (2016) and continues to fulfill its mission of preserving and interpreting the rich natural history of New Mexico.

Albuquerque and the state of New Mexico are world-renowned travel destinations and famous for their unique cuisine, intersection of indigenous, Anglo, and Hispanic cultures, and breathtaking scenic beauty. Albuquerque is centrally located within the state and most state destinations are no more than a 4-hour-drive away. Located within Albuquerque are other points of interest such as Old Town, the Albuquerque Biological Park, the Albuquerque Museum of Art and History, and historic buildings along old Route 66. The city of Santa Fe is an hour drive north of Albuquerque and offers a variety of dining experiences and museums that highlight the unique history of New Mexico.

New Mexico contains a variety of rich and famous vertebrate fossil sites ranging from the late Paleozoic through the Quaternary. Exceptional New Mexico fossil locales include the Pennsylvanian Kinney Brick Quarry, the Permian Prehistoric Trackways National Monument, the Triassic sites of the Ghost Ranch area, Cretaceous, Paleocene, and Eocene sites within the San Juan Basin, Miocene sites of the Española Basin, and numerous Pleistocene cave sites including Dry Cave, Sandia Cave, and U-Bar Cave.

We invite everyone to attend the welcome reception at the New Mexico Museum of Natural History and Science where we will highlight many recent fossil discoveries from New Mexico. We hope you will enjoy all that New Mexico and Albuquerque has to offer during the 78th Annual Meeting of the Society of Vertebrate Paleontology. We can't wait to show you around! Welcome to the Land of Enchantment!

Thomas Williamson, SVP 78th Annual Meeting Host Committee Co-Chair
Phil Gensler, SVP 78th Annual Meeting Host Committee Co-Chair

PRESENTATION POLICIES

SVP Abstracts are reviewed by the Program Committee and members of the Education & Outreach, Preparators', and Romer Prize Committees, as appropriate. Authors are responsible for the technical content of their articles.

Unless specified otherwise, coverage of abstracts presented orally at the Annual Meeting is strictly prohibited until the start time of the presentation, and coverage of poster presentations is prohibited until the relevant poster session opens for viewing. As defined here, "coverage" includes all types of electronic and print media; this includes blogging, tweeting, advanced online publication, and other intent to communicate or disseminate results or discussion presented at the SVP Annual Meeting.

Still photography, video and/or audio taping, or any other electronic recording at the SVP Annual Meeting is strictly prohibited, with the exception of the designated SVP press event. The SVP reserves the right to engage professional photographers or audio/videotape professionals to archive sections of the Meeting for the Society's use.

Editorial policies for unpublished work: If you are planning to submit, or have submitted, your work to a journal that has embargo policies, be sure you are familiar with any restrictions they may impose on disseminating it before publication.

Please address any questions about program practices to the Program Committee or to the Executive Committee.

Citing an Abstract in the 2018 SVP Program and Abstracts Book
This Program and Abstracts Book is an official supplement to the online version of the *Journal of Vertebrate Paleontology*. The citation format for an abstract printed in this book is: *Journal of Vertebrate Paleontology*, Program and Abstracts, 2018, <insert page number here>.

CODE OF CONDUCT

The Society of Vertebrate Paleontology expects meeting attendees to behave in a courteous, collegial, and respectful fashion to each other, student volunteers, SVP staff, and convention center staff. Attendees should respect common sense rules for professional and personal interactions, public behavior (including behavior in public electronic communications), common courtesy, respect for private property, and respect for intellectual property of presenters. Demeaning, abusive, harassing, or threatening behavior towards other attendees or towards volunteers, SVP staff, convention center staff, or security staff is not permitted, either in personal or electronic interactions.

SOCIETY SEXUAL HARASSMENT POLICY

It is the policy of the society that all members are responsible for ensuring that the SVP community is free from sexual harassment in all communications and during the annual conference. The society strongly disapproves of offensive or inappropriate sexual behavior at the annual conference and during any in person or virtual society functions and/or communications. All members should avoid any action or conduct which could be viewed as sexual harassment. Sexual harassment includes unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexually harassing nature, when: (1) submission to the harassment is made either explicitly or implicitly as a term or condition of a society community professional relationship; (2) submission to or rejection of the harassment is used as the basis for employment decisions affecting the individual; or (3) the harassment has the purpose or effect of unreasonably interfering with an individual's professional standing or creating an intimidating, hostile, or offensive environment. Acts of harassment will not be tolerated in relation to the giving of awards and grants, fundraising, acceptance of abstracts, handling of manuscripts, or any other society activity. Any member who has a complaint of sexual harassment by another member should first clearly inform the harasser that his/her behavior is offensive or unwelcome and request that the behavior stop. If the behavior continues, the member must immediately bring the matter to the attention of the society's ethics committee (chaired by the current Vice President). If the Vice President is involved in the harassing activity, the violation should be reported to the President. If the activity does not cease, the accused individual may be dismissed from the membership of the society.

SOCIAL MEDIA GUIDELINES

Please Read Before You Tweet (Or Blog, Or Facebook, Or Instagram…)

The Society of Vertebrate Paleontology encourages open discussion on social media and other outlets at our annual meeting. In order to find a balance between embracing social media and protecting authors' work, we set forth the following guidelines:

- SVP has an embargo in place on discussing presentations until the beginning of the talk or poster session. Please do not discuss presentations until this time if you do not have the authors' permission to do so.

- This embargo exists to protect the authors. As an author, you have permission to break your own embargo or permit someone else to do the same. This includes discussing your own presentation online, posting slides or posters, etc. However, to protect yourself, make sure you are aware of any potential future publisher's policies about early dissemination of work.

- **Do not photograph or video tape a talk or poster without the authors' express permission**. Never post any images or video without the authors' permission.

- While the default assumption is to allow open discussion of SVP presentations on social media, please respect any request by an author to not disseminate the contents of their talk. The following icon may be downloaded from the presenter resources page of the SVP website for inclusion on slides or posters to clearly express when an author does not want their results posted:

We want to thank everyone for following these basic guidelines for online posts of all kinds. As a reminder, the official hashtag of the meeting is #2018SVP. We look forward to seeing your thoughts and discussion online!

Please check the SVP APP for the latest schedule

2018 SVP Schedule of Events

All events are held at the Albuquerque Convention Center unless otherwise noted with an **

Tuesday, October 16

7:00pm–9:00pm	**Special Lecture by Dr. Steve Brusatte** The Rise and Fall of the Dinosaurs	** New Mexico Museum of Natural History and Science

Wednesday, October 17

8:00am–12:15pm	**Technical Session I: Dinosaurs**	Ballroom A
	Technical Session II: Mesozoic Reptiles/Diapsids	Ballroom B
	Podium Symposium: Big Questions, Big Data	Ballroom C
9:30am–6:15 pm	**Exhibit and Poster Viewing Hours** **Colbert Prize Competition Posters** (B1–B35) **Colbert Prize posters will be on display Wednesday through Saturday* **Posters associated with Preparators' Session** (B37–B47) ******Preparators' posters will be on display Wednesday through Saturday* **Posters associated with Podium Symposium "The Beginning of the Age of Crocodiles"** (B48–B53) **These posters will be on display Wednesday through Saturday* **Posters associated with Podium Symposium "Building a Phenomic Universe: Collection, Management, and Applications of Digital Morphological Data"** (B54–B59) **These posters will be on display Wednesday through Saturday* **Regular Session Posters** *(*B36, B60–159) **Education and Outreach Poster Session** (B164–B201) **Education and Outreach posters will be on display Wednesday through Saturday*	Hall 4
12:15pm-1:45pm	**Diversity in Paleontology**	Picuris
1:45pm–4:15pm	**Podium Symposium: The Beginning of the Age of Crocodiles**	Ballroom A
	Technical Session III: Marine Mammals	Ballroom B
	Technical Session IV: Extinction and Diversity	Ballroom C
4:15pm–6:15pm	**Exhibit/Poster Mixer** **Posters associated with Podium Symposium "The Beginning of the Age of Crocodiles"** (B48–B53) **Authors will be present at their posters* **Poster Session I** (**Regular Session Posters,** B36, B60–159) **Poster Session I authors will be present at their posters*	Hall 4

	Education and Outreach Poster Session (B164–B201) **Authors with odd board numbers will be present at their posters*	
7:30pm–10:30pm	**Welcome Reception**	** New Mexico Museum of Natural History and Science

Thursday, October 18

8:00am–12:15pm	**Technical Session V: Quaternary Mammals**	Ballroom A
	Technical Session VI: Amphibians and Early Tetrapods	Ballroom B
	Romer Prize Session	Ballroom C
9:30am–6:15pm	**Exhibit and Poster Viewing Hours** **Colbert Prize Competition Posters** (B1–B35) **Colbert Prize posters will be on display Wednesday through Saturday* **Posters associated with Preparators' Session** (B37–B47) *****Preparators' posters will be on display Wednesday through Saturday* **Posters associated with Podium Symposium "The Beginning of the Age of Crocodiles"** (B48–B53) **These posters will be on display Wednesday through Saturday* **Posters associated with Podium Symposium "Building a Phenomic Universe: Collection, Management, and Applications of Digital Morphological Data"** (B54–B59) **These posters will be on display Wednesday through Saturday* **Regular Session Posters** (B36, B60–163) **Education and Outreach Poster Session** (B164–B201) **Education and Outreach posters will be on display Wednesday through Saturday*	Hall 4
12:30pm–1:30pm	**SVP Business Meeting and Open Forum** An opportunity to bring your questions to SVP leadership!	Ballroom C
1:45pm–4:15pm	**Technical Session VII: Paravians and Birds**	Ballroom A
	Preparators' Session	Ballroom B
	Technical Session VIII: Mesozoic Synapsids, Mammals, and Marsupials	Ballroom C
4:15pm–6:15pm	**Exhibit/Poster Mixer** **Colbert Prize Competition Posters** (B1–B35) **Authors will be present at their posters* **Posters associated with Preparators' Session** (B37–B47) **Authors will be present at their posters* **Poster Session II (Regular Session Posters,** B36, B60–B163) **Poster Session II authors will be present at their posters*	Hall 4
7:30pm–11:30pm	**Student and Postdoc Roundtable and Reprint Exchange**	Ballroom B

Friday, October 19

8:00am–12:15pm	**Technical Session IX: Ungulates and Carnivores**	Ballroom A
	Technical Session X: Stratigraphy and Geochemistry	Ballroom B
	Podium Symposium: Building a Phenomic Universe: Collection, Management, and Applications of Digital Morphological Data	Ballroom C
9:30am–6:15pm	**Exhibit and Poster Viewing Hours** **Colbert Prize Competition Posters** (B1–B35) **Colbert Prize posters will be on display Wednesday through Saturday* **Posters associated with Preparators' Session** (B37–B47) *****Preparators' posters will be on display Wednesday through Saturday* **Posters associated with Podium Symposium "The Beginning of the Age of Crocodiles"** (B48–B53) **These posters will be on display Wednesday through Saturday* **Posters associated with Podium Symposium "Building a Phenomic Universe: Collection, Management, and Applications of Digital Morphological Data"** (B54–B59) **These posters will be on display Wednesday through Saturday* **Regular Session Posters** (B36, B60–162) **Education and Outreach Poster Session** (B164–B201) **Education and Outreach posters will be on display Wednesday through Saturday*	Hall 4
1:45pm–4:15pm	**Technical Session XI: Paleogene Mammals**	Ballroom A
	Technical Session XII: Squamates	Ballroom B
	Technical Session XIII: Archosaurs and Dinosaurs	Ballroom C
4:15pm–6:15pm	**Exhibit/Poster Mixer** **Poster Session III (Regular Session Posters,** B36, B60–-162) **Poster Session III authors will be present at their posters* **Posters associated with Podium Symposium "Building a Phenomic Universe: Collection, Management, and Applications of Digital Morphological Data"** (B54–B59) *****Authors will be present at their posters* **Education and Outreach Poster Session** (B164–B201) *****Authors with even board numbers will be present at their posters*	Hall 4
6:30pm–11:30pm	**Annual Benefit Auction and Social**	**Hyatt Regency Albuquerque, Grand Pavilion

Saturday, October 20

8:00am–12:15pm	**Technical Session XIV: Fishes**	Ballroom A
	Technical Session XV: Geochemistry and Data	Ballroom B
	Technical Session XVI: Dinosaurs	Ballroom C
9:30am–6:15pm	**Exhibit and Poster Viewing Hours** **Colbert Prize Competition Posters** (B1-B35) **Colbert Prize posters will be on display Wednesday through Saturday* **Posters associated with Preparators' Session** (B37-B47) *****Preparators' posters will be on display Wednesday through Saturday* **Posters associated with Podium Symposium "The Beginning of the Age of Crocodiles"** (B48-B53) **These posters will be on display Wednesday through Saturday* **Posters associated with Podium Symposium "Building a Phenomic Universe: Collection, Management, and Applications of Digital Morphological Data"** (B54-B59) **These posters will be on display Wednesday through Saturday* **Regular Session Posters** *(*B36, B60-161) **Education and Outreach Poster Session** (B164–B201) **Education and Outreach posters will be on display Wednesday through Saturday*	Hall 4
1:45pm–4:15pm	**Technical Session XVII: Archosaurs**	Ballroom A
	Technical Session XVIII: Rodents	Ballroom B
	Technical Session XIX: Synapsids	Ballroom C
4:15pm–6:15pm	**Exhibit/Poster Mixer** **Poster Session IV (Regular Session Posters,** B36, B60-161) **Poster Session IV authors will be present at their posters*	Hall 4
7:30pm–10:00pm	**Awards Banquet** **Ticket required for admittance*	Ballroom ABC
10:30pm–1:00am	**After Hours Party**	**Hyatt Regency Albuquerque, Grand Pavilion

2018 SVP Workshops

**For Pre-registered Attendees*

TUE, October 16 9:00am–12:00pm	**Amira-Avizo Software for Paleontology**	Albuquerque Convention Center
TUE, October 16 9:00am—4:00pm	**Techniques in Digital Scientific Illustration: A Guide to Improving Workflow**	Albuquerque Convention Center
TUE, October 16 9:00am—4:30pm	**Expect the Unexpected: Best Practices for Field and Workplace Safety**	Albuquerque Convention Center
TUE, October 16 9:00pm–4:30pm	**Neotoma Paleoecology Database: Facilitating Transparent Data Curation in Vertebrate Paleontology**	Albuquerque Convention Center
TUE, October 16 9:00am–5:00pm	**Science Through Multimedia Stories**	Albuquerque Convention Center
TUE, October 16 9:00am–5:00pm	**Critical Thinking: Teaching the Observational and Tactile Skills Required for Fossil Preparation**	Albuquerque Convention Center
TUE, October 16 9:00am–4:00pm	**Ethics in Paleontology**	Albuquerque Convention Center
TUE, October 16 1:00pm—5:00pm	**Small Natural History Museums Resource Network**	Albuquerque Convention Center

2018 SVP Field Trips

**For Pre-registered Attendees*

For Field Trip pickup and dropoff locations, please check with your Field Trip Leader or go to www.vertpaleo.org/Annual-Meeting/Field-Trips.aspx

Day/Time	Title
TUE, October 16 **Time:** 8:00am – 6:00pm	**Pennsylvanian (Missourian) Vertebrates from the Kinney Brick Quarry Lagerstätte, New Mexico**
MON, October 15 **Time:** 7:00am – 8:30 pm	**Where the Pelycosaurs Roamed: Tour of the Prehistoric Trackways National Monument**
MON, October 15 – TUE, October 16 **Time:** Begins Monday, October 15, at 7:30am. Ends Tuesday, October 16, at 6:00pm	**The Triassic Deposits of Ghost Ranch: Chronicling the Rise of Dinos Near the Equator**
SUN, October 14 – TUE, October 16 **Time:** Begins Sunday, October 14, at 7:00am. Ends Tuesday, October 16, at 4:00pm	**A Traverse Across the K–Pg Boundary of the San Juan Basin, New Mexico**
MON, October 15 – TUE, October 16 **Time:** Begins Monday, October 15, at 8:00am. Ends Tuesday, October 16, at 5:00pm	**Miocene Vertebrates from the Santa Fe Group, Española Basin, Northern New Mexico**
SUN, October 21 – WED, October 24 **Time:** Begins Sunday, October 21, at 7:00am. Ends Wednesday, October 24, at 2:00pm	**Paleontology of Bears Ears National Monument**
SUN, October 21 – TUE, October 23 **Time:** Begins Sunday, October 21, at 7:30am. Ends Tuesday, October 23, at 7:00pm	**Exploring the Upper Triassic Chinle Formation at Petrified Forest National Park**

PROGRAM AT A GLANCE

	Ballroom A	Ballroom B	Ballroom C	Ballroom A	Ballroom B	Ballroom C
	Technical Session I	Technical Session II	Podium Symposium	Technical Session V	Technical Session VI	Romer Prize Session
	WED	WED	WED	THUR	THUR	THUR
8:00 am	FELICE	MASSARE	UHEN	GALVEZ	LASSITER	YANG
8:15 am	NESBIT	WITHDRAWN	CLOSE	GUST	MARJANOVIC	MCAULAY
8:30 am	MORTIMER	ANDERSON	SALLAN	MACIAS	HARIDY	MIYASHITA
8:45 am	GRIFFIN	LIU	DAVIS	FREYMUELLER	ATKINS	BESTWICK
9:00 am	CHAPELLE	SURMIK	DUNNE	MEACHEN	DANTO	CHIBA
9:15 am	CUFF	CAMPBELL	BALK	VAN VALKENBURGH	OTOO	PROFFITT
9:30 am	LOVELACE	DRISCOLL	CLEARY	REUTER	MADDIN	TRAYLER
9:45 am	BARTA	VERRIERE	MANNION	SHORT	FRÖBISCH	TARAILO
10:00 am	COFFEE					
10:15 am	NABAVIZADEH	HIRASAWA	HOPKINS	SHOLTZ	HUTTENLOCKER	WINTRICH
10:30 am	WOZIK	LARSON	HUANG	DESANTIS	MANN	LOUGHNEY
10:45 am	ROBERTS	DEBRAGA	LYONS	BIEDRON	ANDERSON	SMITH
11:00 am	REGALADO FERNANDEZ	MACDOUGAL	BLOIS	LOUYS	GEE	BALISI
11:15 am	SCHMITT	VAN DEN BRANDT	FRASER	SMAIL	SO	WASKOW
11:30 am	PETERMAN	BRINK	DU	LAZAGABASTER	ROY	SAITTA
11:45 am	RADERMACHER	DEMAR	TÓTH	BIERNAT	JIA	MEKARSKI
12:00 pm	LANGEL	SIDOR	SMITH	MAXWELL	HILL	GROSSNICKLE
12:15 pm	BREAK					
1:30 pm						
	Ballroom A	Ballroom B	Ballroom C	Ballroom A	Ballroom B	Ballroom C
	Podium Symposium	Technical Session III	Technical Session IV	Technical Session VII	Preparators' Session	Technical Session VIII
1:45 pm	WILBERG	BERTA	BROKLEHURST	ROY	HENRICI	HOFFMAN
2:00 pm	DRUMHELLER	GEISLER	HAYES	HARTMAN	HALL	HOFFMANN
2:15 pm	SELLERS	LANZETTI	BAMFORTH	MANAFZADE	IKEGAMI	HARPER
2:30 pm	HOLLIDAY	PEREDO	BARRETT	PITTMAN	DI GIACOMO	HENDRICKX
2:45 pm	WERNING	BOESSENECKER	CHIARENZA	CANOVILLE	HAUGRUD	LUNGMUS
3:00 pm	PARKER	BORCE	HOLROYD	FIELD	RHUE	BUCHHOLTZ
3:15 pm	MOLNAR	NELSON	HALLIDAY	O'CONNOR	HOOK	PENG
3:30 pm	TSAI	SHIPPS	CASHMORE	BAILLEUL	DOUGAN	LOPEZ-TORRES
3:45 pm	LESSNER	VALENZUELA-TORO	SAILA	KSEPKA	BROWNE	EVANS
4:00 pm	TURNER	BIEWER	LINDSEY	MUSSER	MILLHOUSE	WROE
4:15 pm	*Poster Session I*			*Poster Session II*		
6:15 pm						

	Ballroom A	Ballroom B	Ballroom C	Ballroom A	Ballroom B	Ballroom C
	Technical Session IX	Technical Session X	Podium Session	Technical Session XIV	Technical Session XV	Technical Session XVI
	FRI	FRI	FRI	SAT	SAT	SAT
8:00 am	SCOTT	STREET	MALLISON	STACK	KEENAN EARLY	SNIVELY
8:15 am	JUKAR	THOMPSON	NEWHAM	GILES	TEJADA	WOODWARD
8:30 am	CANTALAPIEDRA	FIORILLO	WITMER	WILSON	HAUPT	COST
8:45 am	MCLAUGHLIN	TUCKER	BOYER	FRIEDMAN	MILLER	CIGNAC
9:00 am	DELPLANCHE	BELL	HSIANG	JOHANSON	KELLER	BURNHAM
9:15 am	HOUSSAYE	LALLENSACK	VITEK	BRAZAU	VILLASEÑOR	ZAHNER
9:30 am	EMERY-WEATHERALL	MEYER	BARDUA	COATES	CLEMENTZ	FRIEMUTH
9:45 am	BORTHS	QVARNSTRÖM	BRIGHT	WITHDRAWN	HIGGINS	SMITH
10:00 am	COFFEE					
10:15 am	BARRETT	FREDERICKSON	WATANABE	SIME	BADGLEY	FABRI
10:30 am	BIRD	RIEGLER	FERRER	PARDO	BLACKBURN	MAKOVICKY
10:45 am	WANG	CULLEN	TURNER	RICHTER	ROUNTREY	GORSCAK
11:00 am	POLLY	FENDLEY	PORRO	SHELBURNE	CERIO	FRONIMOS
11:15 am	HOCK	MOORE	TSENG	MICHELS	GATESY	MCHUGH
11:30 am	SMILEY	WIDLANSKY	LAUTENSCHLAGER	CLAESON	PINEDA MUNOZ	HECK
11:45 am	SULSER	SECORD	CARNEY	EL-SAYED	WOOD	GOODWIN
12:00 pm	LOCKE	FERANEC	HEERS	CAPOBIANCO	BUTTON	WOODRUFF
12:15 pm	BREAK					
1:30 pm						
	Ballroom A	Ballroom B	Ballroom C	Ballroom A	Ballroom B	Ballroom C
	Technical Session XI	Technical Session XII	Technical Session XIII	Technical Session XVII	Technical Session XVIII	Technical Session XIX
1:45 pm	BEARD	WHITING	SUES	STEIN	BERTRAND	ABBOTT
2:00 pm	SHELLEY	D'AMORE	BUTLER	VARRICCHIO	LAFUMA	REISZ
2:15 pm	SILVIRIA	GREEN	MARSH	GRINHAM	BURROUGHS	FONG
2:30 pm	SOLÉ	WINKLER	HOFFMAN	PRITCHARD	FOX	KULIK
2:45 pm	BLOCH	LE BLANC	WYND	ROONEY	SAMUELS	WHITNEY
3:00 pm	FULWOOD	DONG	SMITH	DUDGEON	ORCUTT	ANGIELCZYK
3:15 pm	SMITH	ARMFIELD	KLEIN	DOLLMAN	CALEDE	KAMMERER
3:30 pm	MULDOON	PHANTRATANAMONGKOL	KING	GROH	WITHNELL	OLROYD
3:45 pm	HOOKER	HEAD	ERICKSON	COSSETTE	CASANOVAS-VILAR	PEECOOK
4:00 pm	ABT	JACISIN	SERTICH	IRMIS	ROBSON	SMITH
4:15 pm	*Poster Session III*			*Poster Session IV*		
6:15 pm						

THANK YOU TO THIS YEAR'S MEETING SPONSORS!

HONORS COLLEGE

DEPARTMENT OF EARTH & PLANETARY SCIENCES

NEW MEXICO MUSEUM OF NATURAL HISTORY & SCIENCE

Silver Sponsor

research casting international

Lane SCIENCE EQUIPMENT CORP.

THE SOCIETY OF VERTEBRATE PALEONTOLOGY
RECOGNITION OF MAJOR DONORS

The following people have made substantial donations to SVP funding initiatives from May 23, 2017, through June 25, 2018. SVP thanks them for their generous support.

Many of our members sponsored student memberships in 2018. Whether you gave a partial membership or donated several memberships, the Society is truly grateful for your generosity and your support of our students.

Information regarding all SVP funds and how to donate to those funds can be found on our website at www.vertpaleo.org. Anyone wishing to make a donation to the Society should contact the SVP business office at svp@vertpaleo.org.

Silver *($10,000+)*

Brass *($1,000+)*

K. Christopher Beard
Annalisa Berta
Marc Carrasco
William Clemens
Kenneth Dial
John Flynn
Allison Gentry
Margaret Stevens
Blaire Van Valkenburgh
Ted Vlamis

Contributor *($100+)*

Edgar Allin
Kenneth Angielczyk
Gerald Bales
Paul Barrett
Anna Behrensmeyer
Christopher Bell
David Berman
Richard Blob
Barbara Brown
Matthew Brown
Julia Clarke
Leigh Cook
Margery Coombs
Darin Croft
Kyle Davies
Larisa DeSantis
Eric Dewar
Robert Douglas
Willard Dye
Rick & Eleanor Early
Nancy Engelhardt-Moore
Russell Engelman
Teng Fang
Harry Fierstine
Robert Fordyce
Michael Gottfried
Ren Hirayama
William Hlavin
Patricia Holroyd
Thomas Holtz
Randall Irmis
Bettie Kehrt
Karen Zak Kent
Taormina Lepore
Jason Lillegraven
John Long
Jin Meng
Jennifer Milano
Wade Miller
Ashley Morhardt
Lyndon Murray
Nathan Myhrvold
Patrick O'Connor & Nancy Stevens
Mark Orsen
Randy Patrick
Judy Peterson
P. David Polly
Donald Rasmussen
Kenneth Rose
Timothy Rowe
Lance Schnatterly
Gerald Schultz
Avi Schwab
Eric Scott
Akiko Shinya
Christian Sidor
William Simpson
Gary Staab
Christian Stauber
Dirk Steiner
James Stevens
Nancy Stevens
Mary Stewart
Michelle Stocker
Glenn Storrs
Mary Strasser
Stuart Sumida
Rhoda Torres
Dov Treiman
Marissa Westerfield
David Whistler
Dale Winkler
Andre Wyss

SVP Congratulates the 2018 Award Winners

Senior Awards

Romer Simpson Lifetime Achievement Award
Dr. Anna K. Behrensmeyer

Gregory Service Award
Dr. Blaire Van Valkenburgh

Morris Skinner Prize
Oscar Carranza-Castaneda

Professional Awards

Hix Preparators Grant
Rose Nyaboke

Lanzendorf PaleoArt Prize 2-D Art
Brian Engh

Lanzendorf PaleoArt Prize Scientific Illustration
Alex Tirabasso

Lanzendorf PaleoArt Prize Sculpture
Boban Filipovic

Lanzendorf PaleoArt Prize for National Geographic Digital Modeling and Animation
Rodolfo Ribeiro

Membership Awards

Honorary Member Award
Dr. Lance Grande and Dr. Angela C. Milner

Scientists From Economically Developing Nations Travel Grant (SEDN)
Hazel Ratidzo Taruvinga

Institutional Membership
Mansoura University, Egypt

Student Awards

Cohen Award for Student Research
Savannah Olroyd

Dawson Pre-Doctoral Fellowship Grant
Sara ElShafie

Estes Graduate Research Grant
Evan Whiting

Patterson Student Fieldwork Grant
Sanaa El-Sayed

Wood Student Research Award
Brian Tannis

Taylor & Francis Award for Best Student Article in JVP - First Place
Aaron R. H. LeBlanc

Taylor & Francis Award for Best Student Article in JVP - Second Place
Brandon R. Peecook

JSG Student Travel Awards

Carla Bardua
Jordan Bestwick
Donald Cerio
Albert Chen
Brigid Christison
Jordan Claytor
Eduardo Cruz Vega
Elizabeth Daly
Mariana Di Giacomo
Catherine Early
Raymond Fong
Samuel Garvey
Danielle Goodvin
Borja Holgado
Zoe Kulik
Fabien LaFuma Wai
Sum Ma
Nuria Morales Garcia
Rachel Narducci
Margot Nelson
Danielle Oberg
Adolfo Pacheco-Castro
Abigail Parker
Minky Warinporn Phantratanamongkol
Viktor Radermacher
Selina Robson
Marc Van den Brandt
Megan Wakui
Jasmina Wiemann
Matthew Wysocki

WEDNESDAY MORNING, OCTOBER 17, 2018

TECHNICAL SESSION I

ALBUQUERQUE CONVENTION CENTER, BALLROOM A

MODERATORS: Ali Nabavizadeh and Christopher Griffin

8:00 **R. N. Felice, A. Watanabe, A. Cuff, L. M. Witmer, M. A. Norell, E. J. Rayfield, A. Goswami** QUANTIFYING CRANIAL CONVERGENCE, EVOLUTIONARY RATES, AND DISPARITY IN THE DINOSAUR SKULL

8:15 **S. J. Nesbitt, C. Griffin, E. Evans, R. T. Mueller, C. Pacheco, F. Preto, S. F. Cabreira, A. Marsh, B. M. Wynd, M. Langer** PREVALENT ONTOGENETIC CHANGES CHARACTERIZE EARLY DINOSAURS AND THEIR CLOSEST RELATIVES: IMPLICATIONS FOR SPECIES IDENTIFICATION, PHYLOGENY, AND THE LOSS OF THESE CHANGES IN LATER DINOSAURS

8:30 **M. Mortimer, N. Gardner, D. Marjanović, A. Dececchi** ORNITHOSCELIDA, PHYTODINOSAURIA, SAURISCHIA: TESTING THE EFFECTS OF MISSCORES IN MATRICES ON BASAL DINOSAUR PHYLOGENY

8:45 **C. T. Griffin, D. Munyikwa, T. J. Broderick, S. Tolan, M. Zondo, S. J. Nesbitt, H. Taruvinga** AN EXCEPTIONAL NEW LATE TRIASSIC (CARNIAN) FOSSIL ASSEMBLAGE FROM ZIMBABWE AND THE BIOGEOGRAPHY OF THE EARLY DINOSAURS ACROSS PANGEA

9:00 **K. E. Chapelle, J. N. Choiniere, R. B. Benson, A. Otero** LOCOMOTORY SHIFTS IN DINOSAURS DURING ONTOGENY

9:15 **A. Cuff, A. Otero, L. Sumner-Rooney, D. Pol, J. R. Hutchinson** RECONSTRUCTING THE ONTOGENY OF THE SAUROPODOMORPH *MUSSAURUS* AND IMPLICATIONS FOR LOCOMOTION

9:30 **D. Lovelace, S. Hartman, B. J. Linzmeier, W. P. Porter** DEEP-TIME APPLICATION OF LINKED MICROCLIMATE AND BIOPHYSICAL MODELS CONSTRAIN THE THERMAL ECOLOGY OF TWO LATE TRIASSIC DINOSAURS (*COELOPHYSIS*, *PLATEOSAURUS*)

9:45 **D. E. Barta** OSTEOHISTOLOGY REVEALS INDIVIDUAL VARIATION IN GROWTH AMONG A LARGE SAMPLE OF THE TRIASSIC THEROPOD DINOSAUR *COELOPHYSIS BAURI* FROM GHOST RANCH, NEW MEXICO

10:00 BREAK

10:15 **A. Nabavizadeh** CRANIAL MUSCULATURE IN HERBIVOROUS DINOSAURS AND THE EVOLUTION OF DIVERSE FEEDING MECHANISMS

10:30 **M. Wosik, M. Whitney, K. Curry Rogers, H. Woodward, D. C. Evans** DEFINING DINOSAUR NEONATAL BODY SIZE USING OSTEOHISTOLOGICAL EVIDENCE

10:45 **L. E. Roberts, J. J. Head** EVOLUTION OF DINOSAUR AXIAL SKELETON DIVERSITY: EVOLUTIONARY DRIVERS AND DEVELOPMENTAL MECHANISMS

11:00 **O. R. Regalado Fernandez, P. Upchurch, P. M. Barrett, P. Mannion, S. C. Maidment** A REASSESSMENT OF THE PHYLOGENY OF BASAL SAUROPODOMORPHS THROUGH COMPARATIVE CLADISTICS AND THE SUPER-MATRIX APPROACH

11:15 **A. D. Schmitt, R. B. Benson, S. Giles, L. M. Witmer, P. M. Sander** GEOMETRIC MORPHOMETRIC ANALYSIS OF THE INNER EAR OF SAUROPODOMORPHA

11:30 **H. Petermann, M. Fabbri, M. Hanson, B. S. Bhullar** A REAPPRAISAL OF THE BASAL SAUROPODOMORPH *ANCHISAURUS POLYZELUS* AND ITS IMPLICATIONS FOR HETEROCHRONY IN SAUROPOD SKULL EVOLUTION

WEDNESDAY MORNING, OCTOBER 17, 2018
TECHNICAL SESSION I
(CONTINUED)

11:45 **V. Radermacher, J. Choiniere, K. Chapelle, W. De Klerk, V. Santucci** NOVEL POSTCRANIAL FEATURES IN A NEW SPECIMEN OF *HETERODONTOSAURUS* (DINOSAURIA, ORNITHISCHIA) REVEALED BY SYNCHROTRON X-RAY COMPUTED TOMOGRAPHY: IMPLICATIONS FOR ORNITHISCHIAN PHYSIOLOGY, EVOLUTION, AND SYSTEMATICS

12:00 **C. R. Langel, M. F. Bonnan** EXPLORING ELBOW KINEMATICS IN THE AMERICAN ALLIGATOR AND DOMESTIC TURKEY: IMPLICATIONS FOR PREDATORY DINOSAUR FORELIMBS

WEDNESDAY MORNING, OCTOBER 17, 2018
TECHNICAL SESSION II
ALBUQUERQUE CONVENTION CENTER, BALLROOM B
MODERATORS: Judy Massare and Kirstin Brink

8:00 **J. A. Massare, W. R. Wahl, D. R. Lomax** SALT GLAND STRUCTURES IN *ICHTHYOSAURUS*?

8:15 **WITHDRAWN**

8:30 **K. L. Anderson, P. S. Druckenmiller, G. M. Erickson, E. Maxwell** BONE MICROSTRUCTURE OF *STENOPTERYGIUS QUADRISCISSUS* (REPTILIA, ICHTHYOSAURIA) FROM THE POSIDONIENSCHIEFER (POSIDONIA SHALE, LOWER JURASSIC) OF GERMANY

8:45 **J. Liu, P. M. Sander, A. Samathi, P. Chanthasit** THE EARLIEST ICHTHYOSAUR FROM THE MIDDLE LOWER TRIASSIC OF THAILAND

9:00 **D. Surmik, T. Szczygielski, K. Janiszewska, B. M. Rothschild** TUBERCULOSIS-LIKE RESPIRATORY INFECTION IN 245-MILLION-YEAR-OLD MARINE REPTILE SUGGESTED BY BONE PATHOLOGIES

9:15 **J. A. Campbell, M. T. Mitchell, S. Werning, J. S. Anderson** BONE HISTOLOGY OF AN ELASMOSAURID (SAUROPTERYGIA, PLESIOSAURIA) FROM THE UPPER CRETACEOUS (CAMPANIAN) DINOSAUR PARK FORMATION OF SOUTHERN ALBERTA

9:30 **D. A. Driscoll, T. Stubbs, A. Dunhill, M. Benton** THE (ALMOST) DEATH AND RESURRECTION OF MESOZOIC MARINE REPTILES: THE MID-CRETACEOUS (EARLY CENOMANIAN–MIDDLE SANTONIAN) DIVERSITY "BOTTLENECK"; IS IT AFFECTED BY FOSSIL COMPLETENESS?

9:45 **A. Verrière, J. Fröbisch** ONTOGENY AND OSSIFICATION PATTERNS IN THE EARLY PERMIAN CLADE MESOSAURIDAE (SAUROPSIDA, PARAREPTILIA)

10:00 BREAK

10:15 **T. Hirasawa, S. Kuratani** DEVELOPMENTAL BIOLOGICAL INFERENCE ON THE EVOLUTION FROM THE RIBCAGE TO THE TURTLE SHELL

10:30 **D. W. Larson, M. J. Vavrek, P. Bell, N. E. Campione, F. Fanti, R. Sissons, C. Sullivan** A HIGH-LATITUDE ASSEMBLAGE OF FOSSIL TURTLES (TESTUDINES) FROM THE LATE CAMPANIAN OF ALBERTA, CANADA

10:45 **M. deBraga, R. R. Reisz** A NEW CAPTORHINID AND ITS CONTRIBUTION TO OUR UNDERSTANDING OF TAXIC DIVERSITY IN THE EARLY PERMIAN CAVE SYSTEM OF RICHARDS SPUR, OKLAHOMA

WEDNESDAY MORNING, OCTOBER 17, 2018
TECHNICAL SESSION II
(CONTINUED)

11:00 **M. J. Macdougall, N. Brocklehurst, J. Fröbisch** THE MORPHOLOGICAL DISPARITY AND PHYLOGENETIC DIVERSITY OF PARAREPTILIA THROUGHOUT THEIR EVOLUTIONARY HISTORY.

11:15 **M. J. Van Den Brandt, B. S. Rubidge, J. Benoit, F. Abdala** UNDERSTANDING MIDDLE PERMIAN PAREIASAUR DIVERSITY: THE CRANIAL MORPHOLOGY OF *NOCHELESAURUS ALEXANDERI* AND *EMBRITHOSAURUS SCHWARZI*

11:30 **K. Brink, T. Grieco, J. Richman** THE DYNAMICS OF TOOTH CYCLING IN POLYPHYODONT VERTEBRATES

11:45 **D. G. DeMar, M. E. Jones, M. T. Carrano** NEW RHYNCHOCEPHALIAN (REPTILIA, LEPIDOSAURIA) MATERIAL FROM THE UPPER JURASSIC MORRISON FORMATION, NORTH-CENTRAL WYOMING, U.S.A. CONSOLIDATES A CLADE OF AMERICAN SPHENODONTINAE

12:00 **C. A. Sidor, B. R. Peecook, C. V. Beightol, T. Kaye, Z. T. Kulik, G. Livingston, W. G. Parker, S. L. Olroyd, M. R. Whitney** A MULTITAXIC BONEBED FEATURING A NEW SHUVOSAURID (ARCHOSAURIA, POPOSAUROIDEA) FROM THE SONSELA MEMBER OF THE CHINLE FORMATION AT PETRIFIED FOREST NATIONAL PARK

WEDNESDAY MORNING, OCTOBER 17, 2018
PODIUM SYMPOSIUM: BIG QUESTIONS, BIG DATA
ALBUQUERQUE CONVENTION CENTER, BALLROOM C
MODERATORS: Danielle Fraser and Richard Butler

8:00 **M. D. Uhen** THE ECOSYSTEM OF FOSSIL VERTEBRATE DATABASES: MUTUALISM OR COMPETITION?

8:15 **R. A. Close, R. B. Benson, R. J. Butler** STANDARDISING FOR SPATIAL SAMPLING BIAS DEMONSTRATES CONSTRAINED DIVERSIFICATION OF PHANEROZOIC TERRESTRIAL TETRAPODS

8:30 **L. Sallan, J. Kim, I. J. Sansom** MASS EXTINCTION AND HABITAT SHIFTS ENABLED THE MID-PALEOZOIC DIVERSIFICATION OF VERTEBRATES

8:45 **E. B. Davis** KEEPING YOUR DATA ALIVE WITH HARMONIZED REPOSITORIES

9:00 **E. M. Dunne, A. J. Farnsworth, S. E. Greene, D. J. Lunt, R. J. Butler** LATE TRIASSIC TETRAPOD DIVERSITY, CLIMATE AND THE RISE OF DINOSAURS

9:15 **M. A. Balk, S. Lyons, M. T. Carrano** TRIASSIC TERRESTRIAL VERTEBRATE COMMUNITY STRUCTURE AND THE EMERGENCE OF MEGAFAUNAL-DOMINATED COMMUNITIES

9:30 **T. J. Cleary, R. B. Benson, S. E. Evans, P. A. Holroyd, P. M. Barrett** THE EFFECT OF SAMPLING BIASES ON LONG-TERM RICHNESS TRENDS OF NON-MARINE LEPIDOSAURS AND TURTLES FROM THE TRIASSIC–PALEOGENE

9:45 **P. Mannion, R. B. Benson, R. J. Butler, M. T. Carrano, T. Cleary** SAMPLING-DRIVEN CONSTRAINTS ON TETRAPOD DIVERSITY DYNAMICS ACROSS THE CRETACEOUS/PALEOGENE BOUNDARY

10:00 BREAK

WEDNESDAY MORNING, OCTOBER 17, 2018
PODIUM SYMPOSIUM: BIG QUESTIONS, BIG DATA (CONTINUED)

10:15 **S. S. Hopkins, E. B. Davis, N. A. Famoso, J. M. Theodor** APPLICATIONS OF UNITARY ASSOCIATIONS TO THE SIMULTANEOUS ANALYSIS OF BIOGEOGRAPHY AND BIOSTRATIGRAPHY: CHALLENGES AND OPPORTUNITIES

10:30 **S. Huang, J. T. Eronen, C. M. Janis, J. J. Saarinen, D. Silvestro, S. A. Fritz** DIFFERENT DIVERSIFICATION PROCESSES UNDERLAY THE INCREASE OF UNGULATE BODY SIZE IN NEOGENE EUROPE AND NORTH AMERICA

10:45 **S. Lyons, F. A. Smith, S. Ernest** THE ROLE OF CLIMATE IN SHAPING MAMMALIAN BODY SIZE DISTRIBUTIONS OVER THE CENOZOIC

11:00 **J. L. Blois, M. C. Fitzpatrick, J. W. Williams, K. Maguire, D. Nieto Lugilde, J. Williams** THE INFLUENCE OF CROSS-TROPHIC ASSOCIATIONS ON COMMUNITY STRUCTURE AT THE END OF THE QUATERNARY

11:15 **D. L. Fraser, A. Villaseñor, M. A. Balk, J. T. Eronen, A. B. Tóth, E. Working Group, A. K. Behrensmeyer, S. Lyons** PROFOUND LATE QUATERNARY BIOTIC HOMOGENIZATION OF NORTH AMERICAN MAMMAL FAUNAS

11:30 **A. Du, Z. Alemseged, R. Bobe, A. K. Behrensmeyer** ASSESSING MAMMALIAN DIVERSITY IN RELATION TO HOMININ EVOLUTION IN THE OMO-TURKANA BASIN, EASTERN AFRICA

11:45 **A. B. Tóth, S. Lyons, E. Working Group, J. B. Alroy** THE END-PLEISTOCENE MEGAFAUNAL EXTINCTION CAUSED A SHIFT IN MAMMAL COMMUNITY STRUCTURE

12:00 **F. A. Smith, R. E. Elliott Smith, S. Lyons, J. L. Payne** THE INFLUENCE OF HOMININS ON PATTERNS OF MAMMAL DIVERSITY

WEDNESDAY AFTERNOON, OCTOBER 17, 2018
PODIUM SYMPOSIUM: THE BEGINNING OF THE AGE OF CROCODILES
ALBUQUERQUE CONVENTION CENTER, BALLROOM A
MODERATORS: Stephanie Drumheller and Casey Holliday

1:45 **E. Wilberg, A. H. Turner, J. Smaers** THE EVOLUTION OF CROCODYLIFORM CRANIAL SHAPE IN A PHYLOGENETIC CONTEXT

2:00 **S. K. Drumheller, E. W. Wilberg** ASSESSING PATTERNS OF CROCODYLIFORM DIET USING GEOMETRIC MORPHOMETRICS, NEONTOLOGY, AND ICHNOLOGY

2:15 **K. C. Sellers, K. Middleton, J. M. Clark, C. M. Holliday** CRANIAL JOINTS AND THE EVOLUTION OF EXTREME FEEDING PERFORMANCE IN CROCODYLIFORMES

2:30 **C. M. Holliday, E. Herbst, M. Jacoby, A. Smolinsky, K. Sellers** MORPHOMETRIC AND MODELING APPROACHES TO UNDERSTANDING THE EVOLUTION OF PSEUDOSUCHIAN MANDIBULAR SYMPHYSES

2:45 **S. Werning, A. H. Turner** HIGH VARIATION IN GROWTH DURATION AND GROWTH RATE IN THE EARLY ANCESTORS OF CROCODYLIA

3:00 **W. G. Parker, M. R. Stocker, A. D. Marsh** THE PURPORTED LATE TRIASSIC CROCODYLOMORPH *PARRISHIA MCCREAI* IS A JUVENILE PHYTOSAUR

WEDNESDAY AFTERNOON, OCTOBER 17, 2018
PODIUM SYMPOSIUM: THE BEGINNING OF THE AGE OF CROCODILES (CONTINUED)

3:15 **J. Molnar, B. S. Bhullar, J. R. Hutchinson** HINDLIMB POSTURE AND MUSCLE ACTIONS IN STEM CROCODYLIA

3:30 **H. P. Tsai, M. L. Turner, A. R. Manafzadeh, S. M. Gatesy** CONTRAST-ENHANCED XROMM REVEALS IN VIVO SOFT TISSUE INTERACTION IN THE HIP OF *ALLIGATOR MISSISSIPPIENSIS*: IMPLICATIONS FOR PSEUDOSUCHIA

3:45 **E. J. Lessner, C. M. Holliday** OSTEOLOGICAL CORRELATES FOR CRANIAL SOMATOSENSATION IN PSEUDOSUCHIANS

4:00 **A. H. Turner, A. Laing, E. W. Wilberg, S. Höhna** ECOLOGICAL TRANSITIONS AND SPECIATION RATES IN CROCODYLOMORPHA: ADAPTING STATE-DEPENDENT DIVERSIFICATION MODELS TO FOSSIL TREES

WEDNESDAY AFTERNOON, OCTOBER 17, 2018
TECHNICAL SESSION III
ALBUQUERQUE CONVENTION CENTER, BALLROOM B
MODERATORS: Annalisa Berta and Robert Boessenecker

1:45 **A. Berta, A. Lanzetti** MARINE MAMMAL FEEDING DIVERSITY THROUGH TIME

2:00 **J. Geisler, B. L. Beatty, R. W. Boessenecker** NEW SPECIMENS OF *CORONODON HAVENSTEINI* PROVIDE INSIGHTS INTO THE TRANSITION FROM RAPTORIAL TO FILTER FEEDING IN WHALES

2:15 **A. Lanzetti, A. Berta, E. G. Ekdale** LOOKING AT FOSSILS IN A NEW LIGHT: TEETH TO BALEEN TRANSITION IN RELATION TO THE ONTOGENY AND PHYLOGENY OF BALEEN WHALES

2:30 **C. M. Peredo** FROM TEETH TO BALEEN: TOOTH LOSS PRECEDES THE ORIGIN OF BALEEN IN WHALES

2:45 **R. W. Boessenecker, M. Churchill, E. Buchholtz, B. L. Beatty, J. H. Geisler** NEW FOSSILS FROM THE OLIGOCENE OF SOUTH CAROLINA CLARIFY THE IDENTITY OF "*SQUALODON*" *TIEDEMANI* AND THE POSTCRANIAL EVOLUTION OF EARLY ODONTOCETES

3:00 **B. Borce, A. Lanzetti, A. Berta** CRANIAL ANATOMY AND SYSTEMATICS OF THE EXTINCT RIVER DOLPHIN *PARAPONTOPORIA* AND RECONSTRUCTION OF THE ANCESTRAL HABITAT OF ODONTOCETE CETACEANS

3:15 **M. D. Nelson, M. D. Uhen** A NEW PLATANISTOID (CETACEA, ODONTOCETI) AND ITS PLACE IN THE EVOLUTION OF THE SQUALODELPHINIDAE AND THE PLATANISTIDAE

3:30 **B. K. Shipps, C. M. Peredo, N. D. Pyenson** AN UNEXPECTED NORTHERNER WITH BURROWED BONES: A NEW MAMMALODONTID (MYSTICETI) FROM THE PACIFIC NORTHWEST WITH *OSEDAX* BORES PROVIDES INSIGHT INTO OLIGOCENE MARINE TAPHONOMY AND MYSTICETE EVOLUTION

3:45 **A. M. Valenzuela-Toro, N. D. Pyenson, P. L. Koch** HOW GOOD IS THE FOSSIL RECORD OF PINNIPEDS? A HISTORIOGRAPHIC EVALUATION OF ITS BIASES AND MODES

4:00 **J. Biewer, J. F. Parham, J. Velez-Juarbe** A REASSESSMENT OF VARIATION IN DENTAL AND MANDIBULAR CHARACTERS OF BASAL ODOBENIDS

WEDNESDAY AFTERNOON, OCTOBER 17, 2018

TECHNICAL SESSION IV

ALBUQUERQUE CONVENTION CENTER, BALLROOM C

MODERATORS: Emily Bamforth and Thomas Halliday

1:45 **N. Brocklehurst, J. Fröbisch** THE DEFINITION OF BIOREGIONS IN PALAEONTOLOGICAL STUDIES OF DIVERSITY AND BIOGEOGRAPHY AFFECTS INTERPRETATIONS: PALEOZOIC TETRAPODS ASA CASE STUDY

2:00 **R. Hayes, G. Puggioni, A. Bednarick, D. E. Fastovsky** QUANTITATIVE ANALYSIS OF THE ADAMANIAN–REVUELTIAN TERRESTRIAL VERTEBRATE EXTINCTION AND REPLACEMENT; LATE TRIASSIC, PETRIFIED FOREST NATIONAL PARK, AZ, U.S.A.

2:15 **E. L. Bamforth, M. Gilbert** LARGE-SCALE SPATIAL BETA DIVERSITY PATTERNS IN THE UPPER CAMPANIAN (LATE CRETACEOUS) DINOSAUR PARK FORMATION OF WESTERN CANADA

2:30 **P. M. Barrett, J. A. Bonsor, N. Cooper** NON-AVIAN DINOSAURS WERE NOT IN TERMINAL DECLINE DURING THE EARLY LATE CRETACEOUS

2:45 **A. A. Chiarenza, P. Mannion, A. Farnsworth, D. Lunt, S. Kelland, P. Allison** ECOLOGICAL NICHE MODELLING SUPPORTS SUSTAINED DINOSAUR DIVERSITY TRENDS PRIOR TO THE CRETACEOUS/PALEOGENE MASS EXTINCTION

3:00 **P. A. Holroyd, S. Finnegan, W. A. Clemens** EXTINCTION SELECTIVITY ACROSS THE K/PG BOUNDARY IN THE CONTINENTAL VERTEBRATE BIOTA

3:15 **T. J. Halliday, M. Dos Reis, A. U. Tamuri, H. Ferguson-Gow, Z. Yang, A. Goswami** DELAYED INCREASE IN MORPHOLOGICAL RATES OF EVOLUTION AFTER THE ORIGIN OF THE PLACENTAL MAMMAL CROWN GROUP

3:30 **D. D. Cashmore, E. Brown, N. Simmons, R. J. Butler** COMPLETENESS OF THE BAT FOSSIL RECORD

3:45 **L. K. Saila, N. J. Matzke** AROUND THE WORLD IN 129 DOGS: THE HISTORICAL PHYLOBIOGEOGRAPHY OF CANINAE, BASED ON A NOVEL CANID PHYLOGENY AND NOW DATABASE DATA

4:00 **E. Lindsey, N. Villavicencio, A. Mychajliw, E. B. Davis, J. Capriles, A. Goldberg, C. Marshall, T. W. Stafford, Jr., T. Guilderson, A. D. Barnosky** REGIONAL EXTINCTIONS OF SOUTH AMERICAN PLEISTOCENE MEGAFAUNA: TAXONOMIC AND BIOGEOGRAPHIC PATTERNS AND INTERACTING EFFECTS OF HUMANS AND ENVIRONMENTAL CHANGES

WEDNESDAY–SATURDAY, OCTOBER 17–20, 2018

SVP 2018 EDWIN H. AND MARGARET M. COLBERT PRIZE COMPETITION POSTER

ALBUQUERQUE CONVENTION CENTER, HALL 4

Authors must be present from 4:15–6:15 p.m. Thursday, October 18

Posters must be removed by 6:30 p.m. on Saturday

B1 **P. C. Sternes, K. Shimada** CAUDAL FIN OF THE LATE CRETACEOUS SHARK, *CRETOXYRHINA MANTELLI* (LAMNIFORMES, CRETOXYRHINIDAE) MORPHOMETRICALLY COMPARED TO THAT OF EXTANT LAMNIFORM SHARKS

B2 **R. L. McKeeby, M. D. Gottfried** DENTAL VARIATION IN A NEONATE GREAT WHITE SHARK (*CARCHARODON CARCHARIAS*) WITH IMPLICATIONS FOR THE SHARK FOSSIL RECORD

B3 **V. Perez, R. Leder, T. Badaut** BODY LENGTH ESTIMATES OF FOSSIL LAMNIFORM SHARKS DERIVED FROM SUMMED WIDTH OF ASSOCIATED DENTITIONS

B4 **M. G. London, M. J. Polcyn, K. Shimada** A NEW PACHYRHIZODONTID FISH (ACTINOPTERYGII, TELEOSTEI) FROM THE UPPER CRETACEOUS EAGLE FORD GROUP OF TEXAS, U.S.A.

B5 **M. A. Bair, M. G. Newbrey, H. J. Martin-Abad, J. Maisey** AGE AND GROWTH OF *PACHYRHIZODUS CANINUS* (TELEOSTEI, CROSSOGNATHIFORMES) FROM THE LATE CRETACEOUS WESTERN INTERIOR SEAWAY

B6 **E. Daly, K. K. Catlett, E. Locke, P. E. Morse, A. Ortiz, G. Schwartz** SCANNING METHODOLOGY AND MEASUREMENT ERROR IN DENTAL TOPOGRAPHIC ANALYSES: A COMPARISON OF MICROCT AND SURFACE LIGHT SCANNING METHODS

B7 **M. L. Perez, A. K. Behrensmeyer** TAPHONOMY OF THE LOWERJURASSIC BLUE LIAS ICHTHYOSAURS OF SOUTHERN ENGLAND

B8 **B. Kligman** SPHENODONTIAN ASSEMBLAGES OF THE CHINLE FORMATION (LATE TRIASSIC: NORIAN), AND THEIR PHYLOGENETIC, BIOGEOGRAPHIC, AND ECOLOGICAL IMPLICATIONS

B9 **P. L. Holman, L. Wilson** INITIAL DESCRIPTION OF THORACIC RIB HISTOLOGY FOR THEGENUS *DOLICHORHYNCHOPS* (SAUROPTERYGIA; PLESIOSAURIA)

B10 **D. T. Ledesma, S. G. Scarpetta** NEW DATA ON DIAGNOSTIC AND APOMORPHIC MORPHOLOGY IN THE SKULLS OF GERRHONOTINE LIZARDS

B11 **C. J. Salcido, E. J. Rayfield, P. Gill, M. B. Soares, A. G. Martinelli** SKULL MECHANICS AND FUNCTIONAL MORPHOLOGY OF BRASILODONTIDAE, THE SISTER CLADE TOMAMMALS

B12 **K. D. Bazzana, B. Gee, R. R. Reisz** NEUROCRANIAL ANATOMY OF THE EARLY PERMIAN REPTILIOMORPH *SEYMOURIA*

B13 **M. Juhn, M. Alfaro, B. Van Valkenburgh** EVOLUTIONARY CONVERGENCE AND EVIDENCE FOR A MACROEVOLUTIONARY RATCHET IN THE FAMILY HYAENIDAE

B14 **D. Oberg, J. X. Samuels** THE CONVERGENCE CONUNDRUM: ADDRESSING MORPHOLOGICAL CONVERGENCE IN THE FAMILY TALPIDAE

B15 **D. A. Esker** STRONTIUM ISOTOPE RATIOS REVEAL DISPARATE GEOGRAPHIC ORIGINS FOR MEGAFAUNA AT WACO MAMMOTH NATIONAL MONUMENT (TX, U.S.A.)

B16 **W. Nguy, R. Secord** MIOCENE GEOGRAPHIC VARIATION OF BIOMES IN NORTH AMERICA FROM STABLE ISOTOPES IN LARGE HERBIVORES

B17 **E. Hall, L. DeSantis** DIETARY ECOLOGY OF COYOTES AND DIRE WOLVES AT MARICOPA BREA DURING THE LATE PLEISTOCENE AS INFERRED FROM DENTAL MICROWEAR TEXTURE ANALYSIS

B18 **S. M. Moran** ASTRAGALUS MORPHOLOGY INDICATES INCREASED CURSORIALITY IN LEPTOMERYCIDS, BUT NOT EQUIDS, DURING THE EOCENE–OLIGOCENE TRANSITION OF NEBRASKA

B19 **P. D. Gillespy, D. R. Prothero** ONTOGENETIC CHANGE IN DISTAL AND PROXIMAL LIMB BONES OF JUVENILE PLEISTOCENE COYOTES (*CANIS LATRANS*) AND DIRE WOLVES (*CANIS DIRUS*) FROM THE RANCHO LA BREA TAR PITS, CALIFORNIA

B20 **S. E. Holte, A. Fabre** 3D GEOMETRIC MORPHOMETRICS ON COMPLETE VERSUS PARTIAL FORELIMB ELEMENTS OF CARNIVORANS

SVP 2018 EDWIN H. AND MARGARET M. COLBERT PRIZE COMPETITION POSTER (CONTINUED)

B21 **J. G. Napoli, A. Martín-Serra, C. M. Janis** FUNCTIONAL MORPHOLOGY OF THE HUMERUS IN STHENURINE KANGAROOS: IMPLICATIONS FOR LOCOMOTOR MODE AND ECOLOGICAL HABITS

B22 **M. A. Madan, K. Long, D. R. Prothero** POSTNATAL LIMB ALLOMETRY IN THE LA BREA GROUND SLOTH *PARAMYLODON HARLANI*

B23 **A. E. Kort, P. Polly** NICHE DIFFERENTIATION IN EOCENE CARNIVORES: UNIQUE LUMBAR SPECIALIZATIONS IN THE OXYAENID *PATRIOFELIS*

B24 **J. Keller, B. Van Valkenburgh** FUNCTIONAL MORPHOLOGY OF THE NECK IN PINNIPEDS: THE LONG AND SHORT OF IT

B25 **E. J. Coombs, M. Churchill, T. Park, J. Geisler, B. L. Beatty, A. Goswami** ECOLOGICAL INFLUENCES ON CRANIAL MORPHOLOGY IN ODONTOCETE WHALES

B26 **B. Wang, M. Zelditch, C. Badgley** JAW DISPARITY IN RELATION TO DIET IN THE BOVIDAE, WITH IMPLICATIONS FOR PALEOECOLOGY

B27 **H. M. Flora, E. Davis** ANTILOCAPRID BEHAVIORAL INFERENCES FROM HEADGEAR MORPHOLOGY

B28 **R. E. Narducci, R. C. Hulbert, J. I. Bloch** FIRST VIRTUAL CRANIAL ENDOCASTS OF THE GIANT ARMADILLO *HOLMESINA* (XENARTHRA, CINGULATA, PAMPATHERIIDAE)

B29 **M. M. Lang, O. C. Bertrand, M. T. Silcox** SCALING PATTERN OF EUARCHONTOGLIRES CEREBELLAR PETROSAL LOBULES: IMPACTS OF LOCOMOTION AND ACTIVITY PATTERN

B30 **A. J. McGrath, J. J. Flynn, A. Wyss** PROTEROTHERIIDS (MAMMALIA, LITOPTERNA) FROM THE EARLY MIOCENE (SANTACRUCIAN SALMA) OF PAMPA CASTILLO, CHILE, AND A PHYLOGENETIC ANALYSIS OF THE GROUP

B31 **C. W. Pellegrom, L. K. Stroik** DENTAL TOPOGRAPHIC ANALYSIS OF MAXILLARY AND MANDIBULAR PHYLLOSTOMID BAT DENTITIONS: IMPLICATIONS FOR DIETARY PREDICTION IN THE FOSSIL RECORD

B32 **P. E. Morse, D. M. Boyer, J. I. Bloch** CHANGES IN DENTAL DEVELOPMENTAL TRAJECTORY AND BODY SIZE IN PRIMATE TAXA ACROSS THE PALEOCENE–EOCENE THERMAL MAXIMUM

B33 **T. Engler, T. Martin** DIFFERENTIATION IN DENTAL MORPHOLOGY AND FUNCTION OF PALEOCENE SMALL MAMMALS AFTER THE CRETACEOUS–PALEOGENE MASS EXTINCTION

B34 **L. Nagendran, K. D. Rose, A. E. Chew, T. M. Bown, M. T. Silcox** UNUSUAL VERTEBRATE ASSEMBLAGE FROM THE MCNEIL QUARRY OF THE BIGHORN BASIN, WYOMING (WILLWOOD FORMATION, EARLY EOCENE, WASATCHIAN NALMA)

B35 **N. Neu-Yagle, J. J. Eberle** A NEW MIDDLE PALEOCENE MAMMALIAN FAUNA FROM THE FORT UNION FORMATION, GREAT DIVIDE BASIN, WYOMING

WEDNESDAY–SATURDAY, OCTOBER 17–20, 2018

POSTERS ASSOCIATED WITH THE PREPARATORS' SESSION

ALBUQUERQUE CONVENTION CENTER, HALL 4

Authors must be present from 4:15–6:15 p.m. Thursday, October 18

Posters must be removed by 6:30 p.m. on Saturday

B37 **M. Fox, E. Lamm, J. Scannella** HISTOLOGICAL SAMPLING OF YPM 1831, THE HOLOTYPE OF *TOROSAURUS "GLADIUS"*: FOSTERING PALEONTOLOGICAL DISCOVERIES THROUGH MUSEUM/RESEARCHER COLLABORATIONS

B38 **C. L. Herbel, R. Skolnick, J. D. McMullin** PROJECT OREODONT: TRAINING VOLUNTEERS TO PREPARE AN HISTORIC BACKLOG

B39 **M. Haji-Sheikh, V. L. Naples** A NEW METHOD OF INCREASING THE EFFICIENCY OF MICRO JACKS IN THE REMOVAL OF MATRIX SURROUNDING A FOSSIL SPECIMEN.

B40 **T. Sato, M. Fox** TESTING MOLDING SEPARATORS FOR COLOR CHANGE AND EFFECTIVENESS

B41 **M. S. Eads, A. B. Heckert** ASSESSING THE USABLE LIFETIME OF TIN AND PLATINUM-BASED SILICONE RUBBERS UNDER HIGH AND LOW STRESS ENVIRONMENTS.

B42 **J. H. Creighton, S. V. Robson, J. M. Theodor** A COMPARISON OF DENTAL MOLDING AND CASTING COMPOUNDS USED FOR MICROWEAR STUDIES

B43 **G. Gonzalez, A. B. Heckert, B. Zimmer** FIDELITY OF "TRADITIONAL" VS "NEW TECH" METHODS OF FOSSIL REPRODUCTION

B44 **W. J. Wilkins, M. Bugbee, E. Storms** PREVENTATIVE MAINTENANCE AT THE MAMMOTH SITE: EXCAVATION AND STABILIZATION METHODS FOR AN ACTIVE IN-SITU BONEBED

B45 **M. Ferrer Ventura, A. Torices, R. San Juan Palacios, P. Navarro-Lorbés** PRESERVATION AND RESTORATION OF THE PALEOICHNOLOGICAL SITE "LA VIRGEN DEL CAMPO" IN ENCISO, LA RIOJA, SPAIN

B46 **M. M. Bugbee, W. J. Wilkins** PREPARATION AND TRANSPORTATION OF A COMPLETE MAMMOTH SKULL FROM CHANNEL ISLANDS NATIONAL PARK, CALIFORNIA, U.S.A.

B47 **N. A. Matthews, R. K. Hunt-Foster, B. H. Breithaupt, M. Lockley** THE IMPACT OF EXCAVATION AND DOCUMENTATION ON ANALYSIS AND INTERPRETATION: A LOOK AT THE ICHNOLOGICAL INTERPRETATIONS AT THE MILL CANYON DINOSAUR TRACKSITE, UTAH

WEDNESDAY–SATURDAY, OCTOBER 17–20, 2018

POSTERS ASSOCIATED WITH THE BEGINNING OF THE AGE OF CROCODILES SYMPOSIUM

ALBUQUERQUE CONVENTION CENTER, HALL 4

Authors must be present from 4:15–6:15 p.m. Wednesday, October 17

Posters must be removed by 6:30 p.m. on Saturday

B48 **M. Von Baczko, J. Desojo, P. Bona** PALEONEUROANATOMICAL DIVERSITY WITHIN PSEUDOSUCHIA (ARCHOSAURIA): LOOKING FOR EVOLUTIONARY PATTERNS

B49 **Y. Wang, C. Sullivan** AMBIGUITIES IN IDENTIFYING THE CERVICODORSAL TRANSITION IN FOSSIL CROCODYLOMORPHS

B50 **H. Yi** A SMALL CROCODYLIFORM (ARCHOSAURIA, CROCODYLOMORPHA) FROM THE EARLY CRETACEOUS JEHOL BIOTA OF CHINA, WITH HINDLIMBS ADAPTED FOR CURSORIAL LOCOMOTION

WEDNESDAY–SATURDAY, OCTOBER 17–20, 2018

POSTERS ASSOCIATED WITH THE BEGINNING OF THE AGE OF CROCODILES SYMPOSIUM (CONTINUED)

B51 **R. B. Sookias** IMPROVING PHYLOGENETIC INFERENCE FROM MORPHOLOGY USING DATA FROM MODERN CROCODYLIA

B52 **C. A. Brochu** HOW A LUMPER BECAME A SPLITTER: THE BLESSING AND CURSE OF MODERN CRYPTIC SPECIES IN CROCODYLIFORM SYSTEMATICS

B53 **F. C. Montefeltro, J. V. Ruiz** THE OLDEST SPHAGESAURID (NOTOSUCHIA, CROCODYLIFORMES) AND IMPLICATIONS FOR THE ORIGINS OF THE NOTOSUCHIAN-DOMINATED ECOSYSTEM IN THE LATE CRETACEOUS OF SOUTHEASTERN BRAZIL

WEDNESDAY–SATURDAY, OCTOBER 17–20, 2018

POSTERS ASSOCIATED WITH BUILDING A PHENOMIC UNIVERSE: COLLECTION, MANAGEMENT, AND APPLICATIONS OF DIGITAL MORPHOLOGICAL DATA SYMPOSIUM

ALBUQUERQUE CONVENTION CENTER, HALL 4

Authors must be present from 4:15–6:15 p.m. Friday, October 19

Posters must be removed by 6:30 p.m. on Saturday

B54 **N. F. Adams, E. J. Rayfield, P. G. Cox, S. N. Cobb, I. J. Corfe** OF MICE AND MULTITUBERCULATES: ASSESSING COMPETITIVE EXCLUSION AND EXTINCTION THROUGH CRANIOMANDIBULAR BIOMECHANICS

B55 **N. M. Morales Garcia, P. G. Gill, E. J. Rayfield** 2D EXTRUDED FINITE ELEMENT ANALYSIS: A NOVEL BIOMECHANICAL TECHNIQUE IN THE STUDY OF EARLY MAMMALS

B56 **M. Wysocki, Z. Tseng** UTILIZING 3-D PRINTING OF DIGITAL MORPHOLOGICAL DATA TO TEST THE MECHANICAL PERFORMANCE OF TEMPOROMANDIBULAR JOINT TRABECULAR BONE STRUCTURE IN CARNIVORANS

B57 **A. E. Baines, V. Selles de Lucas, S. N. Cobb, E. J. Rayfield, J. Bright** FEEDING, AND THE FORM-FUNCTION-BEHAVIOR RELATIONSHIP IN RAPTORS

B58 **J. R. Branin, S. N. Cobb, E. J. Rayfield, J. A. Bright** AN ASSESSMENT OF CONVERGENCE IN ECOLOGY, MORPHOLOGY, AND FUNCTIONAL PERFORMANCE IN OLD AND NEW WORLD VULTURES

B59 **A. M. Kirk, A. Baines, H. Kaplan, R. Carney** MACROPHOTOGRAMMETRIC RECONSTRUCTION OF *ARCHAEOPTERYX*

WEDNESDAY, OCTOBER 17, 2018

POSTER SESSION I

ALBUQUERQUE CONVENTION CENTER, HALL 4

Authors must be present from 4:15–6:15 p.m. Wednesday, October 17

Posters must be removed by 6:30 p.m.

B36 **H. R. Taruvinga, S. Tolan, C. T. Griffin** A *LUANGWA*-LIKE CYNODONT FROM NORTHERN ZIMBABWE AND ENDEMISM ACROSS THE CARNIAN OF SOUTHERN AFRICA

B60 **A. M. Kufner, D. M. Lovelace** TAPHONOMY OF TWO LATE TRIASSIC STEREOSPONDYL MASS DEATH ASSEMBLAGES FROM THE POPO AGIE FORMATION (FREMONT COUNTY, WYOMING)

B61 **S. Chakravorti, D. P. Sengupta, P. Roy** TAPHONOMY OF TRIASSIC TEMNOSPONDYLS OF INDIA

B62 **E. Knutsen** LATE TRIASSIC (CARNIAN) TEMNOSPONDYL ICHNITES FROM SUBURBAN BRISBANE, AUSTRALIA

B63 **J. Driebergen, C. Boyd, J. Person, D. Pagnac** A DIVERSE LISSAMPHIBIAN FAUNA FROM THE FITTERER RANCH LOCALITY (OLIGOCENE 32.5 TO 30 MA) OF NORTH DAKOTA

B64 **J. Fortuny, T. Arbez, E. Mujal, J. Steyer** REVISION OF THE METOPOSAURID TEMNOSPONDYLS FROM THE MIDDLE–LATE TRIASSIC OF MADAGASCAR, AND PALEOBIOGEOGRAPHICAL IMPLICATIONS

B65 **J. C. Cisneros, M. O. Day, B. S. Rubidge** SMALL TETRAPOD AND FISH TRACE FOSSILS FROM THE MIDDLE PERMIAN OF THE SOUTH AFRICAN KAROO

B66 **D. R. Gunnin, B. W. Schubert, K. E. Bredehoeft, J. X. Samuels** A NEW GENUS OF DESMOGNATHAN SALAMANDER (PLETHODONTIDAE) FROM THE EARLY PLIOCENE GRAY FOSSIL SITE OF NORTHEAST TENNESSEE

B67 **G. R. Adams, A. Mann, H. C. Maddin** A NEW EMBOLOMERE FROM THE MISSISSIPPIAN-AGED POINT EDWARD FORMATION OF NOVA SCOTIA, CANADA

B68 **E. C. Herbst, M. Doube, T. R. Smithson, J. Clack, J. R. Hutchinson** PALEOPATHOLOGIES IN CARBONIFEROUS TETRAPODS AND THE EVOLUTION OF BONE HEALING

B69 **S. M. Rowland, M. V. Caputo** TRACKWAY OF A SIDEWAYS-WALKING BASAL TETRAPOD IN THE PENNSYLVANIAN MANAKACHA FORMATION OF GRAND CANYON NATIONAL PARK

B70 **A. L. Mayberry, R. L. Nydam, K. Townsend, J. Mitchell, K. Cooper, K. Manfredi** DENTAL MICROWEAR ANALYSIS OF THREE TAXA OF LATE CRETACEOUS LIZARDS (SQUAMATA, BORIOTEIIOIDEA)

B71 **S. M. Hamilton, I. Paparella, P. Bell, N. E. Campione, F. Fanti, D. W. Larson, R. Sissons, M. Vavrek, C. Sullivan** A MONSTERSAURIAN LIZARD FRONTAL FROM THE CAMPANIAN WAPITI FORMATION OF ALBERTA, CANADA

B72 **M. L. Chavarria-Arellano, D. García-Alcantara, P. Romo de Vivar-Martínez, M. Montellano** LIZARDS FROM EL GALLO FORMATION (CAMPANIAN), BAJA CALIFORNIA, MÉXICO

B73 **C. H. Woolley, J. Sertich** NEW SCINCOMORPHAN AND PLATYNOTAN LIZARDS FROM THE UPPER CRETACEOUS (CAMPANIAN) SAN JUAN BASIN, NEW MEXICO, U.S.A.

B74 **A. Folie, M. L. Augé, R. Smith, A. Phélizon , P. Gigase, T. Smith** REASSESSMENT OF THE MORPHOLOGY AND TAXONOMIC STATUS OF THE VARANID LIZARD *SANIWA ORSMAELENSIS* FROM THE EARLY EOCENE OF NORTHWEST EUROPE

B75 **H. S. Paul, J. J. Jacisin, J. R. Moore** A SERIES OF HIGHLY DIVERS HERPETOFAUNAS FROM THE EOCENE–OLIGOCENE OF NEBRASKA

B76 **S. Onary, A. S. Hsiou** PHYLOGENETIC INCLUSIVITY OF *CHUBUTOPHIS* (SERPENTES, BOIDAE) WITH THE REPORT OF A NEW SPECIES FROM THE LATE MIOCENE OF BRAZIL

B77 **S. G. Scarpetta** A NEW MIOCENE GERRHONOTINE FROM THE CALIENTE FORMATION, CALIFORNIA

B78 **F. Knoll, D. Azar, S. Maksoud, R. López-Antoñanzas** THE REPTILES AND AMPHIBIANS FROM THE LATE MIOCENE OF ZAHLEH, LEBANON

B79 **E. M. Simpson** HERPETOFAUNAL AND BOTANICAL ESTIMATE OF PRECIPITATION AND TEMPERATURE ANNUAL AVERAGES AT GRAY FOSSIL SITE, TENNESSEE

B80 **J. Rej** ONTOGENETIC DEVELOPMENT OF AGAMIDAE (SQUAMATA) WITH IMPLICATIONS FOR FOSSIL SQUAMATA IDENTIFICATION

B81 **L. W. Vinola** FOSSIL RECORD OF THE ROCK IGUANA *CYCLURA* (FAMILY: IGUANIDAE) IN CUBA: IMPLICATIONS FOR ITS SYSTEMATICS, PALEOECOLOGY AND PALEODISTRIBUTION

B82 **A. K. Parker, J. J. Head** CORRELATED BODY SIZE CHANGES IN CENOZOIC TURTLES, CROCODILIANS, AND MAMMALS

B83 **A. Bradley, S. J. Nesbitt, S. H. Burch, R. Irmis, N. Smith, A. H. Turner** STERNAL ELEMENTS OF THE EARLY DINOSAUR *TAWA HALLAE* FILL A CRITICAL GAP IN THE EVOLUTION OF THE STERNUM IN AVEMETATARSALIA (REPTILIA: ARCHOSAURIA)

B84 **E. L. Evans, C. T. Griffin, N. Smith, A. H. Turner, R. B. Irmis, S. J. Nesbitt** ONTOGENETIC CHANGES IN THE FEMUR OF *TAWA HALLAE* AND IMPLICATION FOR SPECIES DIVERSITY OF LATE TRIASSIC DINOSAURS

B85 **Z. Qin, J. M. Clark, X. Xu** A NEW JURASSIC ALVAREZSAURIAN THEROPOD FROM THE SHISHUGOU FORMATION OF WESTERN CHINA DEMONSTRATES AN EARLY DIVERSIFICATION OF THE GROUP

B86 **A. Flores, M. Demic** UNDERSTANDING THE FACTORS UNDERLYING GROWTH VARIATION IN THE THEROPOD DINOSAUR *ALLOSAURUS FRAGILIS*

B87 **J. B. Stiegler, A. J. Moore** COELUROSAURIAN MANUAL DIGITS ARE II, III, IV, AND SOMETIMES V: NEW EVIDENCE CONFLICTS WITH PREVIOUS HYPOTHESES FOR THEROPOD DIGIT REDUCTION

B88 **T. Brougham, S. W. Salisbury, P. R. Bell** NON-AVIAN THEROPOD DIVERSITY IN CRETACEOUS AUSTRALIA: EVIDENCE FROM THE FOSSIL TOOTH RECORD

B89 **M. D'Emic, P. M. O'Connor, J. Gavras, E. Mardakhayava, E. K. Lund** MODELING TOOTH FORMATION TIME TO PREDICT TOOTH REPLACEMENT RATES IN *MAJUNGASAURUS* AND OTHER THEROPOD DINOSAURS

B90 **A. J. Rowe, E. Snively, R. Ridgely, L. M. Witmer** BIOMECHANICS OF JUVENILE TYRANNOSAURID MANDIBLES AND THEIR IMPLICATIONS FOR TYRANNOSAURID BITE FUNCTION

B91 **K. Widrig, H. C. Larsson** BITE FORCE AND CRANIAL KINESIS IN *TYRANNOSAURUS REX*

B92 **M. McKeown, S. Brusatte, T. E. Williamson, K. Schroeder, M. Espy, C. Gautier, J. Hunter, A. Losko, R. Nelson, S. Vogel** THE ENDOCRANIAL ANATOMY OF *BISTAHIEVERSOR SEALEYI* (DINOSAURIA, THEROPODA) AND NEUROSENSORY EVOLUTION IN TYRANNOSAUROIDS

B93 **J. T. Voris, D. K. Zelenitsky, F. Therrien, L. M. Witmer, R. Ridgely** A DESCRIPTION OF TWO NEW JUVENILE SPECIMENS OF *GORGOSAURUS LIBRATUS* (TYRANNOSAURIDAE, ALBERTOSAURINAE): MORPHOLOGICAL VARIATION ASSOCIATED WITH ONTOGENY

B94 **M. A. Loewen, J. Sertich, M. A. Norell** THE PRESENCE OF MULTIPLE LINEAGES OF TYRANNOSAURS IN THE UPPER JURASSIC MORRISON FORMATION, U.S.A., DEMONSTRATES EARLY COSMOPOLITANISM IN TYRANNOSAUROIDEA

B95 **L. Zanno, T. A. Gates, A. Canoville, R. Tucker, H. M. Avrahami, P. J. Makovicky** A DIMINUTIVE TYRANNOSAUROID FROM THE DAWN OF THE LATE CRETACEOUS IN NORTH AMERICA

B96 **J. C. Mallon, J. R. Bura, D. Schumann** A PROBLEMATIC TYRANNOSAURID (DINOSAURIA, THEROPODA) SKELETON AND ITS IMPLICATIONS FOR TYRANNOSAURID DIVERSITY IN THE HORSESHOE CANYON FORMATION (UPPER CRETACEOUS) OF ALBERTA

B97 **T. D. Carr** SIGNIFICANT GEOGRAPHIC RANGE EXTENSION FOR THE SYMPATRIC TYRANNOSAURIDS *ALBERTOSAURUS LIBRATUS* AND *DASPLETOSAURUS TOROSUS* FROM THE JUDITH RIVER FORMATION (LATE CAMPANIAN) OF NORTHERN MONTANA

B98 **J. Simon, D. Evans** ASSESSING HABITAT PARTITIONING IN NON-AVIAN THEROPOD DINOSAURS USING PEDAL MORPHOLOGY: A CASE STUDY OF THE CAENAGNATHID OVIRAPTOROSAUR *MACROPHALANGIA CANADENSIS*

B99 **C. Liao, X. Xu** CRANIAL OSTEOLOGY OF *BEIPIAOSAURUS INEXPECTUS* (THEROPODA, THERIZINOSAURIA)

B100 **D. E. Korneisel** PRESERVATION OF THE THERIZINOSAUR *BEIPIAOSAURUS INEXPECTUS* FROM THE YIXIAN FORMATION OF CHINA: IS IT AS CHEMICALLY EXCEPTIONAL AS IT IS VISUALLY?

B101 **G. F. Funston, P. J. Currie** A SMALL CAENAGNATHID TIBIA FROM THE HORSESHOE CANYON FORMATION (MAASTRICHTIAN): IMPLICATIONS FOR GROWTH AND LIFESTYLE IN OVIRAPTOROSAURS

B102 **S. Wang, Q. Zhang, R. Yang** REINTERPRETATION OF JAW BONE STRUCTURES OF CAENAGNATHID OVIRAPTOROSAURS

B103 **S. Lee, Y. Lee, A. Chinsamy-Turan, J. Lü, R. Barsbold, K. Tsogtbaatar** A NEW SMALL OVIRAPTORID DINOSAUR (DINOSAURIA, THEROPODA) FROM THE NEMEGT FORMATION (LATE CRETACEOUS) OF MONGOLIA

B104 **W. Ma, S. Brusatte, J. Lü, M. Sakamoto** THE SKULL ANATOMY AND FUNCTIONAL DISPARITY OF OVIRAPTOROSAURS

B105 **R. E. Nottrodt, F. Therrien, D. K. Zelenitsky, Y. Kobayashi** NEW ORNITHOMIMID MATERIAL FROM THE DINOSAUR PARK FORMATION OF ALBERTA, CANADA, REVEALS THE PRESENCE OF TWO LARGE ORNITHOMIMOSAUR TAXA DURING THE LATE CAMPANIAN IN NORTH AMERICA

B106 **B. Holgado, A. S. Brum, R. V. Pêgas, K. L. Bandeira, R. G. Souza, A. W. Kellner, D. A. Campos** A NEW UNENLAGIINAE (THEROPDA: DROMAEOSAURIDAE) FROM THE MAASTRICHTIAN OF BRAZIL

B107 **T. R. Pascucci, M. D. D'Emic** GROWTH OF THE DROMAEOSAURID THEROPOD DINOSAUR *DEINONYCHUS ANTIRRHOPUS*

B108 **Y. Yu, X. Xu** CURVATURE OF MANUAL BONES OF MICRORAPTORINE THEROPODS: POSSIBLE IMPLICATION FOR ARBOREAL BEHAVIOR

B109 **T. A. Dececchi, M. Habib, H. C. Larsson** FLIGHTS OF FANCY: MODELING POWERED FLIGHT VERSUS GLIDING IN THE BIZARRE THEROPOD *YI QI* AND ITS BEARING ON THE QUESTION OF THE ORIGINS OF FLIGHT ACROSS PENNARAPTORA

B110 **T. P. Hopp, M. J. Orsen** EVIDENCE THAT 'FOUR-WINGED' PARAVIAN DINOSAURS MAY HAVE USED HINDLIMB FEATHERS FOR BROODING

B111 **T. L. Green, P. M. Gignac** TESTING THE UTILITY OF CASSOWARIES AS LIVING MODELS FOR NON-AVIAN DINOSAUR CRANIAL ORNAMENTS

B112 **R. M. Vice, M. P. Ryan, P. J. Currie, E. B. Koppelhus, Y. Lee, T. Khishigjav** HISTOLOGICAL ANALYSIS OF OVIRAPTORID EGGSHELL FRAGMENTS FROM THE UPPER CRETACEOUS NEMEGT FORMATION OF MONGOLIA WITH ASSOCIATED SKELETAL MATERIAL

B113 **S. E. Oser, K. Chin, J. J. Sertich, D. J. Varricchio** FIRST PARTIAL EGGS FOUND IN THE UPPER CRETACEOUS KAIPAROWITS FORMATION OF SOUTHERN UTAH, U.S.A., REPRESENT A NEW OOTAXON OF LAEVISOOLITHID EGGSHELL

B114 **E. Alger-Meyer, S. E. Oser, J. Sertich, E. A. Smith** A POTENTIAL DINOSAUR CLUTCH FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION (GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH)

B115 **J. Wiemann, T. Yang, M. A. Norell** DINOSAUR EGGS CAME IN VARIOUS COLORS AND PATTERNS

B116 **S. Choi, Y. Lee** ELECTRON BACKSCATTER DIFFRACTION (EBSD) IS A POWERFUL TECHNIQUE FOR FOSSIL EGGSHELL RESEARCH: A NOVEL METHOD PROVIDES CRYSTALLOGRAPHIC INFORMATION ON CONTACT INCUBATION AND A WAY TO IDENTIFY THE TRUE PORE CANAL AND EXTERNAL LAYER

B117 **K. Tanaka, D. K. Zelenitsky, F. Therrien, M. S. Fernandez, H. Saegusa, T. Ikeda, K. Kubota** REPORT ON A THEROPOD NESTING SITE FROM HYOGO, JAPAN

B118 **I. Díaz-Martínez, F. Pérez-Lorente, P. Navarro-Lorbés, E. García-Ortíz, J. I. Canudo, X. Pereda-Suberbiola, A. Torices** A NEW THEROPOD ICHNOTAXON FROM THE LOWER CRETACEOUS ENCISO GROUP (CAMEROS BASIN, SPAIN)

B119 **M. Lockley** THE THEROPOD ICHNOGENUS *SAUREXALLOPUS* BECOMES WIDELY KNOWN IN THE UPPER CRETACEOUS OF NORTH AMERICA

B120 **J. S. Cabrera Hernández, R. Hernández Rivera, M. Montellano** FOSSIL EGGSHELLS AND TWO PERINATAL DINOSAURS FROM THE EL GALLO FORMATION (LATE CRETACEOUS), EL ROSARIO, BAJA CALIFORNIA, MEXICO

B121 **E. R. Przybyszewski, P. Germano , D. J. Varricchio, D. Trexler** NEW INSIGHTS ON A UNIQUE EGGSHELL LOCALITY WITHIN THE LATE CRETACEOUS UPPER TWO MEDICINE FORMATION OF MONTANA

B122 **WITHDRAWN**

B123 **P. Navarro-Lorbés, A. Torices, R. Lostado-Lorza, R. Cid, R. San Juan-Palacios** COULD PTEROSAURS BITE HARD? A STUDY THROUGH FINITE ELEMENT ANALYSIS OF *PREJANOPTERUS CURVIROSTRIS* AS A POSSIBLE DUROPHAGOUS ANIMAL

B124 **K. L. Rosenbach, J. A. Wilson, I. S. Zalmout** PTEROSAUR REMAINS FROM THE LATE CRETACEOUS OF AFRO-ARABIA PROVIDE INSIGHT INTO PTEROSAUR DIVERSITY AND FLIGHT CAPACITY

B125 **H. Kim, J. Park, I. Paik** LARGE PTEROSAUR FOOTPRINTS FROM THE UPPER CRETACEOUS JINDONG FORMATION OF SOUTH KOREA: OCCURRENCE AND PALEOECOLOGICAL IMPLICATIONS

B126 **D. M. Unwin, C. Deeming** AN INTEGRATED MODEL FOR REPRODUCTION AND GROWTH IN PTEROSAURS

B127 **M. Sprague, M. A. McLain** RESOLVING THE *MESADACTYLUS* COMPLEX OF DRY MESA QUARRY, MORRISON FORMATION, COLORADO

B128 **J. I. Mead, R. S. White, S. L. Swift, A. Baez** EXTINCT CAPYBARA, *NEOCHOERUS PINCHNEYI* (HYDROCHOERIDAE) FROM THE RANCHOLABREAN OF TÈRAPA, SONORA, MEXICO

B129 **M. B. Senn, J. R. Moore** ASSESSING THE IMPACT OF THE EOCENE–OLIGOCENE CLIMATE TRANSITION ON THE RODENT FAUNAS OF THE WHITE RIVER GROUP

B130 **M. R. Wyatt, S. S. Hopkins** NEW GEOMYOIDEA FROM THE MIOCENE CAVE BASIN FAUNA OF OREGON

B131 **R. López-Antoñanzas, A. Grossman** NEW SPECIMENS OF THRYONOMYIDAE (RODENTIA) FROM THE EARLY MIOCENE OF KALODIRR (KENYA)

B132 **R. A. Martin, R. C. Hulbert** A REVIEW OF MIDDLE TO LATE MIOCENE CRICETID RODENTS FROM FLORIDA

B133 **A. Pacheco-Castro, O. Carranza-Castañeda, E. Jiménez-Hidalgo** ADVANCES IN THE STUDY OF CRICETIDAE RODENTS FROM LATE HEMPHILLIAN–IRVINGTONIAN OF CENTRAL MEXICO AND THEIR RELATIONSHIP WITH NORTH AMERICA FAUNAS

B134 **G. W. Flora, K. Mackenzie** INCREASING COMPLEXITY IN AN EXCEPTIONALLY LARGE POPULATION OF *AZTLANOLAGUS* (MAMMALIA, LEPORIDAE) FROM THE PLEISTOCENE OF COLORADO

B135 **O. Sanisidro, D. DeMiguel, J. Madurell Malapeira, S. Jovells Vaqué, I. Casanovas-Vilar** REVALIDATION OF THE GENUS *DROMOCERATHERIUM* (PERISSODACTYLA, RHINOCEROTIDAE) AND ITS KEY ROLE WITHIN RHINOCEROTINAE

B136 **R. Schellhorn** MEDIPORTAL RHINOCEROSES FROM THE MIOCENE SANDELZHAUSEN LOCALITY (GERMANY)

B137 **T. Murakami, T. Tsubamoto** REAPPRAISAL OF A RHINOCEROTID LUNAR FROM THE MID-PLIOCENE UENO FORMATION OF THE KOBIWAKO GROUP, CENTRAL JAPAN

B138 **M. Crowe, L. C. Babilonia, E. Scott** A REVIEW OF FOSSILS OF MIDDLE PLEISTOCENE *EQUUS* FROM RALPH B. CLARK REGIONAL PARK, ORANGE COUNTY, CALIFORNIA, US

B139 **E. M. Holt** DISCRIMINANT ANALYSIS OF THE HORSES OF FOSSIL LAKE, OREGON, U.S.A.

B140 **C. I. Barron-Ortiz, C. N. Jass, V. M. Bravo-Cuevas** *EQUUS*: WHERE IS THE GENUS? PHYLOGENETIC ASSESSMENT OF *HARINGTONHIPPUS FRANCISCI* (PERISSODACTYLA, EQUIDAE) AND OTHER HORSES TRADITIONALLY ASSIGNED TO *EQUUS*

B141 **R. L. Bernor, O. Cirilli, A. M. Jukar, R. Potts, L. Rook, B. Sun, S. Wang** THE EURASIAN *EQUUS* DATUM AND EARLY EVOLUTION OF THE GENUS IN EURASIA

B142 **C. M. Janis, J. D. Damuth, K. Travouillon, S. Hand, M. Archer** GLOBAL MAMMALIAN RESPONSE TO MID-MIOCENE PEAK IN ATMOSPHERIC CARBON DIOXIDE

B143 **D. D. DeBlieux, M. E. Thompson, H. Flora** NEW MIOCENE LARGE MAMMAL FOSSILS FROM THE SEVIER RIVER FORMATION ON THE WESTERN MARGIN OF THE COLORADO PLATEAU OF CENTRAL UTAH

B144 **P. Gensler, G. S. Morgan, S. Aby, D. Koning** CHRONOLOGY OF THE LATE MIOCENE (LATE HEMPHILLIAN) SAN JUAN FAUNA, CHAMITA FORMATION, NEW MEXICO

B145 **G. Morgan, S. Aby, P. Gensler, D. Koning, M. Heizler** GEOCHRONOLOGY OF THE CHAMITA FORMATION, NEW MEXICO, AND THE FIRST APPEARANCE OF THE LATE MIOCENE (EARLY HEMPHILLIAN) GROUND SLOTH *PLIOMETANASTES* (MEGALONYCHIDAE) IN NORTH AMERICA

B146 **I. Magallanes, B. J. Macfadden, G. S. Morgan** STABLE CARBON AND OXYGEN ISOTOPES PROVIDE NEW INSIGHTS ON CLIMATE AND PALEOECOLOGY DURING THE MIOCENE OF NORTHERN NEW MEXICO

B147 **M. Barboza** CARBON ISOTOPE ANALYSIS OF MAMMALIAN HERBIVORE TEETH FROM A 10-MILLION-YEAR TIME SPAN IN FLORIDA INCLUDING THE MID MIOCENE CLIMATIC OPTIMUM

B148 **J. Schap, J. X. Samuels** VARIED RESPONSES OF MAMMALS TO THE MIDDLE MIOCENE CLIMATIC OPTIMUM, NON-UNIFORM SHIFTS IN CROWN HEIGHTS OF RODENTS, LAGOMORPHS, AND UNGULATES

B149 **L. Finkelman, P. Z. Barrett, G. Perdue, S. S. Hopkins** SMALL MAMMALS OF THE CROOKED RIVER MASCALL FORMATION

B150 **J. A. Van Couvering, J. A. Harris, E. Delson** AFRICAN LAND MAMMAL AGES

B151 **WITHDRAWN**

B152 **L. Thrasher** FOSSIL TRACKS AND TRACKWAYS FROM THE LATE PLIOCENE BEAR SPRINGS WASH BEDS OF GRAHAM COUNTY, SOUTHEASTERN ARIZONA

B153 **B. J. Burger, L. Jolley** A PIG-LIKE MAMMAL (ARTIODACTYLA, HELOHYIDAE) FROM THE MIDDLE EOCENE (LATE BRIDGERIAN) WASHAKIE FORMATION OF SOUTHWEST WYOMING

B154 **K. Townsend, A. Delgado** THE SKELETON OF *DIPLOBUNOPS* AND IMPLICATIONS FOR UNDERSTANDING VARIATION IN EARLY ARTIODACTYLS

B155 **H. C. Seyler , J. J. Eberle** COMPARING DIETARY NICHE PARTITIONING AMONG THE HORNLESS ARTIODACTYL RUMINANTS *HYPERTRAGULUS*, *HYPISODUS*, AND *LEPTOMERYX* FROM THE EARLY OLIGOCENE (ORELLAN) BRULE FORMATION, TOADSTOOL GEOLOGIC PARK, NEBRASKA

B156 **N. A. Famoso** STATISTICAL ANALYSIS OF DENTAL VARIATION IN OLIGOCENE HYPERTRAGULIDS (MAMMALIA, ARTIODACTYLA) OF OREGON

B157 **S. Maden, J. X. Samuels** THE FIRST CAMELID MATERIAL FROM THE EARLY PLIOCENE GRAY FOSSIL SITE, EASTERN TENNESSEE

WEDNESDAY, OCTOBER 17, 2018
POSTER SESSION I
(CONTINUED)

B158 **D. R. Prothero** A NEW SPECIES OF THE MIOCENE PECCARY *MACROGENIS* WITH BIZARRE FLARING CHEEKBONES

B159 **D. Yang, K. Uno, T. Cerling** INTRATOOTH ISOTOPE PROFILES OF FOSSIL SUIDS FROM THE KOOBI FORA FORMATION (EAST TURKANA, KENYA) INDICATE SEASONALLY STABLE C_4 DIETS BUT SEASONALLY VARIABLE BODY WATER OR HYDROCLIMATE

WEDNESDAY–SATURDAY, OCTOBER 17–20, 2018
POSTERS ASSOCIATED WITH EDUCATION & OUTREACH
ALBUQUERQUE CONVENTION CENTER, HALL 4

Authors must be present from 4:15–6:15 p.m. Wednesday, October 17, for odd-numbered poster boards; Authors must be present from 4:15–6:15 p.m. Friday, October 19, for even-numbered poster boards

Posters must be removed by 6:30 p.m. on Saturday

B164 **K. Bitterman, S. Tomiya, C. M. Redman, K. Cain, J. Meachen** RESEARCH EXPERIENCE IN PALEONTOLOGY CHANGES ATTITUDES, IMPROVES SCIENCE COMMUNICATION, AND INSPIRES HIGH SCHOOL STUDENTS TO PURSUE STEM CAREERS

B165 **T. M. Williams** EVALUATING COMMUNICATION OF EVOLUTIONARY THEORY WITHIN EXHIBITS AT THE STERNBERG MUSEUM OF NATURAL HISTORY

B166 **A. B. Heckert** FINDING FOSSILS ON FRIDAYS (FFF)—USING AN APPRENTICESHIP MODEL TO BUILD A GUILD OF UNDERGRADUATE RESEARCHERS AND EXPAND PALEONTOLOGICAL OUTREACH AT APPALACHIAN STATE UNIVERSITY

B167 **G. J. Bradley** THERE AND BACK AGAIN: BRINGING GLOBAL PALAEONTOLOGY MOOCS BACK INTO THE UNIVERSITY

B168 **S. K. Drumheller, C. D. Sumrall** TENNESSEE GEOPATHS: EXPERIENTIAL LEARNING AS A TOOL FOR RECRUITING AND RETENTION OF COMMUNITY COLLEGE STUDENTS

B169 **S. G. Strait, T. Dillman** WEST VIRGINIA SCIENCE ADVENTURES: FOSTERING STEM DIVERSITY THROUGH UNIVERSITY SPONSORED SCIENCE FESTIVALS

B170 **M. D. Uhen, C. O. George, C. Bentley, P. Berquist, R. Lockwood, L. A. Lukes, K. Rkyer** UTILIZING THE PALEOBIOLOGY DATABASE TO PROVIDE HANDS-ON RESEARCH OPPORTUNITIES FOR UNDERGRADUATES

B171 **C. M. Holliday, C. Cranor, K. Sellers** CROCNET: A PUBLIC RESOURCE FOR CROCODILIAN IMAGING DATA AND VISUALIZATIONS

B172 **S. S. Sumida, K. M. Madalena** PARTNERING VERTEBRATE PALEONTOLOGISTS WITH LOCAL NATIVE AMERICAN HIGH SCHOOL STUDENTS DEVELOPS A DEEPER UNDERSTANDING OF STUDENTS' LANDS WHILE SIMULTANEOUSLY INCREASING PALEONTOLOGICAL ACCESS ON RESERVATION LANDS BELONGING TO THE PUEBLO OF JEMEZ, NEW MEXICO

B173 **L. D. White, P. A. Holroyd, R. W. Boessenecker** FROM THE FIELD TO THE FOSSILS: VIRTUAL FIELD EXPERIENCES IN THE KETTLEMAN HILLS, SAN JOAQUIN VALLEY, CALIFORNIA

B174 **W. J. Binder, L. G. DeSantis, E. Lindsey, J. Meachen, F. R. O'Keefe** TRAINING THE NEXT GENERATION OF SCIENTIFIC RESEARCHERS IN BOTH RESEARCH METHODS AND PUBLIC COMMUNICATION AT RANCHO LA BREA–A MELTING POT OF CURRENT AND ANCIENT DIVERSITY

B175 **M. L. Gold, A. R. West** SHE FOUND FOSSILS: A CROWDFUNDED, MULTI-LINGUAL, SELF- PUBLISHED, CHILDREN'S BOOK ABOUT WOMEN IN PALEONTOLOGY

B176 **M. Barboza** THE FEMMES OF STEM: AN INTERSECTIONAL, INTERDISCIPLINARY PODCAST AND WEB RESOURCE EXPLORING THE HISTORY OF WOMEN IN SCIENCE

B177 **A. Berta, S. Turner** "BONE HUNTERS"? THE HISTORY OF WOMEN IN VERTEBRATE PALEONTOLOGY BOOK PROJECT

B178 **S. Moore, J. Scannella, P. Leggi, C. Ancell, A. Weikert, D. Bowen, N. Ikegami, S. Ikebe, H. Kurosu, M. Nomura** OUR HOME, OUR WORLD: FORGING RELATIONSHIPS IN MONTANA AND JAPAN THROUGH SCIENCE EDUCATION

B179 **K. M. Rivers** UNDERSTANDING ADULT EDUCATION: AN ANALYSIS OF THE DEVELOPMENT OF AN ADULT PROGRAM AT THE STERNBERG MUSEUM OF NATURAL HISTORY

B180 **M. Dickson, A. Deans, H. Thomas, B. Voss, M. McCallum, A. Chen** A CASE STUDY INCONDUCTING AN ONLINE LEARNING EXPERIENCE IN VERTEBRATE PALEONTOLOGY

B181 **J. B. McHugh, S. K. Drumheller-Horton, M. Kane, A. Riedel** UGLY AMBASSADORS: TURNING OVERLOOKED BONE FRAGMENTS INTO EFFECTIVE EMISSARIES OF STEM EDUCATION, MENTORSHIP, AND PUBLIC ENGAGEMENT

B182 **B. K. Shipps** BIG CONCEPTS, SMALL STUDENTS: CONVEYING COMPLEX PALEONTOLOGICAL IDEAS TO STUDENTS AGES 4–12

B183 **N. S. Vitek, C. A. Baker, J. I. Bloch** BRINGING MICROVERTEBRATES INTO THE MATH CLASSROOM: STEM INTEGRATION USING 3D PRINTED FOSSILS AND OTHER BIOLOGICAL OBJECTS

B184 **E. R. Ellwood, N. Graham, E. Lindsey, G. Takeuchi, M. Porter** MICROFOSSIL SORTING FOR A "MOUSE'S EYE VIEW" OF RANCHO LA BREA

B185 **A. M. Mychajliw, L. M. Acosta** SCIENCE FAIR PALEO-PROJECTS AS OPPORTUNITIES FOR HIGH SCHOOL STUDENT MENTORSHIP AND COMMUNITY ENGAGEMENT

B186 **A. Peterson, I. E. Smail, E. Daly, A. Ortiz, H. Edmonds** HUMAN ORIGINS SCIENCE FOR MIDDLE AND HIGH SCHOOL STUDENTS AND TEACHERS: BUILDING AN ONLINE COMMUNITY OF LEARNING

B187 **S. L. Masters** USING FIELD PALEONTOLOGY AS A MEANS TO INSPIRE STEM INTEREST AND CROSS-CURRICULAR EXPERIENTIAL LEARNING IN AN ALL-GIRLS HIGH SCHOOL

B188 **G. Santos, L. Schmitz** UTILIZING MUSEUM COLLECTIONS IN COLLABORATION FOR EXPERIENTIAL LEARNING AND CITIZEN SCIENCE IN HIGHER EDUCATION

B189 **D. A. Levering** STERNBERG EARTH AND LIFE SCIENCE ACADEMY: A MULTI-TIERED APPROACH TO YOUTH OPPORTUNITY ACCESS

WEDNESDAY–SATURDAY, OCTOBER 17–20, 2018
POSTERS ASSOCIATED WITH EDUCATION & OUTREACH (CONTINUED)

B190 **A. K. Hastings, L. Stoneman, K. A. Hastings, C. Deatherage** DINOSAURS IN COMIC BOOKS AS A MEANS OF STEAM ENGAGEMENT WITH MIDDLE SCHOOL STUDENTS IN UNDER-SERVED DISTRICTS IN VIRGINIA, U.S.A.

B191 **S. J. ElShafie, S. S. Sumida** ARTISTS AND PALEONTOLOGISTS EXPLORE SCIENCE ENGAGEMENT THROUGH NARRATIVE IN A SYMPOSIUM AT A SCIENTIFIC CONFERENCE

B192 **K. K. Bramble, C. N. Jass, C. I. Barron-Ortiz, J. Bender** ENGAGING THE SAND AND GRAVEL INDUSTRY TO HELP UNCOVER ALBERTA'S ICE AGE RECORD

B193 **H. Mesraty, E. Lindsey, J. Chapman, A. Mychajliw** WHAT DOES PUBLIC ACCESS TO THE SCIENTIFIC PROCESS LOOK LIKE AT AN URBAN PALEONTOLOGICAL SITE?

B194 **S. E. Holte, S. K. McLain , J. I. Mead** OVER 40 YEARS OF EDUCATION AND PUBLIC OUTREACH AT THE MAMMOTH SITE

B195 **R. E. Narducci, R. C. Hulbert, J. I. Bloch, B. J. Macf.adden, J. R. Bourque, A. R. Poyer, J. Pirlo, N. S. Vitek, C. A. Grant, M. J. Ziegler** RECOVERY AND CURATION OF A CRITICALLY IMPORTANT LATE MIOCENE FOSSIL DEPOSIT IN NORTH-CENTRAL FLORIDA: A RARE OPPORTUNITY FOR CITIZEN SCIENCE AND PUBLIC EDUCATION

B196 **M. R. Stocker, S. J. Nesbitt, L. Sharp** FOSSIL UNWRAPPING PARTIES: THE INTERSECTION OF PALEONTOLOGY, CITIZEN-SCIENCE, AND UNDERGRADUATE RESEARCH OPPORTUNITIES

B197 **J. M. Hodnett, K. M. Montaperto** DINOSAUR PARK: AN HISTORIC FOSSIL SITE AND CITIZEN SCIENTIST EXPERIENCE IN THE GREATER WASHINGTON, D.C. AREA

B198 **R. K. Hunt-Foster, B. Engh, B. H. Breithaupt, N. A. Matthews, G. McDonald** EDUCATION AT BUREAU OF LAND MANAGEMENT PUBLIC FOSSIL SITES IN SOUTHEASTERN UTAH: NEW LIFE FROM OLD BONES

B199 **S. L. Gladish, N. A. Famoso** INCLUDING ALL AUDIENCES: INTERPRETATION AND EDUCATION OPPORTUNITIES AT JOHN DAY FOSSIL BEDS NATIONAL MONUMENT

B200 **B. E. Stoneburg, G. Santos** WITH OUR POWERS COMBINED: INCREASING AUDIENCE REACH FOR SMALL MUSEUMS THROUGH COLLABORATIVE EDUCATION AND OUTREACH INITIATIVES

B201 **B. S. Dooley, B. E. Stoneburg, A. C. Dooley** I.C.E. AGE PROJECT: COMBINING OUTREACH WITH EXHIBIT PRODUCTION

THURSDAY MORNING, OCTOBER 18, 2018
TECHNICAL SESSION V
ALBUQUERQUE CONVENTION CENTER, BALLROOM A
MODERATORS: Julie Meachen and Julien Louys

8:00 **S. U. Galvez, D. R. Prothero** AGE-MORTALITY PROFILES IN LA BREA BISON: INSIGHTS INTO POPULATION DYNAMICS AND TAPHONOMY

8:15 **S. Gust, S. A. McLeod, A. Leger, K. Scott, E. Scott, J. M. Harris** TAR PITS IN PERSPECTIVE: LATE PLEISTOCENE NON-ASPHALTIC MAMMALIAN FAUNAS FROM THE LA BREA PLAIN INDICATE FAUNAL BIAS AT RANCHO LA BREA, CALIFORNIA

THURSDAY MORNING, OCTOBER 18, 2018
TECHNICAL SESSION V
(CONTINUED)

8:30 **M. K. Macias** THREE'S A CROWD: SPATIAL ANALYSIS OF MULTI-TAXA SLOTH LOCALITIES

8:45 **N. A. Freymueller, M. I. Pardi, F. A. Smith** DO COUGARS (*PUMA CONCOLOR*) RE-FILL THE MEGAFELID NICHE FOLLOWING THE PLEISTOCENE MEGAFAUNAL EXTINCTION?

9:00 **J. Meachen, S. Tomiya** THE POSTCRANIAL MORPHOLOGY OF THE BERINGIAN WOLF REVEALS TWO PULSES OF ECOLOGICAL DISAPPEARANCE

9:15 **B. Van Valkenburgh** TOUGHER TIMES FOR YELLOWSTONE GRAY WOLVES: RATES OF TOOTH WEAR AND FRACTURE INCREASE AS PREY NUMBERS DECLINE

9:30 **D. M. Reuter, S. S. Hopkins, S. A. Price** WHAT IS A MAMMALIAN OMNIVORE? INSIGHTS INTO OMNIVORE DIET DIVERSITY, BODY MASS, AND EVOLUTION

9:45 **R. A. Short, A. M. Lawing** COMPARISON OF INFERENCE APPROACHES FOR ECOMETRIC ANALYSES: USING HYPSODONTY TO ESTIMATE PRECIPITATION

10:00 BREAK

10:15 **E. Scholtz, L. G. DeSantis** INVESTIGATING IMPACTS OF NON-NATIVE SPECIES ON AUSTRALIAN MARSUPIAL DIETARY ECOLOGY ACROSS SPACE AND THROUGH TIME

10:30 **L. DeSantis, G. Price, M. Archer** ARIDIFICATION AS A POTENTIAL DRIVER OF THE EXTINCTION OF THE MARSUPIAL LION IN AUSTRALIA

10:45 **E. M. Biedron, L. DeSantis** A MULTIPROXY APPROACH TO TRACKING ARIDITY ACROSS AUSTRALIAN LANDSCAPES USING BRUSHTAIL POSSUMS (MARSUPIALIA, PHALANGERIDAE, *TRICHOSURUS*)

11:00 **J. Louys, G. Price, J. Zaim, Y. Rizal, W. Santoso, A. Trihascaryo** NEW ORANGUTAN-BEARING FOSSIL DEPOSITS FROM WESTERN SUMATRA PROVIDE INSIGHTS INTO PLEISTOCENE ORANGUTAN TAXONOMY AND ECOLOGY

11:15 **I. E. Smail** COMMUNITY DENTAL MORPHOLOGY OF PLIO-PLEISTOCENE CERCOPITHECID PRIMATES: COMPARISONS WITH EXTANT AFRICAN AND ASIAN CERCOPITHECID COMMUNITIES

11:30 **I. A. Lazagabaster** EVOLUTION, TAXONOMY, AND PALEOECOLOGY OF THE SUIDAE (MAMMALIA, ARTIODACTYLA) FROM HADAR AND THE LEE ADOYTA SUB-BASIN, AFAR, ETHIOPIA

11:45 **M. D. Biernat, D. R. Braun, D. B. Patterson, K. E. Reed** INTRA-BASINAL HETEROGENEITY OF MAMMALIAN COMMUNITIES IN THE TURKANA BASIN BETWEEN ~2.0 AND 1.4 MA

12:00 **S. J. Maxwell, P. J. Hopley, P. Upchurch** THE COMPLETENESS OF THE EARLY HOMININ FOSSIL RECORD: IMPLICATIONS FOR DIVERSITY PATTERNS AND THE ORIGIN OF HOMININI

THURSDAY MORNING, OCTOBER 18, 2018
TECHNICAL SESSION VI
ALBUQUERQUE CONVENTION CENTER, BALLROOM B
MODERATORS: Hillary Maddin and Adam Huttenlocker

8:00 **L. S. Lassiter** REVISITING ROMER'S ARMS RACE BETWEEN EURYPTERIDS AND EUVERTEBRATES

8:15 **D. Marjanović** YES, WE CAN HOMOLOGIZE SKULL (AND OTHER) BONES OF ACTINOPTERYGIANS AND TETRAPODS

THURSDAY MORNING, OCTOBER 18, 2018
TECHNICAL SESSION VI
(CONTINUED)

8:30 **Y. Haridy, B. Gee, R. R. Reisz** RETENTION OF FISH LIKE TOOTH REPLACEMENT IN THE PALATAL DENTITION OF PERMIAN TETRAPODS

8:45 **J. Atkins, R. R. Reisz, H. C. Maddin** PERTURBING *HOX* GENE EXPRESSION DOMAINS PRODUCE NEW AND ANCESTRAL CRANIAL MORPHOLOGIES IN EXTANT AMPHIBIANS

9:00 **M. Danto, F. Witzmann, S. Triepel, C. Mitgutsch, N. B. Froebisch** THE IMPLICATION OF THE VERTEBRAL DEVELOPMENT ON THE ORIGIN OF LISSAMPHIBIANS

9:15 **B. K. Otoo, J. R. Bolt, E. Lombard** A LEG UP: *WHATCHEERIA* AND ITS NEW CONTRIBUTIONS TO TETRAPOD ANATOMY

9:30 **H. C. Maddin, A. Mann, B. Hebert** A NEW PERMIAN-LIKE FAUNA PRESERVED WITHIN A SINGLE FOSSILIZED STUMP FROM THE CARBONIFEROUS OF NOVA SCOTIA

9:45 **J. Fröbisch, C. F. Kammerer, H. Sues, E. Frey, F. Witzmann, M. Jansen** THE KORBACH FISSURE FILL: COMPOSITION AND BIOGEOGRAPHY OF A LATE PERMIAN PALEOEQUATORIAL FAUNA FROM CENTRAL EUROPE

10:00 BREAK

10:15 **A. K. Huttenlocker, D. S. Berman, A. C. Henrici, J. Jung, J. D. Pardo, T. Schlotterbeck, S. S. Sumida** TERRESTRIAL LIFE ELEVATED: NEW DATA ON CARBONIFEROUS–PERMIAN VERTEBRATE BIOCHRONOLOGY IN SOUTHEASTERN UTAH AND ITS GLOBAL IMPLICATIONS

10:30 **A. Mann, H. C. Maddin** A NEW LONG-BODIED RECUMBIROSTRAN FROM MAZON CREEK WITH A FULL PELAGE OF SCALES REVEALS AMNIOTE-LIKE ULTRASTRUCTURAL INTEGUMENTARY PATTERNS

10:45 **J. S. Anderson, J. D. Pardo, R. B. Holmes** AN ENIGMATIC TETRAPOD FROM FIVE POINTS, OHIO (UPPER CARBONIFEROUS), FURTHER SUPPORTS AISTOPOD PLACEMENT AMONG THE TETRAPOD STEM GROUP

11:00 **B. M. Gee, R. R. Reisz** HISTOLOGICAL SKELETOCHRONOLOGY OF THE EARLY PERMIAN STEM LISSAMPHIBIAN *DOLESERPETON*

11:15 **C. So, A. M. Kufner, A. K. Huttenlocker, J. Pardo, D. Lovelace** UNUSUAL FOSSORIAL STEREOSPONDYL FROM THE TRIASSIC OF WYOMING WITH IMPLICATIONS FOR THE ORIGINS OF GYMNOPHIONA

11:30 **P. P. Roy, D. P. Sengupta, S. P. Chakravorti** RICH OCCURRENCES OF CAPITOSAUR AMPHIBIANS FROM THE MIDDLE TRIASSIC DENWA FORMATION OF CENTRAL INDIA

11:45 **J. Jia, K. Gao** A STEM HYNOBIID (AMPHIBIA, URODELA) FROM THE UPPER JURASSIC OF WESTERN LIAONING PROVINCE, CHINA, SHEDS NEW LIGHTS ON EVOLUTION OF SALAMANDER LIMBS

12:00 **R. V. Hill, J. McCartney, E. M. Roberts, L. Tapanila, K. M. Claeson, K. Heilbronn, M. Bouaré, M. O'Leary** THE TETRAPOD FAUNA OF THE TRANS-SAHARAN SEAWAY IN THE LATE CRETACEOUS AND EARLY PALEOGENE OF MALI

THURSDAY MORNING, OCTOBER 18, 2018

ROMER PRIZE SESSION

ALBUQUERQUE CONVENTION CENTER, BALLROOM C

MODERATORS: Mark Uhen and Mark Clementz

8:00 **T. Yang** CLUTCH ARCHITECTURE, NEUTRON TOMOGRAPHY, AND ELEMENTAL MAPPING REVEAL HATCHING ASYNCHRONY AND COMMUNAL NESTING IN OVIRAPTORID DINOSAURS AND HIGHLIGHT THEIR PECULIAR REPRODUCTIVE BIOLOGY

8:15 **S. Macaulay** THE EVOLUTION OF BODY PROPORTIONS AND LOCOMOTION IN BIRDS

8:30 **T. Miyashita** ONTOGENY OF PALEOZOIC STEM LAMPREYS AS A TEST OF CYCLOSTOME-BASED MODELS OF VERTEBRATE ANCESTRY

8:45 **J. Bestwick** DIETARY ECOLOGY OF PTEROSAURS USING QUANTITATIVE 3D TEXTURAL ANALYSIS OF TOOTH MICROWEAR

9:00 **K. Chiba** TESTING OSTEOHISTOLOGY-BASED BODY MASS GROWTH CURVE RECONSTRUCTION IN EXTANT AND EXTINCT TETRAPODS

9:15 **J. V. Proffitt** MORPHOLOGICAL, BIOMECHANICAL, AND SENSORY EVOLUTION IN EARLY PENGUINS FOLLOWING THE TRANSITION TO FLIGHTLESS WING-PROPELLED DIVING

9:30 **R. B. Trayler** PATAGONIAN ARIDIFICATION AND ECOLOGICAL SHIFTS AT THE ONSET OF THE MID-MIOCENE CLIMATIC OPTIMUM

9:45 **D. A. Tarailo** CHANGES IN DISPERSAL CAPACITY THROUGH TIME WITHIN CROCODYLIA

10:00 BREAK

10:15 **T. Wintrich** THE INTERVERTEBRAL DISK GAVE REPTILES IMPROVED AXIAL MOBILITY– MORPHOLOGICAL, HISTOLOGICAL, AND PHYLOGENETIC EVIDENCE FOR INTERVERTEBRAL DISKS IN FOSSIL NON-MAMMALIAN AMNIOTES

10:30 **K. M. Loughney** PRESERVATION AND FAUNAL CHANGE OF MAMMALS IN THE BARSTOW FORMATION, SOUTHERN CALIFORNIA, AND THEIR IMPLICATIONS FOR TURNOVER AT THE HEMINGFORDIAN–BARSTOVIAN BOUNDARY

10:45 **G. J. Smith** COUPLING PALEOECOLOGICAL PROXIES TO INFER THE DIETARY ECOLOGY OF EXTINCT MEGAHERBIVORES

11:00 **M. Balisi** CLIMATE AS MODULATOR OF THE MACROEVOLUTIONARY RATCHET: DIVERSIFICATION AND TURNOVER IN NORTH AMERICAN FOSSIL CANIDS

11:15 **K. Waskow** GROWTH RATES AND AGE DISTRIBUTION OF DIFFERENT JURASSIC SAUROPOD TAXA: IMPLICATIONS FOR LIFE HISTORY TRAITS AND ECOLOGY BASED ON DORSAL RIB HISTOLOGY

11:30 **E. T. Saitta** MOLECULAR STABILITY AND MOBILITY: PROTEIN DIAGENESIS IN OPEN AND CLOSED TAPHONOMIC SYSTEMS

11:45 **M. C. Mekarski** LIMBS INTO FINS: CONVERGENT EVOLUTION AND THE POLYPHYLY OF THE MOSASAURIDAE

12:00 **D. Grossnickle** JAW CORRELATES OF DIET PROVIDE NOVEL INSIGHT ON THE ADAPTIVE RADIATION OF EARLY MAMMALS

THURSDAY AFTERNOON, OCTOBER 18, 2018

TECHNICAL SESSION VII

ALBUQUERQUE CONVENTION CENTER, BALLROOM A

MODERATORS: Armita Manafzadeh and Daniel Ksepka

1:45 **A. Roy, M. Pittman, T. Kaye, X. Wang, X. Zheng, X. Xu** FURTHER INVESTIGATON OF THE SOFT-TISSUE ANATOMY AND WING CONFIGURATION OF THE 'BAT-WINGED' PENNARAPTORAN DINOSAUR *YI QI*

2:00 **S. Hartman, M. Mortimer, D. M. Lovelace** A TESTABLE MACROEVOLUTIONARY FRAMEWORK FOR CHARACTER ACQUISITION IN THE ORIGIN OF AVIAN FLIGHT

2:15 **A. R. Manafzadeh, K. Padian** COULD PTEROSAURS AND BASAL MANIRAPTORANS ADOPT A BATLIKE HIP POSE? AN ANALYSIS USING "ROM MAPPING," A NEW METHOD FOR COMPARING JOINT MOBILITIES

2:30 **M. Pittman, R. Pei, P. Goloboff, T. Dececchi, M. Habib, T. Kaye, H. Larsson, M. Norell, S. Brusatte, X. Xu** GRADUAL BUILD-UP OF POWERED FLIGHT POTENTIAL AMONG CLOSE AVIAN RELATIVES REVEALED BY COMBINING PHYLOGENETIC, AERODYNAMIC, AND ANATOMICAL DATA

2:45 **A. Canoville, M. Schweitzer, L. Zanno** NEW DATA ON THE SKELETAL DISTRIBUTION OF MEDULLARY BONE IN NEORNITHES: PALEOBIOLOGICAL IMPLICATIONS

3:00 **D. Field, M. Hanson, D. A. Burnham, L. E. Wilson, K. J. Super, D. J. Ehret, J. A. Ebersole, B. S. Bhullar** COMPLETE *ICHTHYORNIS* SKULL ILLUMINATES MOSAIC ASSEMBLY OF THE AVIAN HEAD

3:15 **J. O'Connor, J. Maina, Y. Pan, M. Wang, X. Wang, Y. Wang, X. Zheng, Z. Zhou** A SPECIMEN OF *ARCHAEORHYNCHUS* PRESERVING SIGNIFICANT SOFT TISSUE INCLUDING THE FIRST PROBABLE OCCURRENCE OF FOSSILIZED LUNGS

3:30 **A. Bailleul, J. O'Connor, H. You, D. Li, Z. Zhou** A NEW SPECIMEN OF ENANTIORNITHINE FROM THE LOWER CRETACEOUS XIAGOU FORMATION WITH PRESERVATION OF AN UNUSUAL MINERALIZED TISSUE

3:45 **D. Ksepka, A. Balanoff, N. Smith, J. Smaers** EVOLUTION OF AVIAN BRAIN SIZE: COMBINING FOSSIL AND MODERN EVIDENCE

4:00 **G. M. Musser, D. J. Field, D. Ksepka** NEW MATERIAL OF *PELLORNIS* CLARIFIES PATTERN AND TIMING OF THE EXTANT GRUIFORM RADIATION

THURSDAY AFTERNOON, OCTOBER 18, 2018

PREPARATORS' SESSION

ALBUQUERQUE CONVENTION CENTER, BALLROOM B

MODERATORS: Steve Jabo and Matthew Smith

1:45 **A. C. Henrici, D. S. Berman, S. S. Sumida, A. K. Huttenlocker, T. Schlotterbeck** THE LATE PENNSYLVANIAN BIRTHDAY BONEBED FROM THE HALGAITO FORMATION OF VALLEY OF THE GODS, SOUTHEASTERN UTAH: COLLECTION, PREPARATION, AND PHOTODOCUMENTATION.

2:00 **L. Hall, D. Zelinski, A. R. McGee, M. Ryan** FISHING WITH SILICON CARBIDE: PREPARING DIVERSE MARINE VERTEBRATES FROM THE LATE DEVONIAN (FAMENNIAN) CLEVELAND MEMBER OF THE OHIO SHALE, OHIO, U.S.A.

2:15 **N. Ikegami, P. Leiggi, C. Ancell** THE PREPARATION PROJECT: A GLOBAL PARTNERSHIP BETWEEN THE MIFUNE DINOSAUR MUSEUM, KUMAMOTO, JAPAN, AND THE MUSEUM OF THE ROCKIES, MONTANA, U.S.A.

THURSDAY AFTERNOON, OCTOBER 18, 2018
PREPARATORS' SESSION
(CONTINUED)

2:30 **M. Di Giacomo, C. M. Goodwin** CRACKS, GREEN FOSSILS, AND MELTED BONE: CHARACTERIZATION OF PREPARATION DAMAGE USING SEM AND TOF-SIMS

2:45 **S. J. Haugrud** ULTRA-THIN SMALL MAMMAL CRANIAL RECONSTRUCTION IN THE 0.5–0.7 MILLIMETER RANGE USING BUTVAR B-76

3:00 **V. R. Rhue** MAINTAINING DATA LABEL INTEGRITY: A REVIEW OF MATERIALS AND TECHNIQUES FOR AFFIXING LABELS TO VERTEBRATE FOSSILS, HOUSINGS, ANDCOLLECTION STORAGE AREAS

3:15 **J. A. Hook, V. R. Rhue** THE CURATION, CONSERVATION, AND DIGITIZATION OF A PLEISTOCENE FAUNA FROM GYPSUM CAVE, NEVADA, U.S.A.

3:30 **L. G. Dougan, D. W. Krause, J. Sertich, P. Sullivan, J. R. Groenke** EVALUATION OF NOVEL VISUALIZATION SOFTWARE FOR VIRTUAL PALEONTOLOGY

3:45 **I. D. Browne** OPTIMIZING THE SUB-OPTIMAL: USING POINT-AND-SHOOT DIGITAL CAMERAS, GREEN PAPER, AN IMAGE PROCESSING ALGORITHM, AND A KITCHEN TIMER TO BUILD AN INEXPENSIVE SEMI-AUTOMATED 3D SCANNER

4:00 **A. Millhouse, H. Little** DEVELOPING BEST PRACTICES TO IMPROVE FOSSIL DATA QUALITY AND ACCESSIBILITY

THURSDAY AFTERNOON, OCTOBER 18, 2018
TECHNICAL SESSION VIII
ALBUQUERQUE CONVENTION CENTER, BALLROOM C
MODERATORS: Jacqueline Lungmus and Tony Harper

1:45 **E. A. Hoffman, T. B. Rowe** LARGE CLUTCH OF JURASSIC MAMMALIAMORPH PERINATES AND EVOLUTION OF MAMMALIAN REPRODUCTION AND GROWTH

2:00 **S. Hoffmann, R. Shahid, A. Watanabe, P. Gill** LARGE SAMPLING FROM EARLY JURASSIC FISSURE FILLINGS REVEALS VARIATION IN COCHLEAR CANAL SHAPE IN THE BASAL MAMMALIAFORM *MORGANUCODON*

2:15 **T. Harper, G. W. Rougier** CRETACEOUS STEM-THERIAN PETROSALS FROM MONGOLIA PROVIDE EARLIEST EVIDENCE FOR MODERN COCHLEAR PHYSIOLOGY

2:30 **C. Hendrickx, F. Abdala, J. Choiniere, R. Benson** THE DENTITION IN GOMPHODONTIA (CYNODONTIA, CYNOGNATHIA): DISPARITY, RATE OF EVOLUTION, AND DENTAL COMPLEXITY THROUGH TIME

2:45 **J. K. Lungmus, K. D. Angielczyk** MORPHOLOGICAL DISPARITY ACROSS THE SYNAPSID FORELIMB: SUBORDER-LEVEL PATTERNS ACROSS 80 MILLION YEARS OF SYNAPSID EVOLUTION

3:00 **E. Buchholtz, A. Feldman, Z. Yozgyur** COMPOSITE STRUCTURE AND HOMOLOGY IN THE THERIAN PRESTERNUM: A HYPOTHESIS

3:15 **A. Peng, N. Toews, A. Brannick, G. P. Wilson** AN ONTOGENETIC INVESTIGATION OF A CRETACEOUS NORTH AMERICAN MAMMAL, *DIDELPHODON VORAX* (METATHERIA, MARSUPIALIFORMES, STAGODONTIDAE), THROUGH QUANTITATIVE AND DESCRIPTIVE ANALYSES OF THE DENTARY

THURSDAY AFTERNOON, OCTOBER 18, 2018
TECHNICAL SESSION VIII
(CONTINUED)

3:30 **S. López-Torres, Ł. Fostowicz-Frelik** THE PHYLOGENETIC POSITION OF THE ANAGALIDAE WITHIN EUARCHONTOGLIRES AND ITS IMPLICATIONS FOR THE EVOLUTION OF GLIRES AND EUARCHONTA

3:45 **A. R. Evans, T. I. Pollock, A. Olah** BLADE RUNNER: FUNCTIONAL PERFORMANCE OF BLADED TEETH IN *THYLACOLEO* AND *PROPLEOPUS*

4:00 **S. Wroe, G. Sansalone** THE ORAL APPARATUS OF MARSUPIALS IS MORE INTEGRATED BUT NOT LESS MORPHOLOGICALLY DIVERSE THAN THAT OF PLACENTAL CARNIVORES

THURSDAY, OCTOBER 18, 2018
POSTER SESSION II
ALBUQUERQUE CONVENTION CENTER, HALL 4
Authors must be present from 4:15–6:15 p.m. Thursday, October 18

Posters must be removed by 6:30 p.m.

B36 **H. R. Taruvinga, S. Tolan, C. T. Griffin** A *LUANGWA*-LIKE CYNODONT FROM NORTHERN ZIMBABWE AND ENDEMISM ACROSS THE CARNIAN OF SOUTHERN AFRICA

B60 **R. T. Figueroa, M. Friedman, V. Gallo** REDESCRIPTION AND PHYLOGENETIC ANALYSIS OF *BRAZILICHTHYS MACROGNATHUS* (OSTEICHTHYES, ACTINOPTERYGII) FROM THE EARLY PERMIAN OF BRAZIL

B61 **K. N. Sievers, T. Daeschler** DESCRIBING THE LOWER JAW OF THE STEM TETRAPOD *TIKTAALIK ROSEAE* (LATE DEVONIAN: FRASNIAN) THROUGH COMPUTED TOMOGRAPHY DATA

B62 **D. Elliott, L. S. Lassiter** A PHYLOGENETIC ANALYSIS OF THE CYATHASPIDIDAE (AGNATHA, HETEROSTRACI)

B63 **Q. Wang, E. Hernandez-Ochoa, M. Viswanathan, E. Luczak, Y. Wu, J. Granger, J. Yang, R. Lovering, A. Cammarato, M. Schneider, G. S. Bever, M. E. Anderson** AN INTEGRATIVE LOOK AT VERTEBRATE ORIGINS

B64 **O. B. Afanassieva** MORPHOGENESIS OF THE EXOSKELETON IN EARLY VERTEBRATES (OSTEOSTRACI, AGNATHA): MODES OF THE HORIZONTAL GROWTH

B65 **WITHDRAWN**

B66 **C. Duffin, D. J. Ward, B. H. Lauer, R. L. Lauer** AN ASSOCIATED DENTITION OF *AGASSIZODUS* (CHONDRICHTHYES, EUGENEODONTIFORMES) FROM THE UPPER CARBONIFEROUS OF MISSOURI

B67 **J. M. Hodnett, E. D. Grogan, R. Lund, J. Maisey, J. S. Denton, D. Elliott, S. Lucas** A CEPHALIC TENACULUM BEARING HOLOCEPHALAN (CHONDRICHTHYES, HOLOCEPHALI) FROM THE LATE PENNSYLVANIAN ATRASADO FORMATION OF NEW MEXICO

B68 **W. M. Itano** DENTAL ARRANGEMENT OF *PSEPHODUS* (CHONDRICHTYES, COCHLIODONTIFORMES), BASED ON A NEW SPECIMEN FROM THE MISSISSIPPIAN OF INDIANA

B69 **B. H. Lauer, E. V. Popov, C. Duffin, D. J. Ward, R. L. Lauer** A NEW HOLOMORPHIC SPECIMEN OF THE RARE HOLOCEPHALIAN FISH, *CHIMAEROPSIS PARADOXA*, FROM THE LATE JURASSIC PLATTENKALK OF GERMANY

THURSDAY, OCTOBER 18, 2018

POSTER SESSION II
(CONTINUED)

B70 **Y. Delgado, A. B. Heckert, J. R. Foster** GEOCHEMICAL ANALYSES AND PETROGRAPHIC OBSERVATIONS OF UPPER TRIASSIC (ADAMANIAN) COPROLITES FROM THE MONITOR BUTTE FORMATION, LOWER CHINLE GROUP, NEAR WINGATE MESA, SOUTHEASTERNUTAH.

B71 **S. J. Rodgers, R. Irmis, N. Smith, M. R. Stocker, S. J. Nesbitt, A. H. Turner, A. C. Pritchard, J. C. Olori** THE MICROVERTEBRATE FISH FAUNA OF THE HAYDEN QUARRY, GHOST RANCH, NEW MEXICO: IMPLICATIONS FOR PRESERVATIONAL ENVIRONMENT AND CHINLE BIOSTRATIGRAPHY

B72 **M. D. Gottfried, R. McKeeby** OUT OF GONDWANA: A RECORD OF THE CRETACEOUS COELACANTH *AXELRODICHTHYS* (ACTINISTIA, MAWSONIIDAE) FROM NIGER

B73 **P. S. Druckenmiller, D. B. Brinkman, G. M. Erickson, J. A. Lopez** A HIGH LATITUDE FRESHWATER ICHTHYOFAUNA FROM THE LATE CRETACEOUS PRINCE CREEK FORMATION (MAASTRICHTIAN) OF NORTHERN ALASKA

B74 **N. S. Mizrahi, I. M. Fendley, L. N. Weaver, P. R. Renne, G. P. Wilson, T. S. Tobin** GAR SCALE OXYGEN ISOTOPE COMPOSITION ACROSS THE CRETACEOUS–PALEOGENE BOUNDARY IN THE HELL CREEK REGION, MONTANA

B75 **Z. M. Boles, P. Ullmann, I. Putnam** ADDITIONS TO THE VERTEBRATE FAUNA OF JEAN AND RIC EDELMAN FOSSIL PARK, INCLUDING TEMPORAL RANGE EXTENSIONS ACROSS THE K/PG BOUNDARY

B76 **N. A. Brand, A. B. Heckert, R. K. Hunt-Foster, J. R. Foster** ON THE BANKS OF THE WESTERN INTERIOR SEAWAY: POSSIBLE MARINE INFLUENCE AT THE J&M SITE OF THE WILLIAMS FORK FORMATION (UPPER CRETACEOUS: CAMPANIAN) IN COLORADO BASED ON A NEWLY DESCRIBED MICROVERTEBRATE FOSSIL ASSEMBLAGE

B77 **K. M. Madalena, S. S. Sumida** AN OCCURRENCE OF THE LATE CRETACEOUS HYBODONTIFORM SHARK *PTYCHODUS WHIPPLEI* FROM THE MANCOS SHALE IN THE HOLY GHOST QUADRANT ON RESERVATION LANDS BELONGING TO THE PUEBLO OF JEMEZ, NORTH-CENTRAL NEW MEXICO, U.S.A.

B78 **K. Shimada, M. J. Everhart** ONTOGENETIC GROWTH PATTERN OF THE LATE CRETACEOUS LAMNIFORM SHARK, *CRETODUS* '*CRASSIDENS*,' BASED ON A SKELETAL REMAIN FROM KANSAS, U.S.A.

B79 **R. J. Hacker, M. G. London, K. Shimada** REMAINS OF AN ENIGMATIC CRETACEOUS BONY FISH, *PALAEONOTOPTERUS GREENWOODI* (TELEOSTEI, OSTEOGLOSSOMORPHA), FROM ALABAMA, U.S.A., AND THEIR STRATIGRAPHIC AND PALEOBIOGEOGRAPHIC SIGNIFICANCE

B80 **J. A. Díaz-Cruz, J. Alvarado-Ortega** A NEW ENCHODONTID FISH *ENCHODUS*-LIKE FROM CENOMANIAN DEPOSITS FROM THE EL CHANGO QUARRY (CINTALAPA MEMBER, SIERRA MADRE FORMATION), CHIAPAS, MEXICO

B81 **K. G. Ollinger, A. F. Guzmán** POPULATION STRUCTURE OF FOSSIL CYPRINIDS FROM HUATEPEC, A SITE AT THE NORTHEAST BASIN OF MEXICO

B82 **H. M. Maisch IV, M. A. Becker, J. A. Chamberlain Jr.** BIOEROSION OF MEGATOOTHED SHARK TEETH: IMPLICATIONS FOR TIMING VERTEBRATE FOSSIL LAG DEPOSIT FORMATION IN ONSLOW BAY, NORTH CAROLINA, U.S.A.

THURSDAY, OCTOBER 18, 2018
POSTER SESSION II
(CONTINUED)

B83 **G. A. Wilbert, J. A. Frederickson, N. J. Czaplewski, K. S. Smith** NEW *ICTIOBUS* SPECIES (CYPRINIFORMES, CATOSTOMIDAE) FROM THE LATE MIOCENE (CLARENDONIAN) OGALLALA FORMATION, BEAVER COUNTY, OKLAHOMA

B84 **X. L. Ross, C. M. Robins, J. P. Walker** ANALYSIS OF MIOCENE SHARK TEETH DISTRIBUTION: COLLECTION FROM THE CALAVERAS DAM SITE, CALIFORNIA

B85 **D. J. Ward, E. Bernard** A NEW SPECIES OF THE LAMNIFORM SHARK *PAROTODUS* FROM THE OLIGOCENE OF JAPAN

B86 **P. E. dePolo, N. P. Kelley** TINY GIANTS: PROBABLE *SHONISAURUS POPULARIS* EMBRYOS FROM BERLIN-ICHTHYOSAUR STATE PARK

B87 **D. Jiang, R. Motani, A. Tintori, O. C. Rieppel, M. Zhou, H. Lu** PALATINE VIEW OF *WANGOSAURUS BREVIROSTRIS,* A BASAL PISTOSAUR SAUROPTERYGIAN FROM THE LATE MIDDLE TRIASSIC (LADINIAN) OF XINGYI OF SOUTHWESTERN CHINA

B88 **C. de Miguel Chaves, F. Ortega, A. Pérez-García** INCREASING THE TRIASSIC DISPARITY OF SAUROPTERYGIA: A NEW BIZARRE SIMOSAURID FROM THE UPPER TRIASSIC OF SPAIN

B89 **T. Konishi, P. Jimenez-Huidobro, M. W. Caldwell** NOT JUST SMALL: THE SMALLEST-KNOWN NEONATAL INDIVIDUAL OF *TYLOSAURUS* (MOSASAURIDAE, TYLOSAURINAE) SHEDS NEW LIGHT ON ONTOGENY AND EVOLUTION OF THE TYLOSAURINE ROSTRUM

B90 **R. Carr, J. Scannella** A NEW PLIOPLATECARPINE MOSASAUR FROM THE BEARPAW FORMATION, MONTANA, U.S.A.: TAXONOMIC AND PALEOBIOLOGIC IMPLICATIONS

B91 **J. R. Lively** MODELING THE PHYLOGENETIC AND MORPHOLOGICAL DIVERSIFICATION OF MOSASAURINAE: INSIGHTS FROM TWO NEW GENERA FROM THE WESTERN INTERIOR SEAWAY

B92 **S. T. Garvey, T. Konishi** UNUSUAL DENTITION IN THE NORTHERNMOST SPECIMEN OF *TYLOSAURUS* (SQUAMATA, MOSASAURIDAE) SUGGESTS ADAPTATION FOR PISCIVORY

B93 **J. P. Nassif, L. M. Witmer, R. C. Ridgely** PRELIMINARY OSTEOLOGICAL EVIDENCE FOR SECONDARY LOSS OF A TYMPANIC MEMBRANE IN MULTIPLE CLADES OF ORNITHISCHIAN DINOSAURS

B94 **I. Damdinsuren, B. Zorigt, C. Tsogtbaatar** COMPARATIVE LONG BONE HISTOLOGY OF ORNITHISCHIAN DINOSAURS

B95 **B. T. Breeden** FRAGMENTARY SPECIMENS PROVIDE EVIDENCE FOR HIDDEN TAXONOMIC DIVERSITY OF ORNITHISCHIAN DINOSAURS WITHIN THE LOWER JURASSIC KAYENTA FORMATION (NORTHEASTERN ARIZONA, U.S.A.)

B96 **T. J. Raven, S. C. Maidment, P. M. Barrett** THE FIRST PHYLOGENETIC SUPER-MATRIX OF THE ARMOURED DINOSAURS (ORNITHISCHIA, THYREOPHORA)

B97 **K. Morgan, C. A. Suarez, J. I. Kirkland** CAUDAL PLATE SHAPE ANALYSIS OF POLACANTHID TYPE ANKYLOSAURS

B98 **T. L. Ford** ASIAN ANCESTRY FOR NORTH AMERICA'S LARGEST ANKYLOSAUR, *ANKYLOSAURUS*?

B99 **D. Anduza, M. D. Lombardo** STEGOSAUR PLATE FUNCTION: THERMOREGULATION VS. DISPLAY, AND A NOVEL HYPOTHESIS

THURSDAY, OCTOBER 18, 2018
POSTER SESSION II
(CONTINUED)

B100 **G. J. Retallack, J. M. Theodor, E. B. Davis, S. S. Hopkins, P. Z. Barrett** FIRST DINOSAUR (ORNITHOPODA) FROM THE CRETACEOUS OF OREGON, U.S.A.

B101 **M. Shibata, Y. Azuma** EARLY CRETACEOUS IGUANODONT PALEOBIOGEOGRAPHY IN ASIA

B102 **R. S. Nagesan, M. J. Vavrek, J. D. Pardo, J. A. Campbell, J. S. Anderson** THE FIRST RECORD OF A DINOSAUR FROM THE CADOMIN FORMATION (LOWER CRETACEOUS) OF SOUTHWESTERN ALBERTA, CANADA

B103 **Y. TSUKIJI, Y. Azuma, F. Shiraishi, M. Shibata, Y. Noda** TWO ICHNOGENERA OF IGUANODONTID FOOTPRINTS FROM THE LOWER CRETACEOUS KITADANI FORMATION, FUKUI, JAPAN: ICHNOTAXONOMIC IMPLICATIONS

B104 **A. Prieto-Marquez, V. Fondevilla, A. G. Sellés, B. Vila, A. Galobart** NEW IGUANODONTIAN DINOSAURS FROM THE LATE CRETACEOUS IBERO-ARMORICAN ISLAND OF THE SOUTHWESTERN EUROPEAN ARCHIPELAGO

B105 **Y. Kobayashi, C. Tsogtbaatar, T. Khishigjav, R. Takasaki, T. Tanaka, P. J. Currie, G. F. Funston, J. Yoshida, E. B. Koppelhus** A NEW IGUANODONTIAN DINOSAUR WITH A "PYGOSTYLE" FROM THE LOWER CRETACEOUS KHUKHTEEG FORMATION OF DORNOGOVI PROVINCE, MONGOLIA

B106 **P. Cruzado-Caballero, J. M. Gasca, L. S. Filippi, I. Cerda, A. C. Garrido** A NEW SOUTH AMERICAN ORNITHOPOD DINOSAUR FROM THE SANTONIAN BAJO DE LA CARPA FORMATION (NEUQUÉN PROVINCE, ARGENTINA)

B107 **M. F. Guenther, A. Macmillan, N. Bank** THE INFLUENCE OF HETEROCHRONY ON THE EVOLUTION OF THE HADROSAUROID DENTARY

B108 **A. A. Farke, Y. Liu, O. R. Vazquez** ANATOMY AND FUNCTIONAL MORPHOLOGY OF THE ORAL RHAMPHOTHECAE IN HADROSAURIDAE (ORNITHISCHIA, DINOSAURIA)

B109 **A. Lownsdale, F. Freeman, J. Sertich, K. Mackenzie** MORPHOMETRIC ANALYSIS OF CRANIOFACIAL VARIATION IN AN *EDMONTOSAURUS* BONEBED FROM THE LANCE FORMATION, WYOMING

B110 **K. A. Kelley, A. T. McDonald, D. G. Wolfe** A JUVENILE HADROSAUR FROM THE UPPER CRETACEOUS (LOWER CAMPANIAN) ALLISON MEMBER, MENEFEE FORMATION, NEW MEXICO

B111 **N. Campione, P. R. Bell, R. Sissons, F. Fanti, C. Sullivan, M. J. Vavrek** A JUVENILE CORYTHOSAUR (LAMBEOSAURINAE) FROM THE WAPITI FORMATION OF WESTERN ALBERTA, CANADA

B112 **E. Armour Smith, J. Sertich, E. Alger-Meyer, C. Sartin** EVIDENCE FOR A SECOND LAMBEOSAUR FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION (GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH)

B113 **S. Conti, A. Prieto-Marquez, A. G. Sellés, B. Vila, A. Galobart, M. J. Benton** THE OLDEST LAMBEOSAURINE DINOSAURS OF EUROPE

B114 **R. Takasaki, A. R. Fiorillo, Y. Kobayashi, R. S. Tykoski** THE FIRST LAMBEOSAURINE MATERIAL FROM THE LISCOMB BONEBED OF THE UPPER CRETACEOUS PRINCE CREEK FORMATION, ALASKA

B115 **J. M. Bourke, T. A. Gates, T. A. Birthisel, D. C. Evans, L. M. Witmer, R. C. Ridgely, W. Ditto, L. Zanno** AIRWAY VARIATION AND ACOUSTIC SIGNALING IN THE CREST OF PARASAUROLOPHINE HADROSAURIDS (DINOSAURIA: ORNITHOPODA) BASED ON SPECIMENS FROM SOUTHERN UTAH

THURSDAY, OCTOBER 18, 2018
POSTER SESSION II
(CONTINUED)

B116 **E. T. Drysdale, F. Therrien, D. K. Zelenitsky** ONTOGENETIC VARIABILITY OF DIAGNOSTIC CHARACTERS IN *PROSAUROLOPHUS MAXIMUS* (HADROSAURIDAE; SAUROLOPHINAE): IMPLICATIONS FOR THE RECOGNITION OF JUVENILE INDIVIDUALS

B117 **G. B. Scofield** POPULATION ANALYSIS OF HADROSAUR TEETH FROM EGG MOUNTAIN QUARRY, UPPER CRETACEOUS, TWO MEDICINE FORMATION, NORTHWEST MONTANA

B118 **L. Zhang, C. Jin, Q. Yin, M. Huyskens, D. Jin, J. Zhang, F. Jin, X. Xu** A NEW DINOSAUR FOSSIL LOCALITY OF MID-CRETACEOUS AGE IN NORTHEASTERN CHINA

B119 **C. Yu, C. Tsogtbaatar, B. Zorigt, M. Norell** A BASAL CERATOPSIAN DINOSAUR FROM THE EARLY CRETACEOUS OF MONGOLIA AND THE EARLY EVOLUTIONARY HISTORY OF THIS GROUP

B120 **V. Arbour, D. C. Evans, J. Simon, T. Cullen** DINOSAURS OF THE NORTHERN INTERIOR MOUNTAINS OF BRITISH COLUMBIA, CANADA, INCLUDING A NEW HIGH LATITUDE LEPTOCERATOPSID

B121 **E. M. Morschhauser, A. T. McDonald, D. G. Wolfe** ABOLISHING THE KIDS' TABLE: A PRELIMINARY ATTEMPT AT ASSESSING THE PHYLOGENETIC POSITION OF *ZUNICERATOPS CHRISTOPHERI* USING ALL OF CERATOPSIA

B122 **J. P. Wilson, A. L. Ferguson, J. D. Gardner** 'PENDULAR' SWINGS IN THE EVOLUTION OF CENTROSAURINE CRANIAL ORNAMENTATION

B123 **R. S. Tykoski, A. R. Fiorillo, K. Chiba** NEW SPECIMENS AND RE-DIAGNOSIS OF THE ARCTIC CENTROSAURINE DINOSAUR *PACHYRHINOSAURUS PEROTORUM*

B124 **E. R. Goldsmith, A. R. Tumarkin-Deratzian, M. V. Padalkar, D. E. Grandstaff, A. R. Fiorillo, R. D. Ash, N. Pleshko, S. M. Chemtob** BONE HISTOLOGY AND GEOCHEMICAL TAPHONOMY OF ARCTIC CENTROSAURINE CERATOPSIDS FROM THE KIKAK-TEGOSEAK QUARRY (NORTH SLOPE, ALASKA)

B125 **C. M. Brown** HOMOLOGY OF PARIETOSQUAMOSAL FRILL EPIOSSIFICATIONS IN CERATOPSIDAE (DINOSAURIA: ORNITHISCHIA)

B126 **J. B. Scannella, J. R. Horner** *TOROSAURUS* OR *TRICERATOPS*? ASSESSING THE POSTORBITAL HORN CORE MICROSTRUCTURE OF THE HOLOTYPE OF *TOROSAURUS GLADIUS* REVEALS NEW INSIGHTS INTO CERATOPSID HORN GROWTH

B127 **A. C. Morhardt, C. Campbell, S. Bhalla, M. Steinkruger, M. Miller-Thomas, V. Mellnick, B. Thomas** STUDY OF ENDOCRANIAL ANATOMY AND ONTOGENY IN THE LATE CRETACEOUS NON-AVIAN DINOSAUR GENUS *TRICERATOPS* USING COMPUTED TOMOGRAPHY AND 3-DVISUALIZATION

B128 **D. W. Krause, S. Hoffmann, J. R. Wible, G. Rougier, Y. Hu** LOWER JAW MORPHOLOGY OF A NEW GONDWANATHERIAN MAMMAL FROM THE LATE CRETACEOUS OF MADAGASCAR

B129 **T. E. Williamson, S. Brusatte, J. E. Janecka, S. L. Shelley, M. Spaulding, J. R. Wible** THE BEGINNING OF THE AGE OF MAMMALS: NEW INSIGHTS ON THE RISE OF PLACENTALIA BASED ON A PRELIMINARY COMPREHENSIVE PHYLOGENY

B130 **H. Z. Fulghum, L. N. Weaver, M. Whitney, G. P. Wilson** COMPARATIVE OSTEOHISTOLOGY OF EXTANT SMALL-BODIED MAMMALS WITH IMPLICATIONS FOR UNDERSTANDING THE GROWTH DYNAMICS OF MESOZOIC MAMMALS

THURSDAY, OCTOBER 18, 2018
POSTER SESSION II
(CONTINUED)

B131 **J. E. Cohen, B. M. Davis, R. Cifelli** GEOLOGICALLY OLDEST PEDIOMYOIDEA (MAMMALIA, MARSUPIALIFORMES) FROM THE LATE CRETACEOUS OF NORTH AMERICA AND REVIEW OF AQUILADELPHIDAE

B132 **L. N. Weaver, G. P. Wilson, L. Krumenacker, J. R. Moore, D. J. Varricchio** MULTITUBERCULATE MAMMALS FROM THE MID-CRETACEOUS (EARLY CENOMANIAN) WAYAN FORMATION OF SOUTHEASTERN IDAHO

B133 **I. J. Corfe, L. Fostowicz-Frelik, P. Cox, S. Cobb, K. Janiszewska** AN EXCEPTIONALLY PRESERVED JUVENILE SPECIMEN OF THE MULTITUBERCULATE *TOMBAATAR SABULI* PROVIDES NEW DATA ON MULTITUBERCULATE DENTAL DEVELOPMENT

B134 **M. Chen, J. Meng, Y. Wang, F. Mao** GEOMETRIC MORPHOMETRIC ANALYSIS OF THE MANUS AMONG MESOZOIC MAMMALS AND ITS IMPLICATION FOR THEIR FEEDING ECOLOGY

B135 **H. W. Ermer, E. J. Sargis, G. P. Wilson, T. R. Lyson, S. G. Chester** EARLIEST PALEOCENE MULTITUBERCULATES FROM THE CAMEL BUTTE LOCALITY OF THE FORT UNION FORMATION, SOUTHEASTERN MONTANA

B136 **J. Claytor, G. P. Wilson, W. A. Clemens** EARLIEST PUERCAN 1 (PU1) FAUNAS FROM MONTANA WITH HIGH-RESOLUTION INSIGHTS ON MAMMALIAN FAUNAL RECOVERY AFTER THE K–PG MASS EXTINCTION EVENT

B137 **D. M. Birlenbach, D. L. Fox** MORPHOLOGICAL SIMILARITY IN THE DENTITION OF RODENTS, MULTITUBERCULATES, AND PLESIADAPIFORMS DURING THE LATE PALEOCENE IN NORTH AMERICA

B138 **E. B. Larson, A. E. Chew, K. A. Nichols, T. M. Bown** ANALYSIS OF UNUSUAL ABUNDANCE OCCURRENCES OF *HYOPSODUS* (CONDYLARTHRA) AND *HYRACOTHERIUM* (PERISSODACTYLA) IN THE LOWER EOCENE WILLWOOD FORMATION, BIGHORN BASIN, WYOMING, AND RESOLUTION FOR BIOHORIZON C

B139 **L. Holbrook, S. G. Chester, S. Paparo** INVESTIGATIONS OF THE SKELETON OF *MENISCOTHERIUM* (MAMMALIA) AND ITS PHYLOGENETIC IMPLICATIONS USING MICRO-CT

B140 **K. Miyata** OSTEOLOGY OF A SMALL BRONTOTHERE (MAMMALIA, PERISSODACTYLA, BRONTOTHERIIDAE) FROM THE LOWER EOCENE NAKAKOSHIKI FORMATION, KAGOSHIMA PREFECTURE, JAPAN

B141 **B. Bai, Y. Wang, Q. Li, J. Meng** BIOSTRATIGRAPHY AND DIVERSITY OF PALEOGENE PERISSODACTYLS FROM THE ERLIAN BASIN OF INNER MONGOLIA, CHINA

B142 **I. Ferrusquia Villafranca, V. Pérez-Crespo, J. Ruiz-González, P. Morales-Puente, E. Cienfuegos-Alvarado** THE DIET OF CF. *HYRACODON* SP. (PERISSODACTYLA, HYRACODONTIDAE) FROM THE RANCHO GAITÁN LOCAL FAUNA, LATE EOCENE (CHADRONIAN) OF CHIHUAHUA, NORTHERN MÉXICO, INFERRED FROM CARBON AND OXYGENE STABLE ISOTOPE RELATIONSHIPS

B143 **R. Rabenstein, J. Habersetzer, T. Lehmann, I. Ruf, G. F. Gunnell (†), K. D. Rose** FORELIMB ANATOMY OF *EUROTAMANDUA JORESI* FROM THE MIDDLE EOCENE OF MESSEL, GERMANY, BASED ON COMPUTED TOMOGRAPHY: SYSTEMATIC IMPLICATIONS

B144 **E. Kirk, I. K. Lundeen, S. Egberts** EARLY BIRD: A NEW MIDDLE EOCENE VERTEBRATE FOSSIL LOCALITY FROM THE CANOE FORMATION OF SOUTHWEST TEXAS

THURSDAY, OCTOBER 18, 2018
POSTER SESSION II
(CONTINUED)

B145 **E. Evanoff, K. A. Brill, L. Moxness** USING HISTORICAL PHOTOGRAPHS TO LOCATE FOSSIL LOCALITIES OF EARLY VERTEBRATE PALEONTOLOGISTS: EXAMPLES FROM THE BRIDGER BASIN IN SOUTHWEST WYOMING AND THE WHITE RIVER BADLANDS OF SOUTH DAKOTA

B146 **I. K. Lundeen** CONTEXTUALIZING THE MAMMALIAN FAUNA OF THE BRIDGERIAN FANTASIA FOSSIL LOCALITY FROM CARTER MOUNTAIN, WYOMING

B147 **M. F. Jones, K. C. Beard** A NEW SPECIES OF *CEUTHOLESTES* (MAMMALIA, NYCTITHERIIDAE) FROM SOUTHERN WYOMING, INCLUDING THE FIRST UPPER DENTITION REPORTED FOR THE GENUS

B148 **R. H. Dunn, D. K. Anderson** NEW SPECIMENS OF RODENTS AND PRIMATES FROM THE SAND WASH BASIN CORROBORATE AN EARLIEST UINTAN AGE

B149 **S. P. Zack, T. A. Penkrot** NEW LEPTICTIDS (MAMMALIA) FROM THE UINTAN (EOCENE) OF SAN DIEGO COUNTY, CALIFORNIA

B150 **A. Granquist, J. R. Moore** A DIVERSE ASSEMBLAGE OF WHITE RIVER INSECTIVORES INDICATING A RESPONSE TO THE EOCENE–OLIGOCENE CLIMATE TRANSITION

B151 **B. L. Steed, J. X. Samuels, C. S. Scott, J. M. Theodor** NEW CRANIODENTAL MATERIAL OF *MICROPTERNODUS* CF. *M. MORGANI* FROM THE TURTLE COVE MEMBER OF THE JOHN DAY FORMATION, OREGON

B152 **B. E. Christison, F. Gaidies, S. Pineda-Munoz, A. R. Evans, D. Fraser** COMPARISON OF CREODONT AND CARNIVORAN DENTAL MORPHOLOGY FROM THE CALF CREEK LOCAL FAUNA (LATE EOCENE) OF SASKATCHEWAN

B153 **X. Yan, J. M. Base, M. R. Borths, A. A. Farke** ANATOMY OF THE MALLEUS AND ECTOTYMPANIC IN *HYAENODON MUSTELINUS* (MAMMALIA, HYAENODONTA)

B154 **S. M. Mills, T. C. Arbor, M. A. Tornow** PALEOENVIRONMENT OF THE LATE EOCENE WHITEHEAD CREEK LOCALITY, NEBRASKA

B155 **B. D. Armijo, W. Abt, J. R. Moore** LARGE MAMMAL TAXONOMIC RESPONSE TO THE EOCENE–OLIGOCENE CLIMATE TRANSITION IN NORTHWESTERN NEBRASKA

B156 **D. Mitchell, S. Wroe** PREDICTING THE FEEDING ECOLOGY OF AN EXTINCT KANGAROO FROM CRANIOFACIAL MORPHOLOGY–INFERENCE FROM EXTANT DIPROTODONT HERBIVORES

B157 **J. A. Case** CHANGES IN ROSTRAL LENGTH UNDERLIES SPECIES DIVERSIFICATION IN LATEST OLIGOCENE EKTOPODONTID MARSUPIALS FROM SOUTH AUSTRALIA

B158 **A. R. Carroll, R. J. Rowe, W. C. Clyde** TESTING GEOGRAPHIC RANGE SHIFT AS AN EXPLANATION FOR HYPERTHERMAL MAMMAL BODY SIZE CHANGES

B159 **T. Tsubamoto** ESTIMATION OF BODY MASS FROM THE CALCANEUM OF LAND MAMMALS

B160 **F. Mizuno** THE MECHANICAL MODEL TO CREATE THE GUIDEPOST FOR RECONSTRUCTING MAMMALIAN HIND LIMB POSTURE

B161 **G. M. Semprebon, L. M. Uttecht, W. J. Sanders** WHAT CAN ENAMEL MICROWEAR REVEAL ABOUT THE DIETARY BEHAVIOR OF *MOERITHERIUM* AND *PHIOMIA* FROM THE FAYUM REGION OF EGYPT?

THURSDAY, OCTOBER 18, 2018

POSTER SESSION II

(CONTINUED)

B162 **M. A. Purnell, N. F. Adams, C. Nedza, L. Rychlik** TESTING THE SENSITIVITY OF DENTAL MICROWEAR TEXTURE ANALYSIS AS A DIETARY PROXY: CAN IT DETECT NICHE PARTITIONING IN SYMPATRIC SPECIES?

B163 **C. Tarng, R. W. Graham, M. Fantle** ISOTOPIC FINGERPRINTING OF FOSSIL SMALL MAMMALS IN BLACK HILLS CAVES

FRIDAY MORNING, OCTOBER 19, 2018

TECHNICAL SESSION IX

ALBUQUERQUE CONVENTION CENTER, BALLROOM A

MODERATORS: Win McLaughlin and Paul Barrett

8:00 **E. Scott** RE-EVALUATING THE EVOLUTION AND PHYLOGENETIC SIGNIFICANCE OF THE PASSIVE STAY APPARATUS IN EQUID SHOULDERS

8:15 **A. M. Jukar** DIVERSITY AND BIOGEOGRAPHY OF SOUTH ASIAN PLIOCENE HIPPARIONINE HORSES

8:30 **J. Cantalapiedra, J. Prado, O. Sanisidro, M. Alberdi** TAXONOMIC AND ECOMORPHOLOGICAL DIVERSIFICATION IN HORSES

8:45 **W. N. McLaughlin** INSIGHT INTO THE DISPERSAL AND PHYLOGENY OF NEOGENE RHINOCEROTIDS FROM A NEW KYRGYZ CHILOTHERE

9:00 **R. A. Delplanche, J. D. Orcutt** NICHE PARTITIONING, TAPHONOMY, AND THE DISTRIBUTION OF HEMPHILLIAN RHINOCEROTIDS AND EQUIDS

9:15 **A. Houssaye, C. Etienne, C. Mallet, R. Cornette** FUNCTIONAL, PHYLOGENETIC, AND ALLOMETRIC SIGNALS IN THE SHAPE EVOLUTION OF THE ASTRAGALUS AND CALCANEUS OF MODERN AND FOSSIL RHINOCEROTOIDEA

9:30 **M. Emery-Wetherell, S. Canada, K. Grande** A PRELIMINARY PHYLOGENETIC ANALYSIS OF TRUNK EVOLUTION IN OREODONTS (ORDER CETARTIODACTYLA, SUPERFAMILY MERYCOIDODONTOIDEA)

9:45 **M. R. Borths, N. J. Stevens** CHANGES IN HYAENODONT DIVERSITY DURING THE CARNIVORAN INVASION OF AFRO-ARABIA

10:00 BREAK

10:15 **P. Barrett, S. S. Hopkins** WHAT (IF ANYTHING) IS A BARBOUROFELID? RE-EVALUATING THE NUMBER OF CARNIVORAN SABERTOOTH LINEAGES WITH TOTAL-EVIDENCE BAYESIAN TECHNIQUES

10:30 **D. J. Bird, L. Fox-Rosales, B. Van Valkenburgh** OLFACTION WRITTEN IN BONE: USING THE CLOSE LINK BETWEEN CRIBRIFORM PLATE AND OLFACTORY RECEPTOR GENE REPERTOIRE SIZE TO PREDICT OLFACTORY ABILITY IN *SMILODON FATALIS*

10:45 **X. Wang, S. C. White, M. Balisi, J. Biewer, J. Sankey, D. Garber, Z. Tseng** THE PROOF IS IN THE POOPING: FIRST COPROLITES FROM BONE-CRACKING DOGS PROVIDE NEW INSIGHT INTO BONE CONSUMPTION IN *BOROPHAGUS* AND THEIR UNIQUE ECOLOGICAL NICHE

FRIDAY MORNING, OCTOBER 19, 2018
TECHNICAL SESSION IX
(CONTINUED)

11:00 **P. Polly, J. J. Head** REGIONAL PATTERNS IN LOCOMOTOR ECOMETRICS INCARNIVORA: MIOCENE AND PRESENT

11:15 **D. Hock, R. Secord** A TAXON-FREE, MULTI-PROXY MODEL FOR MIOCENE NORTHAMERICAN PALEOECOLOGICAL INTERPRETATIONS

11:30 **T. M. Smiley, R. C. Terry, C. Badgley, A. Bahadori, W. E. Holt, T. Rasbury** WERE MOUNTAIN PASSES HIGHER IN THE MIDDLE MIOCENE?

11:45 **R. B. Sulser, R. D. Macphee** INFERRING IMMIGRATION OF ISLAND INSECTIVORES: A NEW DESCRIPTION OF A NESOPHONTID MAMMAL FROM THE MIOCENE OF HISPANIOLA

12:00 **E. M. Locke, I. Nengo, G. T. Schwartz** DENTAL TOPOGRAPHIC CHANGE WITH WEAR INTHE EARLY MIOCENE STEM CERCOPITHECOID *NOROPITHECUS BULUKENSIS* (PRIMATES, VICTORIAPITHECIDAE) AND A COMPARISON WITH EXTANT CERCOPITHECIDAE

FRIDAY MORNING, OCTOBER 19, 2018
TECHNICAL SESSION X
ALBUQUERQUE CONVENTION CENTER, BALLROOM B
MODERATORS: Jason Moore and Isabel Fendley

8:00 **H. P. Street** VERTEBRATE DIVERSITY AND ENVIRONMENT OF A LATE CRETACEOUS BEARPAW SEA BONEBED FROM SASKATCHEWAN

8:15 **M. G. Thompson, M. J. Ryan, C. Schröder-Adams** PALEOENVIRONMENTS OF THE MID-CAMPANIAN FOREMOST FORMATION AND THE EVOLUTION OF THE LATE CAMPANIAN BIOTA OF THE BELLY RIVER GROUP OF SOUTHERN ALBERTA, CANADA

8:30 **A. R. Fiorillo, P. McCarthy, Y. Kobayashi, T. Tanaka, R. Takasaki, C. Tsogtbaatar, M. B. Suarez, G. Shimer, R. S. Tykoski** COMPARATIVE VERTEBRATE ICHNOLOGY, SEDIMENTOLOGY, AND PALEOPRECIPITATION BETWEEN TWO CRETACEOUS HIGH-LATITUDE NON-MARINE ECOSYSTEMS (NANUSHUK FORMATION, CENOMANIAN, AND CHIGNIK FORMATION, CAMPANIAN–MAASTRICHTIAN), ALASKA

8:45 **R. T. Tucker, P. J. Makovicky, L. E. Zanno** RECENT ADVANCES IN TEMPORAL CALIBRATION FOR NEWLY DISCOVERED DINOSAURIAN ASSEMBLAGES IN THE MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION, CENTRAL UTAH, U.S.A.

9:00 **P. Bell, F. Fanti, L. Hart, L. Milan, S. Craven, T. Brougham, E. Smith** REVISED AGE AND PALAEOECOLOGY OF THE DINOSAUR-BEARING GRIMAN CREEK FORMATION AT LIGHTNING RIDGE, NSW, AUSTRALIA

9:15 **J. N. Lallensack, M. Buchwitz** EVALUATING SIZE CONSTRAINTS ON LOCOMOTION IN SAUROPOD DINOSAURS USING TRACKWAY DATA

9:30 **C. A. Meyer, M. Belvedere, D. Marty** SAUROPOD TRACKWAY TANGO: A NEW LOOK AT TRACKWAY GAUGE THROUGH TIME

9:45 **M. Qvarnström** NOVEL DATA ON TROPHIC FOOD WEBS IN ANCIENT ECOLOGICAL COMMUNITIES REVEALED FROM COPROLITES (FOSSIL FAECES)

10:00 BREAK

FRIDAY MORNING, OCTOBER 19, 2018

TECHNICAL SESSION X
(CONTINUED)

10:15 **J. A. Frederickson** ONTOGENETIC DIETARY SHIFTS IN *DEINONYCHUS ANTIRRHOPUS* (THEROPODA; DROMAEOSAURIDAE): INSIGHTS INTO SOCIAL BEHAVIOR IN RAPTORIAL DINOSAURS USING STABLE ISOTOPE ANALYSIS

10:30 **M. Riegler, B. C. Gill, R. L. Anemone, B. Nachman, M. R. Stocker** ISOTOPIC GEOCHEMISTRY AS AN INDEPENDENT ECOLOGICAL PROXY IN EXTANT AND EXTINCT LIZARDS: DIET AND ARIDITY IN EARLY EOCENE SQUAMATES

10:45 **T. M. Cullen** TESTING ECOLOGICAL HYPOTHESES OF EXTANT AND CRETACEOUS COASTAL FLOODPLAIN FOREST SYSTEMS USING STABLE ISOTOPE ANALYSES

11:00 **I. M. Fendley, C. J. Sprain, M. Marvin-Dipasquale, P. R. Renne, T. S. Tobin, L. N. Weaver** MERCURY CHEMOSTRATIGRAPHY AS A DISTAL INDICATOR OF DECCAN VOLCANISM RECORDED IN THE HELL CREEK REGION, MONTANA

11:15 **J. R. Moore** FANS EVERYWHERE? ASSESSING THE UBIQUITY OF PALAEOENVIRONMENTAL CHANGE CONSISTENT WITH A DISTRIBUTIVE FLUVIAL SYSTEM DRIVER IN THE VERTEBRATE FOSSIL RECORD

11:30 **S. J. Widlansky, R. Secord, A. E. Chew, W. C. Clyde** CARBON ISOTOPE STRATIGRAPHY AND MAMMAL TURNOVER THROUGH POST-PETM HYPERTHERMALS IN THE FIFTEENMILE CREEK AREA (BIGHORN BASIN, WYOMING)

11:45 **R. Secord** PALEOENVIRONMENTS IN THE WIND RIVER BASIN DURING THE EARLY EOCENE CLIMATIC OPTIMUM–INFERENCES FROM STABLE CARBON ISOTOPES IN MAMMALS

12:00 **R. S. Feranec, D. C. Pagnac, B. E. Crowley, K. C. Maguire, L. G. DeSantis** IMPLICATIONS OF C_4 PLANTS TO FAUNAL ADAPTATIONS DURING THE EARLY TO MIDDLE MIOCENE IN NORTH AMERICA

FRIDAY MORNING, OCTOBER 19, 2018

PODIUM SYMPOSIUM: BUILDING A PHENOMIC UNIVERSE: COLLECTION, MANAGEMENT, AND APPLICATIONS OF DIGITAL MORPHOLOGICAL DATA

ALBUQUERQUE CONVENTION CENTER, BALLROOM C

MODERATORS: Akinobu Watanabe and Jen Bright

8:00 **H. Mallison, M. Belvedere** QUICK, CHEAP, AND NOT DIRTY AT ALL: EXTREMELY RAPID PHOTOGRAMMETRY TECHNIQUES FOR MASS DIGITIZING IN VERTEBRATECOLLECTIONS

8:15 **E. Newham, I. J. Corfe, P. Gill, P. Schneider, K. Robson Brown, P. Brewer** MICRO-FEATURES AND MEGA-DATA: A CASE STUDY FOR EXPLORING LIFE ON THE SMALL SIDE AT THE SYNCHROTRON

8:30 **L. M. Witmer, R. C. Ridgely, W. R. Porter, D. G. Cerio** FLESHING OUT THE PAST BY ENHANCING RADIOGRAPHIC CONTRAST IN THE PRESENT: SPICECT, DICECT, AND VASCULAR INJECTION OF EXTANT DIAPSIDS TO BETTER UNDERSTAND DINOSAUR BIOLOGY

8:45 **D. M. Boyer, J. M. Winchester, S. Mukherjee, T. McGeary, T. Ryan, D. C. Blackburn** DEPOSIT YOUR 3D DATA, BUILD A VIRTUAL MUSEUM: MORPHOSOURCE

9:00 **A. Y. Hsiang, D. J. Field, K. Nelson, L. E. Elder, E. C. Sibert, P. M. Hull** HIGH-THROUGHPUT 2D AND 3D MORPHOLOGICAL DATA ACQUISITION USING AUTOMORPH: VERTEBRATE AND INVERTEBRATE CASE STUDIES

FRIDAY MORNING, OCTOBER 19, 2018

PODIUM SYMPOSIUM: BUILDING A PHENOMIC UNIVERSE: COLLECTION, MANAGEMENT, AND APPLICATIONS OF DIGITAL MORPHOLOGICAL DATA (CONTINUED)

9:15 **N. S. Vitek, D. M. Boyer, S. G. Strait, J. I. Bloch** AUTOMATED GEOMETRIC MORPHOMETRIC METHODS AS A COMPONENT OF THE PHENOMIC TOOLKIT: A CASE STUDY USINGPALEOGENE PERADECTIDS (MAMMALIA, MARSUPIALIA)

9:30 **C. Bardua, R. N. Felice, A. Watanabe, A. Goswami** BEST PRACTICES FOR CAPTURINGAND ANALYZING HIGH DIMENSIONAL SHAPE DATA: AN AMPHIBIAN CASE STUDY

9:45 **J. A. Bright, C. R. Cooney, E. J. Capp, A. M. Chira, E. C. Hughes, C. J. Moody, L. O. Nouri, Z. K. Varley, G. H. Thomas** WWW.MARKMYBIRD.ORG: CROWD-SOURCING MACRO-EVOLUTIONARY PATTERNS IN BEAK SHAPE

10:00 BREAK

10:15 **A. Watanabe, P. M. Gignac** HIGH-DIMENSIONAL SHAPE ANALYSIS OF ENDOCASTS AND BRAIN RECONSTRUCTIONS REVEALS THE PRECISE APPLICABILITY OF ENDOCASTS AS A NEUROANATOMICAL CORRELATE IN ARCHOSAURS

10:30 **E. A. Ferrer, M. Salerno, S. Wei, W. Gao, X. Li, P. Vaska, A. Balanoff** UNRAVELING THE EVOLUTIONARY HISTORY OF THE AVIAN BRAIN THROUGH BEHAVIORALNEUROIMAGING

10:45 **M. L. Turner, P. L. Falkingham, S. M. Gatesy** WHERE DOES FOOTPRINT MORPHOLOGY COME FROM? INTEGRATING 3D METHODS FOR EXPLORING DINOSAUR TRACK FORMATION

11:00 **L. B. Porro, E. J. Rayfield** THREE-DIMENSIONAL RECONSTRUCTION AND BIOMECHANICAL MODELLING OF TETRAPOD SKULLS ACROSS THE WATER–LAND TRANSITION

11:15 **Z. Tseng, J. J. Flynn** 3D MORPHOMETRIC AND BIOMECHANICAL ANALYSES SUGGEST STRUCTURE-FUNCTION COVARIATION WITH NON-FEEDING ECOLOGICAL VARIABLES INFLUENCES EVOLUTION OF FEEDING SPECIALIZATION IN CARNIVORA

11:30 **S. Lautenschlager** FOSSIL REPLICANTS–INTEGRATING PRESERVED AND THEORETICAL MORPHOLOGIES IN BIOMECHANICAL ANALYSES

11:45 **R. Carney, H. Kaplan, A. Kirk, A. Baines, S. Mason** *ARCHAEOPTERYX HOLOGRAPHICA*: BRINGING THE URVOGEL BACK TO LIFE WITH SCIENTIFIC ANIMATION AND VR/AR

12:00 **A. M. Heers, J. Rankin, J. R. Hutchinson** SKELETONS IN MOTION: ONTOGENY AND EVOLUTION OF AVIAN LOCOMOTION

FRIDAY AFTERNOON, OCTOBER 19, 2018

TECHNICAL SESSION XI

ALBUQUERQUE CONVENTION CENTER, BALLROOM A

MODERATORS: Kathleen Muldoon and Christopher Beard

1:45 **K. Beard, G. Metais** BIOGEOGRAPHIC IMPLICATIONS OF AN INSULAR CLADE OF GONDWANAN METATHERIANS FROM THE EOCENE PONTIDE TERRANE, NORTH-CENTRAL ANATOLIA

2:00 **S. L. Shelley** RESOLVING THE PHYLOGENY OF PALEOCENE MAMMALS: THE PERIPTYCHIDAE

2:15 **J. Silviria, T. E. Williamson, J. R. Moore, C. Myers** BIOGEOGRAPHY AND BIOSTRATIGRAPHY OF EUTHERIAN MAMMALS DURING THE PUERCAN NORTH AMERICAN LAND MAMMAL AGE (PALEOCENE, EARLIEST DANIAN)

FRIDAY AFTERNOON, OCTOBER 19, 2018
TECHNICAL SESSION XI
(CONTINUED)

2:30 **F. Solé, B. Mennecart, K. Le Verger, V. Fischer, R. P. Speijer, T. Smith** CRITICAL ANALYSIS OF CARNIVORAN MAMMAL SUCCESS IN EUROPE DURING THE PALEOGENE

2:45 **J. I. Bloch, P. E. Morse, N. Vitek, D. M. Boyer, S. L. Wing** IMPLICATIONS OF IMMIGRANT ARRIVAL TIMES DURING THE PALEOCENE–EOCENE THERMAL MAXIMUM FOR MAMMAL HABITAT SPECIFICITY

3:00 **E. L. Fulwood** CLIMATE CHANGE AND RATES OF BODY SIZE EVOLUTION IN NORTH AMERICAN EOCENE EUPRIMATES

3:15 **T. Smith, R. Rana, K. Kumar, A. Folie, R. H. Dunn, F. Solé, S. P. Zack, K. D. Rose** NEW DATA ON THE EARLY EOCENE MAMMALS AND OTHER VERTEBRATES FROM THE CAMBAY SHALE FORMATION EXPOSED IN LIGNITE MINES OF GUJARAT, WESTERN INDIA

3:30 **K. M. Muldoon, G. F. Gunnell, J. Zonneveld, W. S. Bartels** NEW SPECIES OF HYAENODONTA (MAMMALIA) FROM THE EARLY MIDDLE EOCENE AT SOUTH PASS, GREEN RIVERBASIN, WYOMING

3:45 **J. J. Hooker** HIGH DIVERSITY OF NYCTITHERIIDAE (MAMMALIA, LATE EOCENE, U.K.) REVEALS NEW RELATIONSHIPS AND A COMPLEX PATTERN OF DISPERSALS, FLEETING DOMINANCE, GRADUAL EVOLUTION, AND EXTINCTION

4:00 **W. E. Abt, B. Armijo, J. R. Moore** TRENDS IN DIET, BODY SIZE, HABITAT OCCUPANCY, AND WATER DEPENDENCY ASSOCIATED WITH THE EOCENE–OLIGOCENE CLIMATE TRANSITION IN TOADSTOOL GEOLOGIC PARK, NEBRASKA

FRIDAY AFTERNOON, OCTOBER 19, 2018
TECHNICAL SESSION XII
ALBUQUERQUE CONVENTION CENTER, BALLROOM B
MODERATORS: Aaron Le Blanc and Roxanne Armfield

1:45 **E. T. Whiting, D. L. Fox** ECOLOGICAL BIOGEOGRAPHY OF EXTANT NORTH AMERICAN LIZARDS IN RELATION TO CLIMATE AND PHYSIOGRAPHY: A MODERN COMPARATIVE DATASET FOR PALEOBIOLOGY AND CONSERVATION

2:00 **D. C. D'Amore, H. C. Juarez** TOOTH MORPHOLOGY LINKED TO BODY SIZE AND PREY COMPLIANCE IN THE SNAKE TRIBE THAMNOPHINII, AND ITS SIGNIFICANCE IN RECONSTRUCTING TROPHIC LINKS IN FOSSIL ECOSYSTEMS.

2:15 **C. C. Green, L. E. Wilson** OSTEOHISTOLOGY AND SKELETOCHRONOLOGY IN AN ONTOGENETIC SERIES OF *CLIDASTES* (SQUAMATA, MOSASAURIDAE): GROWTH AND METABOLIC RATES IN BASAL MOSASAURIDS

2:30 **D. E. Winkler, E. Schulz-Kornas, T. M. Kaiser, T. Tütken** FIRST 3D ENAMEL SURFACE TEXTURE ANALYSIS OF EXTANT REPTILES: ESTABLISHING A REFERENCES DATA SET FOR DIET RECONSTRUCTION OF EXTINCT SAUROPSIDS

2:45 **A. R. Leblanc, I. Paparella, M. Doschak, M. W. Caldwell** A DIFFERENT LOOK AT PLEURODONTY: THE HISTOLOGICAL AND PHYLOGENETIC SIGNIFICANCE OF SQUAMATE TOOTHATTACHMENT AND THE IMPORTANCE OF USING THE RIGHT PLANE OF SECTION

FRIDAY AFTERNOON, OCTOBER 19, 2018
TECHNICAL SESSION XII
(CONTINUED)

3:00 **L. Dong, Y. Wang, Y. Wang, S. E. Evans** A NEW VARANID FROM THE EARLY EOCENE OF CHINA, WITH IMPLICATIONS FOR THE EVOLUTION OF THE VARANIDAE

3:15 **R. E. Armfield, T. E. Williamson, J. J. Head** CRANIAL OSTEOLOGY AND SYSTEMATICS OF *HELAGRAS PRISCIFORMIS* AND THE EARLY EVOLUTION OF CROWN MACROSTOMATAN SNAKES.

3:30 **M. Phantratanamongkol, J. J. Head** PELVIC AND HINDLIMB ANATOMY IN EXTANT AND FOSSIL SNAKES: IMPLICATIONS FOR RESOLVING CONTROVERSIAL PHYLOGENETIC HYPOTHESES.

3:45 **J. J. Head, J. I. Bloch, A. F. Rincón, J. Moreno-Bernal, J. Bourque, C. Jaramillo** POSTCRANIAL ANATOMY OF THE GIANT SNAKE *TITANOBOA CERREJONENSIS*: IMPLICATIONS FOR ESTIMATING ECOLOGY AND BODY SIZE

4:00 **J. J. Jacisin, A. M. Lawing** BUILDING A BACKBONE FOR SNAKE ECOMETRICS USING MIDDLE TRUNK VERTEBRAL MORPHOLOGY.

FRIDAY AFTERNOON, OCTOBER 19, 2018
TECHNICAL SESSION XIII
ALBUQUERQUE CONVENTION CENTER, BALLROOM C
MODERATORS: Hans-Dieter Sues and Adam Marsh

1:45 **H. Sues, R. R. Schoch, R. Irmis, J. B. Desojo** NEW ARCHOSAURIFORM REPTILE FROM THE MIDDLE TRIASSIC (LADINIAN) OF GERMANY DOCUMENTS GREATER TROPHIC DIVERSITY AMONG EARLY ARCHOSAURIFORMES

2:00 **R. J. Butler, A. Jones, E. Buffetaut, G. Mandl, T. Scheyer, O. Schultz** A NEW SPECIES OF *MYSTRIOSUCHUS* FROM THE LATE TRIASSIC OF AUSTRIA PROVIDES EVIDENCE FOR MARINE ADAPTIONS IN PHYTOSAURS

2:15 **A. D. Marsh, M. E. Smith, W. Parker, R. Irmis, B. T. Kligman** NEW SPECIMENS OF *ACAENASUCHUS GEOFFREYI* (ARCHOSAURIA: PSEUDOSUCHIA) SUPPORT THE PRESENCE OF A NEW TRIASSIC CLADE OF ARMORED PSEUDOSUCHIANS IN NORTH AMERICA

2:30 **D. K. Hoffman, H. Edwards, P. M. Barrett, S. J. Nesbitt** RECONSTRUCTING THE ARCHOSAUR RADIATION: QUANTITATIVE DESCRIPTION OF A MIDDLE TRIASSIC ARCHOSAURIFORM TOOTH ASSEMBLAGE FROM THE RUHUHU BASIN (TANZANIA) AND ITS IMPACT ON TRAIT EVOLUTION AND ECOLOGICAL INTERPRETATIONS

2:45 **B. M. Wynd, S. J. Nesbitt, A. B. Heckert** SKULL ELONGATION IN STEM ARCHOSAUR CRANIAL DISPARITY: RE-EVALUATING *DOSWELLIA SIXMILENSIS* (ARCHOSAURIFORMES: PROTEROCHAMPSIA) TO EXAMINE PHYLOGENETIC DISTRIBUTION OF MORPHOLOGICAL DISPARITY

3:00 **N. Smith, R. Irmis, S. J. Nesbitt, A. H. Turner** NEW MATERIAL OF *DROMOMERON ROMERI* (ARCHOSAURIA: DINOSAUROMORPHA) FROM THE UPPER TRIASSIC CHINLE FORMATION OF NEW MEXICO PROVIDES INSIGHT INTO THE EVOLUTIONARY MORPHOLOGY OF EARLY DINOSAUROMORPHS

3:15 **H. Klein, A. Lagnaoui, T. Zouheir, A. Hminna, S. Lucas, H. Saber, J. Schneider** LADINIAN–CARNIAN (MIDDLE–LATE TRIASSIC) EVOLUTION OF DINOSAURIFORMES: INDICATIONS FROM THE FOOTPRINT RECORD

FRIDAY AFTERNOON, OCTOBER 19, 2018

TECHNICAL SESSION XIII

(CONTINUED)

3:30 **L. King** ENDOCRANIAL SHAPE CHANGE AND VASCULAR IMPRESSIONS IN *PSITTACOSAURUS*: EFFECT OF ONTOGENY ON A CHINESE CERATOPSIAN'S NEUROANATOMY

3:45 **G. M. Erickson, K. L. Anderson, P. S. Druckenmiller** GROWTH CURVE FOR THE ARCTIC HADROSAURID *UGRUNAALUK KUUKPIKENSIS* FROM THE EARLY MAASTRICHTIAN PRINCE CREEK FORMATION OF NORTHERN ALASKA

4:00 **J. J. Sertich, M. A. Loewen, M. A. Getty** A NEW CHASMOSAURINE HIGHLIGHTS EXTRAORDINARY CERATOPSID RICHNESS IN THE UPPER CRETACEOUS (CAMPANIAN) KAIPAROWITS FORMATION OF SOUTHERN UTAH, U.S.A.

FRIDAY, OCTOBER 19, 2018

POSTER SESSION III

ALBUQUERQUE CONVENTION CENTER, HALL 4

Authors must be present from 4:15–6:15 p.m. Friday, October 19

Posters must be removed by 6:30 p.m.

B36 **H. R. Taruvinga, S. Tolan, C. T. Griffin** A *LUANGWA*-LIKE CYNODONT FROM NORTHERN ZIMBABWE AND ENDEMISM ACROSS THE CARNIAN OF SOUTHERN AFRICA

B60 **T. Szczygielski, J. Słowiak, T. Sulej** NEW DATA ON THE SHELL STRUCTURE OF THE BASAL MOST TRUE TURTLES, *PROTEROCHERSIS* SPP.

B61 **S. G. Lucas, A. J. Lichtig** NEW MORPHOLOGY OF *CHINLECHELYS*, A LATE TRIASSIC TURTLE FROM NEW MEXICO, U.S.A.

B62 **H. F. Smith, B. Adrian, C. R. Noto, A. Grossman** A NEW SPECIES OF THE NANHSIUNGCHELYID TURTLE *BASILEMYS* FROM THE ARLINGTON ARCHOSAUR SITE, WOODBINE FORMATION, TEXAS, U.S.A.

B63 **B. Adrian, H. F. Smith, C. R. Noto, A. Grossman** A DIVERSE TURTLE ASSEMBLAGE FROM THE ARLINGTON ARCHOSAUR SITE, WOODBINE FORMATION (CENOMANIAN), TEXAS, U.S.A.

B64 **C. Zhou, L. Li, D. Li, W. Wu** NEW SPECIMENS OF THE FRESHWATER SINEMYDID TURTLE *ORDOSEMYS* WITH IMPLICATIONS FOR DIVERSITY, PALEOECOLOGY AND PALEOGEOGRAPHY

B65 **L. Li, K. Gao, C. Zhou** OSTEOLOGY OF *MANCHUROCHELYS MANCHOUKUOENSIS* BASED ON A NEW SPECIMEN, AND PHYLOGENETIC RELATIONSHIPS OF EUCRYPTODIRAN TURTLES

B66 **J. Borst, A. T. McDonald, D. G. Wolfe** NEW MATERIAL OF TURTLES (TESTUDINES) FROM THE UPPER CRETACEOUS MENEFEE FORMATION OF NEW MEXICO

B67 **N. S. Ong, R. Irmis, C. G. Levitt-Bussian** THE HISTOLOGICAL ONTOGENY OF ORNAMENTED ADOCUSIANS AND TRIONYCHIDS FROM THE UPPER CRETACEOUS (CAMPANIAN) KAIPAROWITS FORMATION OF UTAH

B68 **M. K. Abdel Gawad, G. A. Abu El-Kheir** QUSEIR TESTUDINES REMAINS FROM THE LATE CRETACEOUS KHARGA AREA, SOUTH WESTERN DESERT, EGYPT

B69 **C. A. Suarez, M. Frucci, J. Pittman** OXYGEN ISOTOPIC COMPOSITION OF TURTLE PHOSPHATE FROM THE LOWER CRETACEOUS HOLLY CREEK FORMATION, ARKANSAS U.S.A. A TOOL FOR UNDERSTANDING THE HYDROLOGIC CYCLE IN GREENHOUSE WORLDS

FRIDAY, OCTOBER 19, 2018
POSTER SESSION III
(CONTINUED)

B70 **D. Yamamura, C. A. Suarez, A. Titus, H. Manlove** LARGEST FRESHWATER TURTLE FROM THE CRETACEOUS OF NORTH AMERICA: STABLE ISOTOPE COMPOSITION OF THE TOXICHELID-LIKE TURTLE FROM THE KAIPAROWITS FORMATION

B71 **D. J. Ehret, A. D. Gentry, T. Harrell, Jr.** AN UNUSUAL NEW MARINE TURTLE(TESTUDINES, PANCHELONIOIDEA) FROM THE LATE CRETACEOUS, MAASTRICHTIAN COON CREEK FORMATION OF TENNESSEE, U.S.A.

B72 **P. V. Ullmann, K. J. Lacovara** NEW INSIGHTS INTO THE OSTEOLOGY AND PHYLOGENETIC AFFINITIES OF THE CRETACEOUS–PALEOGENE CHELONIID SEA TURTLE *CATAPLEURAREPANDA*

B73 **O. A. Lopez-Conde, J. Sterli, M. L. Chavarria-Arellano, J. Alvarado-Ortega, H. Porras-Muzquiz** THE FIRST RECORDS OF PROTOSTEGIDAE IN MEXICO (LATE CRETACEOUS)

B74 **M. Peters, J. W. Reumer, M. Bosselaers, K. Post** A LEATHERBACK TURTLE (TESTUDINES, DERMOCHELYIDAE) FROM THE MIOCENE OF THE WESTERSCHELDE, THENETHERLANDS

B75 **G. I. Alvarado, A. J. Lichtig, S. G. Lucas** *TESTUDO COSTARRICENSIS,* A PURPORTEDTORTOISE FROM THE OLIGO–MIOCENE OF COSTA RICA, IS *OLIGOPHERUS LATICUNEA*

B76 **S. E. Jasinski** FOSSIL EMYDIDS (TESTUDINES: EMYDIDAE) FROM EASTERN TENNESSEE AND THEIR IMPLICATIONS FOR THE EVOLUTION OF THE EMYDIDAE

B77 **A. F. Guzman, C. A. Hernández-Luna** *HESPEROTESTUDO* (TESTUDINES, TESTUDINIDAE) SHELL REMAINS FROM ZACATECAS, MÉXICO

B78 **M. L. Al-Fadani, M. I. Al-Najjar, A. A. Bahameem, Y. S. Al-Mufarreh, I. S. Zalmout, P. D. Gingerich, J. A. Wilson** THE FIRST RECORD OF *NEOCHELYS FAJUMENSIS* (PODOCNEMIDIDAE, SIDE-NECKED TURTLE) FROM THE LATE EARLY OLIGOCENE SHUMAYSI FORMATION OF WESTERN SAUDI ARABIA

B79 **J. A. Moretti, E. Johnson, L. C. Bement** A CONCENTRATION OF YOUNG ADULT *HESPEROTESTUDO* (TESTUDINES: TESTUDINIDAE) FROM THE LATE NEOGENE OF BEAVER COUNTY, OKLAHOMA, PROVIDES EVIDENCE OF ONTOGENETIC VARIATION AND POTENTIAL BURROWING

B80 **A. J. Lichtig, S. G. Lucas`** THE LATE CENOZOIC TURTLE *MEIOLANIA PLATYCEPS* WAS AQUATIC

B81 **D. M. Bramble, J. H. Hutchison** EARS TO THE GROUND: SEISMIC RECEPTION AND THE EVOLUTION OF A NOVEL SENSORY SYSTEM IN NORTH AMERICAN GOPHERTORTOISES

B82 **S. L. Denarie, J. Choiniere, J. Stiegler, A. Moore, J. M. Clark** DINOSAUR HUNTING IN THE KINGDOM OF LESOTHO: NEW DISCOVERIES FROM THE EARLY JURASSIC UPPER ELLIOTFORMATION

B83 **B. W. McPhee, J. Bittencourt, M. C. Langer, C. Apaldetti, A. A. Da-Rosa** REASSESSMENT OF *UNAYSAURUS TOLENTINOI* (DINOSAURIA, SAUROPODOMORPHA) FROM THE LATETRIASSIC (EARLY NORIAN) OF BRAZIL

B84 **W. McClure, M. Korbitz, B. A. Schumacher** *EOSAUROPUS* (SAUROPODOMORPH) TRACKWAY FROM THE CHINLE INTERVAL (UPPER TRIASSIC) OF THE PURGATOIRE RIVER VALLEY, SOUTHEASTERN COLORADO

B85 **T. Abdul Kareem, J. A. Wilson** STRUCTURE AND EVOLUTIONARY IMPLICATIONS OF TAIL CLUBS ATTRIBUTED TO THE SAUROPOD DINOSAUR *KOTASAURUS YAMANPALLIENSIS* FROM THE EARLY TO MIDDLE JURASSIC OF INDIA

FRIDAY, OCTOBER 19, 2018
POSTER SESSION III
(CONTINUED)

B86 **A. J. Moore, J. M. Clark, X. Xu** THE PHYLOGENY OF MIDDLE-LATE JURASSIC CHINESE SAUROPODS AND THE EVOLUTIONARY DEVELOPMENT OF THE EPIPOPHYSEAL-PREZYGAPOPHYSEAL LAMINA

B87 **X. Ren, J. Huang, H. You** A SECOND MAMENCHISAURID DINOSAUR FROM THE MIDDLE JURASSIC OF EASTERN CHINA

B88 **F. M. Holwerda, J. Liston, E. Tschopp, M. Evans** ISOLATED VERTEBRAE REVEAL A DIVERSE SAUROPOD FAUNA IN THE OXFORD CLAY (CALLOVIAN, PETERBOROUGH, ENGLAND), EQUIVALENT TO THE MORRISON AND TENDAGURU FORMATIONS.

B89 **J. A. Wilson, D. J. Vander Weele, A. N. Rountrey** CROSS-SECTIONAL GEOMETRY OF THE FORE AND HIND LIMBS OF *JOBARIA TIGUIDENSIS* AND THE EVOLUTION OF MESAXONY AND ENTAXONY IN SAUROPODS

B90 **T. Sekiya, M. Shibata, Y. Azuma** A NEW CAMARASAURID SPECIMEN FROM THE LATE JURASSIC MORRISON FORMATION OF WYOMING, U.S.A.

B91 **J. E. Peterson, D. M. Lovelace, M. V. Connely, J. B. McHugh, S. Hartman, L. Hayes, F. Strey** COMPUTED TOMOGRAPHY, SEGMENTATION, AND RAPID PROTOTYPING OF THE DENTAL BATTERIES OF AN APATOSAURINE (SAUROPODA, DIPLODOCIDAE) SPECIMEN FROM THE UPPER JURASSIC MORRISON FORMATION, COMO BLUFF, WYOMING

B92 **P. Mocho, L. M. Chiappe** NEW CAMARASAURID SPECIMEN FROM THE GNATALIE QUARRY IN SOUTHERN UTAH (MORRISON FORMATION, U.S.A.)

B93 **J. A. Whitlock, J. A. Wilson** THE LATE JURASSIC SAUROPOD DINOSAUR *"MOROSAURUS" AGILIS* MARSH 1889 REEXAMINED AND REINTERPRETED AS A DICRAEOSAURID

B94 **E. Tschopp, O. Mateus, M. Marzola, M. Norell** INDICATIONS FOR A HORNY BEAK AND EXTENSIVE SUPRAORBITAL CONNECTIVE TISSUE IN DIPLODOCID SAUROPODS

B95 **J. Yoshida, C. Tsogtbaatar, Y. Kobayashi, T. Khishigjav** A NEW SAUROPOD FROM THE LATE JURASSIC OF MONGOLIA

B96 **S. S. Salakka, S. F. Poropat, I. J. Corfe, B. P. Kear** TOOTH GROWTH AND REPLACEMENT RATES OF THE SAUROPOD *EUHELOPUS* REVEALED WITH SYNCHROTRON AND LAB MICRO-TOMOGRAPHY

B97 **M. J. Ryan, D. C. Evans** THE FIRST OCCURRENCE OF A SAUROPOD BODY FOSSIL IN CANADA, WITH IMPLICATIONS FOR THE "SAUROPOD HIATUS" IN NORTH AMERICA

B98 **M. Jacobs, A. S. Gale, D. Bullen, J. Lockwood** WHERE DID THE SAUROPODS ROAM? USING GASTROLITHS OF THE EARLY CRETACEOUS WESSEX FORMATION, WEALDEN GROUP OF THE ISLE OF WIGHT, ENGLAND TO INFER PALAEOGEOGRAPHY AND PALAEOECOLOGY

B99 **S. Ishigaki, B. Mainbayar, K. Tsogtbaatar, R. Nishimura, S. Tsutanaga, S. Hayashi, M. Saneyoshi** FIRST GIANT SAUROPOD TRACKWAY WITH METER-SIZED FOOTPRINTS FROM THE UPPER CRETACEOUS OF THE GOBI DESERT, MONGOLIA

B100 **M. Habib** STANDING TALL: NEW TITANOSAUR MATERIAL FROM NEW MEXICO PROVIDES INSIGHTS INTO THE POSTURE AND GAIT OF GIANT LATE CRETACEOUS SAUROPODS

B101 **G. A. Abu El-Kheir, M. K. Abdelgawad, W. G. Kassab** A NEW RECORD OF MAASTRICHTIAN SAUROPOD DINOSAUR FROM THE DAKHLA BASIN, WESTERN DESERT, EGYPT

FRIDAY, OCTOBER 19, 2018
POSTER SESSION III
(CONTINUED)

B102 **T. R. Holtz** "INTEGUMENTARY STATUS: IT'S COMPLICATED": PHYLOGENETIC, SEDIMENTARY, AND BIOLOGICAL IMPEDIMENTS TO RESOLVING THE ANCESTRAL INTEGUMENT OF MESOZOIC DINOSAURIA

B103 **R. J. Bykowski** ASSESSING PATTERNS OF ECOLOGICAL ASSOCIATION AND HABITAT PREFERENCE IN NORTH AMERICAN DINOSAURS

B104 **J. C. Cahal** BIOGEOGRAPHY OF LATE CRETACEOUS NORTH AMERICAN DINOSAURS: AN APPLICATION OF CLADISTIC BIOGEOGRAPHY TO EXTINCT BIOTAS

B105 **F. A. Villegas-Garin, M. D. Uhen** MESOZOIC PARAVIAN AND PTEROSAURIAN PALEOENVIRONMENTAL DISTRIBUTION OF THE (PALEO) NORTHERN HEMISPHERE

B106 **D. Malinzak** PALEOBIOGEOGRAPHIC ANALYSIS OF LATE MAASTRICHTIAN LARAMIDIA AND TESTING HYPOTHESES RELATED TO FAUNAL PROVINCIALITY

B107 **G. Panasci, D. J. Varricchio** DINOSAUR FOOTPRINTS FROM THE CONIACIAN FRONTIER FORMATION DEPOSITS OF SOUTHWESTERN MONTANA

B108 **B. A. Schumacher** EXTENSIVE NEW TRACKWAYS OF *MEGALOSAURIPUS* AND *PARABRONTOPODUS* AT "DINOSAUR LAKE", THE PURGATOIRE VALLEY DINOSAUR TRACKSITE, MORRISON FORMATION, SOUTHEASTERN COLORADO

B109 **J. Nakajima, Y. Kobayashi, C. Tsogtbaatar, T. Tanaka, R. Takasaki, T. Khishigjav, P. J. Currie, A. R. Fiorillo** DINOSAUR TRACKS AT THE NEMEGT LOCALITY: PALEOBIOLOGICAL AND PALEOENVIRONMENTAL IMPLICATIONS

B110 **K. E. Lippincott, L. E. McIntosh, H. C. Larsson, A. Dececchi** DO EPIGENETICS AFFECT MORPHOLOGICAL CHARACTERS AND INFLUENCE PHYLOGENETIC RECONSTRUCTIONS IN BIRDS AND NON-AVIAN DINOSAURS?

B111 **Y. Wu, P. Wu, L. M. Chiappe, D. J. Bottjer, C. Chuong** TOOTH CYCLING CONTROL: GROWTH RATE AND REPLACEMENT PATTERN IN LIVING ALLIGATORS WITH IMPLICATIONS FOR DENTITION PATTERN IN MESOZOIC BIRDS

B112 **M. Hanson, B. S. Bhullar** CONTEXTUALIZING THE MOSAIC EVOLUTIONARY ASSEMBLY OF THE MODERN BIRD SKULL

B113 **C. Sullivan, J. O'Connor** THE POSSIBLE PALEOBIOLOGICAL SIGNIFICANCE OF LONG UNCINATE PROCESSES IN THE EARLY CRETACEOUS BASAL BIRDS *JEHOLORNIS* AND *CONFUCIUSORNIS*

B114 **L. M. Chiappe, W. Nava, A. G. Martinelli, R. Tucker, H. Alvarenga** A REMARKABLE ASSEMBLAGE OF ENANTIORNITHINE BIRDS FROM THE LATE CRETACEOUS OF SOUTHEASTERN BRAZIL

B115 **P. Houde** EARLY PALEOGENE AVIFAUNA OF THE CLARKS FORK BASIN, NORTH-CENTRAL WYOMING

B116 **S. C. Hood, C. R. Torres, M. A. Norell, J. A. Clarke** NEW EARLY RECORDS OF NEOAVIAN BIRD CLADES FROM THE EARLIEST EOCENE BUMBANIAN OF MONGOLIA

B117 **D. W. Fowler, E. A. Freedman Fowler, J. M. Alexander** THE FINEST FOSSIL OWL

B118 **P. A. Kloess, A. W. Poust, T. Stidham** A PARTIAL DENTARY FROM A LARGE BONY-TOOTHED BIRD (AVES: PELAGORNITHIDAE) FROM THE EOCENE LA MESETA FORMATION OF SEYMOUR ISLAND, ANTARCTICA

FRIDAY, OCTOBER 19, 2018
POSTER SESSION III
(CONTINUED)

B119 **D. R. Lawver, C. Boyd** A NEW AVIAN OOTAXON FROM THE BRULE FORMATION(OLIGOCENE) OF NORTH DAKOTA

B120 **C. Boisvert, T. J. Thomson, N. Lopez-Carranza** A MEADOWLARK, A CASSOWARY AND A PUFFIN WALK INTO A BAR: A CASE STUDY FOR IDENTIFYING CLAW SPECIALIZATION IN EXTINCT ANIMALS

B121 **T. Stidham, Z. Li, N. G. Jablonski, X. Ji** THE OLDEST, DIVERSE MODERN-TYPE FRESHWATER DIVING BIRD COMMUNITY FROM THE LATE MIOCENE OF YUNNAN, CHINA

B122 **T. Lowi-Merri, J. Simon, A. R. Reynolds, K. L. Seymour, D. Evans** TAPHONOMIC ANALYSIS OF AVIFAUNAL REMAINS FROM THE PLEISTOCENE TAR PITS OF TALARA, PERU

B123 **L. Claessens, J. P. Hume, A. Janoo, J. P. Wiersma, V. Rupear, J. Mungur-Medhi, K. F. Rijsdijk** PALEONTOLOGICAL SURVEY OF THE MOKA MOUNTAIN RANGE, MAURITIUS

B124 **O. D. Grunmeier, M. Demic** SCALING OF STATICALLY DERIVED OSTEOCYTE LACUNAE: IMPLICATIONS FOR PALEOPHYSIOLOGICAL RECONSTRUCTION

B125 **J. Kane, B. N. Kelly, L. M. Petersen, L. B. Hildreth, D. L. Russell, L. A. Zogby, L. Claessens** BIOMECHANICAL RECONSTRUCTION OF HEAD-BOBBING IN THE DODO (*RAPHUS CUCULLATUS*)

B126 **N. Crouch, J. A. Clarke** GLOBAL COOLING AND THE EVOLUTION OF GIGANTIC FLIGHTLESS BIRDS

B127 **A. Chen, D. Field** SHINING A LIGHT ON NIGHTBIRD RELATIONSHIPS: A TOTAL-EVIDENCE PHYLOGENY OF STRISORES

B128 **H. T. Chase, E. O'Brien, B. Tobalske** BIRD TO THE BONE: TRABECULAR MORPHOLOGY IN THE AVIAN SHOULDER

B129 **A. V. Hogan, A. Watanabe, A. M. Balanoff, G. S. Bever** EVOLUTIONARY PATTERNS IN THE OLFACTORY SYSTEM OF DEVELOPING CHICKS

B130 **C. M. Early, L. M. Witmer** ASSESSING THE UTILITY OF BRAIN ENDOCASTS AS PROXIES FOR INTERNAL NEUROANATOMY AND FUNCTIONAL CAPABILITIES IN EXTINCT BIRDS

B131 **G. San Martin Flores, L. Nagendran, M. T. Silcox** GEOMETRIC MORPHOMETRICS ON TREESHREW CRANIAL ENDOCASTS: A COMPARATIVE ANALYSIS OF SCANDENTIAN AND PLESIADAPIFORM BRAIN SHAPES

B132 **K. R. Selig, E. J. Sargis, S. G. Chester, M. T. Silcox** THREE-DIMENSIONAL GEOMETRIC MORPHOMETRIC ANALYSIS OF TREESHREW LOWER MOLARS: DENTAL MORPHOLOGY OF THE EXTINCT *PRODENDROGALE YUNNANICA* (SCANDENTIA, TUPAIIDAE)

B133 **B. W. Rodwell, K. A. Nichols, T. M. Bown** INVESTIGATING DIETARY NICHE PARTITIONING IN THE EARLIEST NORTH AMERICAN EUPRIMATES *TEILHARDINA* AND *TETONIUS* (ANAPTOMORPHINAE), AND *CANTIUS* (NOTHARCTINAE) USING HIGH RESOLUTION PROFILOMETRY AND DENTAL TOPOGRAPHIC ANALYSES

B134 **E. J. Sargis, S. G. Chester, J. I. Bloch, M. T. Silcox, T. E. Williamson** FUNCTIONAL MORPHOLOGY OF A REMARKABLY COMPLETE SKELETON OF *MIXODECTES PUNGENS*: EVIDENCE FOR ARBOREALITY IN AN ENIGMATIC EUTHERIAN FROM THE EARLY PALEOCENE

B135 **J. Crowell, R. L. Anemone** NEW ADAPID MATERIAL FROM WYOMING'S GREAT DIVIDEBASIN: DIVERSITY AND BIOGEOGRAPHY IN THE EARLY WASATCHIAN OF THE AMERICAN WEST

B136 **R. Bhagat, M. T. Silcox** EVOLUTION OF EARLY EUPRIMATE LOCOMOTOR AGILITY AND HEARING SENSITIVITY: INSIGHTS FROM THE INNER EAR OF *CANTIUS* SP. (BIGHORN BASIN, WYOMING, EARLY EOCENE, WASATCHIAN NALMA)

B137 **S. G. Chester, J. I. Bloch, D. M. Boyer, E. J. Sargis** HIND LIMB MORPHOLOGY OF PALEOGENE MICROMOMYID PLESIADAPIFORMS (EUARCHONTA, PRIMATES)

B138 **R. C. Ely** DIETARY ECOLOGICAL NICHE DISPERSION IN AN ECOMORPHOSPACE OF PLATYRRHINE PRIMATES AND ITS ASSOCIATION WITH CRANIALINTEGRATION

B139 **WITHDRAWN**

B140 **H. M. Edmonds, E. Daly, I. E. Smail** GOING BACK TO OUR ROOTS: ZYGOMATIC ARCHROOT POSITION IN RELATION TO DIET IN LIVING AND FOSSIL PRIMATES

B141 **A. McGrosky, N. Grider-Potter, A. Kemp,F. Mcgechie** HEAD MECHANICAL PROPERTIES IN EXTANT PRIMATES WITH IMPLICATIONS FOR FOSSIL TAXA

B142 **N. J. Czaplewski, G. S. Morgan** MID-CENOZOIC EMBALLONURIDAE (MAMMALIA, CHIROPTERA) FROM PENINSULAR FLORIDA: DEMISE OF AN ARCHAIC LINEAGE AND THE ORIGIN OF NEOTROPICAL DICLIDURINES

B143 **Y. Kimura, D. Fukui, S. Kawada, M. Yoshiyuki, N. Suzuki** EMERGED FROM THE DARKNESS: THE DISCOVERY OF INSECTIVOROUS BAT SUBFOSSILS FROM AN OCEANIC ISLAND INJAPAN

B144 **M. Alberdi, S. Darroch, R. Racicot** COMPARATIVE MORPHOLOGY OF PINNIPED (CARNIVORA, PINNIPEDIMORPHA) CRANIAL ENDOCASTS: INSIGHTS INTO SEMI-AQUATIC SENSORY SYSTEMS

B145 **J. Velez-Juarbe** NEW DATA ON THE EARLY OTARIID *PITHANOTARIA STARRI*

B146 **I. Koretsky, A. Alexander, S. Rahmat** ECOMORPHOTYPES IN THE FAMILY PHOCIDAE (TRUE SEALS) SUPPORTED BY EVIDENCE FROM SOME OTHER VERTEBRATES

B147 **C. Everett, A. Wyss, T. Demere** A SKULL AND ASSORTED POSTCRANIA OF *ENALIARCTOS* (PINNIPEDIMORPHA) FROM THE PYSHT FORMATION OF WASHINGTON, U.S.A.

B148 **K. Tate-Jones, S. S. Hopkins, E. B. Davis** A NEW MIDDLE MIOCENE DESMATOPHOCID PINNIPED (MAMMALIA, CARNIVORA) FROM THE OREGON COAST AND ITS POTENTIAL FOR GREATER RESOLUTION OF PINNIPED PHYLOGENY AND PALEOECOLOGY

B149 **E. G. Ekdale, T. A. Deméré** TOOTH-TO-BALEEN TRANSITION IN MYSTICETES: NEW CT EVIDENCE OF VASCULAR STRUCTURES ON THE PALATE OF *AETIOCETUS WELTONI* (MYSTICETI,CETACEA)

B150 **J. Gatesy, A. Berta, T. Demere, E. G. Ekdale, J. El Adli, M. R. McGowen** CONTRASTING INTERPRETATIONS OF THE TEETH TO BALEEN TRANSITION IN MYSTICETECETACEANS

B151 **F. P. Parada-Arrau, C. S. Gutstein** NEO-TAPHONOMIC COMPARISON OF THE MASS DEATHS OF CETACEANS THAT OCCURRED IN THE CHILEAN PATAGONIA IN MARCH 2015 AND JULY 2016

B152 **M. Churchill, J. Geisler, B. L. Beatty, A. Goswami** MODULARITY OF THE COMMON DOLPHIN SKULL (*DELPHINUS DELPHIS*)

B153 **R. Racicot, S. Darroch, R. Boessenecker, J. Geisler** MY HEAD HERTZ: HEARING ABILITIES IN AN EARLY SIMOCETID (CETACEA, ODONTOCETI) AS RECONSTRUCTED FROM MICROCT SCANS

FRIDAY, OCTOBER 19, 2018
POSTER SESSION III
(CONTINUED)

B154 **C. S. Gutstein, M. A. Cozzuol, J. M. Mpodozis** PROBLEMS AND POSSIBLE SOLUTIONS TO THE PHYLOGENY WITHIN PANDELPHINA, ESPECIALLY INIOIDEA (CETACEA,ODONTOCETI)

B155 **K. M. Awalt, J. F. Parham, J. Velez-Juarbe** DESMOSTYLIANS FROM THE 'TOPANGA' FORMATION OF ORANGE COUNTY, CALIFORNIA, WITH COMMENTS ON TOOTH ONTOGENY OF PALEOPARADOXIIDS

B156 **K. Matsui, Y. Kimura, M. Nagata, H. Inose, K. Ikeda, B. L. Beatty, T. Hirata, T. Shinmura, S. Agematsu, K. Sashida** THE SLEEPING BEAUTY: A DESMOSTYLIAN FOSSIL RE-DISCOVERED FROM THE GEOLOGICAL COLLECTIONS AT THE UNIVERSITY OF TSUKUBA

B157 **F. A. Perini, M. A. Cozzuol** AN EXTINCT SPECIES OF *TRICHECHUS* LINNAEUS, 1758 (SIRENIA, TRICHECHIDAE) FROM THE LATE PLEISTOCENE OF SOUTHWESTERN AMAZONIA

B158 **A. Grass** CT IMAGING OF THE INTERNAL ANATOMY OF SLOTH CLAWS

B159 **C. A. Kirchhoff, R. K. McAfee, S. B. Cooke** RECORD OF OSTEOPATHOLOGIES IN LATE PLEISTOCENE–EARLY HOLOCENE SLOTHS (MAMMALIA, PILOSA, MEGALONYCHIDAE)FROM HISPANIOLA

B160 **R. K. McAfee, S. M. Beery** INTRASPECIFIC VARIATION IN *ACRATOCNUS* (MAMMALIA,PILOSA, MEGALONYCHIDAE) ACROSS THE GREATER ANTILLES

B161 **J. C. Sagebiel** XENARTHRANS FROM THE GULF COAST OF TEXAS AND THE DISTRIBUTIONOF *NOTHROTHERIOPS*

B162 **T. J. Gaudin, A. Boscaini, B. Mamani-Quispe, P. Antoine, F. Pujos** NEW MATERIAL OF THE EXTINCT SLOTH *SIMOMYLODON UCCASAMAMENSIS* (XENARTHRA, MYLODONTIDAE) FROM THEPLIOCENE OF THE BOLIVIAN ALTIPLANO: SYSTEMATIC AND PALEOBIOLOGICAL IMPLICATIONS

SATURDAY MORNING, OCTOBER 20, 2018
TECHNICAL SESSION XIV
ALBUQUERQUE CONVENTION CENTER, BALLROOM A
MODERATORS: Zerina Johanson and Sanaa El-Sayad

8:00 **J. Stack, J. M. Hodnett, S. Lucas, L. Sallan** *TANYRHINICHTHYS*, A LONG-ROSTRUMED CARBONIFEROUS RAY-FINNED FISH (ACTINOPTERYGII), AND THE EVOLUTION OFELONGATE SNOUTS IN FISHES

8:15 **S. Giles, M. Friedman** ENDOSKELETAL ANATOMY OF PLATYSOMIDS SUPPORTS A CARBONIFEROUS ORIGIN FOR CHONDROSTEI

8:30 **C. D. Wilson, J. D. Pardo, J. S. Anderson** A NEW, BASAL ACTINOPTERYGIAN FROM NOVA SCOTIA: STEM GROUP SURVIVORSHIP IN THE EARLY CARBONIFEROUS

8:45 **M. Friedman, S. Giles** EXCEPTIONAL PRESERVATION IN A PENNSYLVANIAN FISH AND THE LIMITS OF NEUROANATOMICAL INFERENCE FROM ACTINOPTERYGIAN CRANIAL ENDOCASTS

9:00 **Z. Johanson, K. Trinajstic, S. L. Cumbaa, M. Ryan** 3D IMAGING OF A JUVENILE*DUNKLEOSTEUS* PROVIDES INSIGHTS INTO THE DEVELOPMENT OF THE SYNARCUAL IN ARTHRODIRES ("PLACODERMI")

SATURDAY MORNING, OCTOBER 20, 2018
TECHNICAL SESSION XIV
(CONTINUED)

9:15 **M. D. Brazeau, M. Castiello, M. Friedman** THE HEAD AND SHOULDER OF A STENSIOELLIDFISH RESOLVES THE PLACODERM-GRADE AFFINITY OF THIS GROUP

9:30 **M. Coates, S. Sang, R. Troll, M. Friedman, Z. Johanson, K. Tietjen** THE UNEXPECTED FACEOF *HELODUS SIMPLEX*

9:45 **WITHDRAWN**

10:00 BREAK

10:15 **J. A. Sime, M. Friedman, L. Sallan** NEW RAY-FINNED FISH (ACTINOPTERYGII) TAXA FROM THE LATE DEVONIAN OF EASTERN NORTH AMERICA EXPOSE UNEXPECTED DIVERSITY OF EARLY FRESHWATER FORMS

10:30 **J. D. Pardo, C. F. Kammerer, C. A. Marsicano, K. D. Angielczyk, J. Fröbisch, R. M. Smith, J. C. Cisneros, M. Richter** PALEOZOIC CROWN LUNGFISHES FROM GONDWANA FORESHADOW THE EARLY TRIASSIC RECOVERY FAUNA

10:45 **M. Richter, J. C. Cisneros, C. F. Kammerer, J. Pardo, C. A. Marsicano, J. Fröbisch, R. Smith, K. D. Angielczyk** DEEP-BODIED RAY-FINNED FISHES (OSTEICHTHYES, ACTINOPTERYGII) FROM THE PEDRA DE FOGO FORMATION IN NE BRAZIL AND THEIR PHYLOGENETIC AND PALEOGEOGRAPHIC AFFINITIES

11:00 **E. C. Shelburne** FISH FOOD: AN ANALYSIS OF CONVERGENT EVOLUTION IN THE FEEDING STRUCTURE OF *XIPHACTINUS AUDAX* AND *MEGALOPS ATLANTICUS* USING LANDMARK-BASED GEOMETRIC MORPHOMETRICS

11:15 **A. N. Michels, L. E. Wilson** THE USE OF MORPHOSPACE OCCUPATION TO AID IN UNDERSTANDING TROPHIC ECOLOGY OF ACTINOPTERYGIAN CLADES IN THE WESTERN INTERIOR SEAWAY

11:30 **K. M. Claeson, E. Roberts, R. V. Hill, L. Tapanila, J. McCartney, M. Bouaré, M. O'Leary** FISHES FROM THE TRANS-SAHARAN SEAWAY OF MALI, AFRICA

11:45 **S. E. El-Sayed, M. Friedman, H. Sallam** SOME LIKE IT HOT: REVEALING PALEOTROPICALFISH DIVERSITY DURING THE PALEOCENE-EOCENE THERMAL MAXIMUM

12:00 **A. Capobianco, M. Friedman, H. Beckett, P. D. Gingerich, G. Carnevale** SABER-TOOTHED GIANT ANCHOVIES (TELEOSTEI, ENGRAULOIDEA) FROM THE EARLY–MIDDLE EOCENE OF BELGIUM AND PAKISTAN

SATURDAY MORNING, OCTOBER 20, 2018
TECHNICAL SESSION XV
ALBUQUERQUE CONVENTION CENTER, BALLROOM B
MODERATORS: Robert Feranec and Julia Tejada

8:00 **E. M. Keenan Early** IDENTIFICATION OF MORPHOLOGICALLY UNIDENTIFIABLE BONEUSING COLLAGENOUS PROTEIN

8:15 **J. V. Tejada, B. J. Macf.adden, L. Bermudez, G. Rojas, R. Salas-Gismondi, J. J. Flynn** BODY MASS PREDICTS DIET-BIOAPATITE $\Delta^{13}C$ ISOTOPE ENRICHMENT IN HERBIVOROUS MAMMALS

8:30 **R. J. Haupt, M. Clementz** BONE CARBONATE–COLLAGEN SPACING OF STABLE CARBON ISOTOPE VALUES IN EXTANT TREE SLOTHS AND IMPLICATIONS FOR THE INTERPRETATION OF GROUND SLOTH DIET

8:45 **J. H. Miller, B. E. Crowley, D. C. Fisher, R. Secord** TRACKING AN AMERICAN MASTODON: ISOTOPIC RECONSTRUCTION OF LANDSCAPE USE FROM A SERIALLY SAMPLED TUSK

9:00 **J. S. Keller, J. T. Cordova, F. A. Smith, S. D. Newsome** SMALL MAMMAL PALEOECOLOGY FOLLOWING THE TERMINAL PLEISTOCENE MEGAFAUNAL EXTINCTION

9:15 **A. Villaseñor, E. A. Elliott Smith, C. P. Tomé, S. Lyons, S. D. Newsome, F. A. Smith** WHO'S EATING WHOM? THE CONSEQUENCES OF TERMINAL PLEISTOCENE MEGAFAUNAL EXTINCTION ON THE ISOTOPIC NICHE SPACE OF LARGE MAMMALS IN THE EDWARDS PLATEAU, TX

9:30 **M. T. Clementz, T. Minckley, J. Meachen** THERE AND BACK AGAIN: POLLEN AND SEDIMENTARY ORGANIC MATTER RECORDS ASSOCIATED WITH PLEISTOCENE MEGAFAUNA RECOVERED FROM NATURAL TRAP CAVE, WY

9:45 **P. Higgins, J. Meachen** PRONGHORN, PRONGHORN, WHY DOST THOU RUN SO SWIFT?

10:00 BREAK

10:15 **C. Badgley, S. Domingo, D. Martín-Perea, J. J. Negro** GATEWAY TO THE FOSSIL RECORD: THE SKELETAL ASSEMBLAGE OF DOÑANA NATIONAL PARK, SPAIN

10:30 **D. C. Blackburn, J. I. Bloch, Z. Luo, E. L. Stanley, O. Takano** THE OVERT THEMATIC COLLECTIONS NETWORK: 3D ANATOMICAL DATA FOR NEARLY EVERY LIVING VERTEBRATE GENUS

10:45 **A. N. Rountrey, M. S. Levine** COMMUNITY STANDARDS FOR 3D DATA PRESERVATION: OWNERSHIP OF 3D DATA

11:00 **D. G. Cerio, F. J. Degrange, C. P. Tambussi, R. C. Ridgely, L. M. Witmer** MODELING VISUAL ABILITIES IN EXTINCT SPECIES USING VIRTUAL OPHTHALMOSCOPY, WITH A CASE STUDY IN PREDICTING EYE SIZE, OPTICAL PARAMETERS, AND VISUAL FIELDS IN TERROR BIRDS (AVES: PHORUSRHACIDAE).

11:15 **S. M. Gatesy, D. Perry, K. Hatala** A BIPLANAR X-RAY APPROACH FOR STUDYING THE 3-D DYNAMICS OF HUMAN TRACK FORMATION AND FOR INTERPRETING FOSSIL HOMININ TRACKS

11:30 **S. Pineda-Munoz, S. Lyons, A. B. Tóth, A. K. Behrensmeyer** LESSONS IN DESIGNING DATABASES FOR EXAMINING PALEOCOMMUNITIES THROUGH GEOLOGICAL TIME

11:45 **J. R. Wood, V. L. Santucci, J. Wolin, J. Meachen, N. A. Matthews, B. H. Breithaupt** STRUCTURE FROM MOTION PHOTOGRAMMETRY ENHANCES NATIONAL PARK SERVICE VERTEBRATE FOSSIL DOCUMENTATION, PRESERVATION, RESEARCH, AND EDUCATION

12:00 **K. Button, L. E. Zanno** PUT A BEAK ON IT: DATA-DRIVEN RECONSTRUCTION OF KERATINOUS SOFT TISSUE IN THEROPOD DINOSAURS

SATURDAY MORNING, OCTOBER 20, 2018

TECHNICAL SESSION XVI

ALBUQUERQUE CONVENTION CENTER, BALLROOM C

MODERATORS: Holly Woodward and Mark Goodwin

8:00 **E. Snively, H. O'Brien, D. M. Henderson, A. J. Rowe** TYRANNOSAURIDS WERE ABLE TO TURN MORE RAPIDLY THAN OTHER LARGE THEROPODS

8:15 **H. N. Woodward, K. Tremaine, S. A. Williams, J. R. Horner, N. P. Myhrvold** FEMUR AND TIBIA OSTEOHISTOLOGY CONFIRMS THE JUVENILE STATUS OF TWO MEDIUM-SIZED LATEST CRETACEOUS TYRANNOSAURIDS AND INDEPENDENTLY TESTS THE '*NANOTYRANNUS*' HYPOTHESIS

8:30 **I. N. Cost** CRANIAL KINESIS IN *TYRANNOSAURUS REX*: INTERPRETING THE BIOMECHANICAL ENVIRONMENT OF SKULLS

8:45 **P. M. Gignac, G. M. Erickson** THE BIOMECHANICS BEHIND EXTREME OSTEOPHAGY IN *TYRANNOSAURUS REX*

9:00 **D. A. Burnham, K. L. Atkins-Weltman, E. M. Jevnikar** A NEW JUVENILE *TYRANNOSAURUS REX* FROM THE HELL CREEK FORMATION OF EASTERN MONTANA PROVIDES INSIGHTS INTO CRANIAL AND DENTAL ONTOGENY

9:15 **M. Zahner, W. Brinkmann** THE FIRST THEROPOD SKELETON FROM SWITZERLAND? A NEW TAXON IMPROVES OUR KNOWLEDGE OF THE EARLY EVOLUTION OF NEOTHEROPOD DINOSAURS

9:30 **W. J. Freimuth, D. J. Varricchio** AN ALVAREZSAURID FROM THE LATE MAASTRICHTIAN OF EASTERN MONTANA WITH IMPLICATIONS FOR SYSTEMATICS AND BIOGEOGRAPHY

9:45 **D. K. Smith, D. G. Wolfe, R. K. Sanders** APPENDICULAR MUSCLE RECONSTRUCTIONS IN THERIZINOSAURS WITH MUSCULAR CHANGES IN THE MANIRAPTORAN OPISTHOPUBLIC PELVIS

10:00 BREAK

10:15 **M. Fabbri, T. Young, J. Wiemann, B. S. Bhullar, M. Norell** A DINOSAURIAN ORIGIN FOR THE AVIAN SINGLE OVIDUCT

10:30 **P. Makovicky, E. Gorscak, C. Zhou** A NEW SPECIMEN OF THE LARGE-BODIED DROMAEOSAURID *TIANYURAPTOR* PROVIDES NEW INSIGHTS ON MICRORAPTORINE ANATOMY, TAXONOMY, AND PLUMAGE EVOLUTION.

10:45 **E. Gorscak, P. M. O'Connor** A NEW TITANOSAURIAN SAUROPOD DINOSAUR FROM THE MID-CRETACEOUS MTUKA MEMBER (GALULA FORMATION) OF TANZANIA AND POTENTIAL FAUNAL CONNECTIONS WITH THE EARLY CRETACEOUS DINOSAUR BEDS OF MALAWI

11:00 **J. A. Fronimos, M. C. Lamanna** AN ARTICULATED TITANOSAURIAN (DINOSAURIA, SAUROPODA) POSTCRANIAL SKELETON FROM THE LATE CRETACEOUS OF TEXAS, WITH IMPLICATIONS FOR THE TAXONOMIC STATUS OF *ALAMOSAURUS SANJUANENSIS*

11:15 **J. B. McHugh, S. K. Drumheller-Horton, A. Riedel, M. Kane** AN ALTERED ASSEMBLAGE: BONE SURFACE MODIFICATIONS ON VERTEBRATE MATERIAL FROM THE UPPER JURASSIC MYGATT-MOORE QUARRY IN RABBIT VALLEY, COLORADO

11:30 **C. T. Heck, H. N. Woodward** USING BONE MICROSTRUCTURE TO INFER INTRASKELETAL GROWTH AND POSTURAL SHIFTS IN THE HADROSAURID DINOSAUR *MAIASAURA PEEBLESORUM*

11:45 **M. B. Goodwin, D. C. Evans, N. R. Carroll, C. Woodruff, J. Wilson** COMPARATIVE CRANIAL ANATOMY OF NEW, LONG-HORNED, FLAT-HEADED ONTOGIMORPHS OF *PACHYCEPHALOSAURUS* (DINOSAURIA, ORNITHISCHIA) FROM THE HELL CREEK FORMATION, MONTANA REVEALS NOVEL FEATURES IN THE SKULL

12:00 **D. Woodruff, D. Evans, M. B. Goodwin** THE ENIGMATIC UPPER CRETACEOUS PACHYCEPHALOSAURINE *SPHAEROTHOLUS*: NEW INSIGHT INTO ITS DEVELOPMENT ALLIFE HISTORY AND DIVERSITY

SATURDAY AFTERNOON, OCTOBER 20, 2018

TECHNICAL SESSION XVII

ALBUQUERQUE CONVENTION CENTER, BALLROOM A

MODERATORS: Adam Pritchard and Selina Groh

1:45 **K. Stein, T. Huang, E. Prondvai, J. Baele, M. Sander, R. R. Reisz** EGGSHELL OF BASAL SAUROPODOMORPH DINOSAURS AND THE ORIGIN OF THE AMNIOTE EGGSHELL

2:00 **D. J. Varricchio, J. R. Moore** QUANTITATIVE AND QUALITATIVE ASSESSMENT OF MODERN NESTING SITE TAPHONOMY

2:15 **L. Grinham, C. VanBuren, D. B. Norman** THE EVOLUTION AND ASSOCIATED TRAITSOF FACULTATIVE BIPEDALITY IN DIAPSIDS: IMPLICATIONS FOR IDENTIFYING ARCHOSAUROMORPH LOCOMOTOR TRANSITIONS

2:30 **A. C. Pritchard, E. Clark, K. Walls, B. S. Bhullar** TESTING FUNCTIONAL HYPOTHESES IN A TRIASSIC DIAPSID REPTILE–3D MODELING OF MODERN MUSCLES ANDRANGE-OF-MOTION MODELING INFORM DIGGING IN *DREPANOSAURUS*

2:45 **L. A. Rooney, J. X. Samuels** POSTCRANIAL MORPHOLOGY AND THE LOCOMOTORADAPTATIONS OF EXTANT AND EXTINCT CROCODYLOMORPHS AND LEPIDOSAURS

3:00 **T. W. Dudgeon, H. C. Maddin, D. Evans, J. Mallon** THE MORPHOLOGY AND FUNCTION OF THE INNER EAR OF *CHAMPSOSAURUS* (DIAPSIDA: CHORISTODERA)

3:15 **K. N. Dollman, J. Choiniere, J. M. Clark, P. Viglietti, M. Norell, X. Xu** SECONDARY PALATE EVOLUTION IN EARLY CROCODYLOMORPHS: FUNCTIONAL AND PHYLOGENETIC IMPLICATIONS

3:30 **S. Groh** NEW APPROACHES TO NEOSUCHIAN (ARCHOSAURIA, CROCODYLOMORPHA) PHYLOGENETIC RELATIONSHIPS AND IMPLICATIONS FOR LONGIROSTRINE SNOUT EVOLUTION

3:45 **A. Cossette** A SYSTEMATIC REVIEW OF THE GIANT ALLIGATOROID *DEINOSUCHUS* FROM THE CAMPANIAN OF NORTH AMERICA AND ITS IMPLICATIONS FOR THE RELATIONSHIPS AT THE ROOT OF CROCODYLIA

4:00 **R. B. Irmis, J. J. Sertich, T. Green** A NEW CROCODYLIAN FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION OF SOUTHERN UTAH, U.S.A., INDICATES DIVERSIFICATION OF ALLIGATORIDAE PRIOR TO THE END-CRETACEOUS MASS EXTINCTION

SATURDAY AFTERNOON, OCTOBER 20, 2018

TECHNICAL SESSION XVIII

ALBUQUERQUE CONVENTION CENTER, BALLROOM B

MODERATORS: Jonathan Calede and Ornella Bertrand

1:45 **O. C. Bertrand, M. T. Silcox** ENDOCRANIAL SHAPE VARIATION WITHIN THE SQUIRREL-RELATED CLADE AND THEIR FOSSIL RELATIVES USING 3D GEOMETRIC MORPHOMETRICS: CONTRIBUTIONS OF LOCOMOTION AND PHYLOGENY TO BRAIN SHAPE

2:00 **F. O. Lafuma, J. Clavel, I. J. Corfe, G. Escarguel, É. Renvoisé** TWO-CUSP ADDITION EVENTS UNDERLIE THE EVOLUTION–BUT NOT THE DEVELOPMENT–OF MOLARS IN ARVICOLINAE (RODENTIA, CRICETIDAE)

2:15 **R. W. Burroughs** IDENTIFYING DEVELOPMENTAL CONSTRAINTS TO UNDERSTAND CONVERGENCE IN RODENT DENTITION

2:30 **D. L. Fox, A. Kort, K. P. McNulty** SPECIES RECOGNITION AND NICHE CONSERVATISM OF *PEROGNATHUS* (RODENTIA, HETEROMYIDAE) DURING THE LATEST PLEISTOCENE AND HOLOCENE OF THE SOUTHERN GREAT PLAINS, U.S.A.

2:45 **J. X. Samuels, J. Schap** THE STRUCTURE OF RODENT AND LAGOMORPH COMMUNITIES ACROSS THE CENOZOIC OF NORTH AMERICA: THE IMPORTANCE OF REGIONAL TOPOGRAPHY AND CLIMATIC DIFFERENCES

3:00 **J. D. Orcutt, C. B. Vietri** THE SKELETON OF *OTOSPERMOPHILUS MCKAYENSIS* AND THE EVOLUTION OF BURROWING IN GROUND SQUIRRELS

3:15 **J. J. Calede** THE PHYLOGENETIC RELATIONSHIPS OF ENTOPTYCHINE GOPHERS AND THE RISE OF BIOLOGICAL DIVERSITY IN BURROWING RODENTS

3:30 **C. B. Withnell** A TIME-CALIBRATED PHYLOGENY OF NORTH AMERICAN ARVICOLINE RODENTS: INSIGHTS INTO DIVERSIFICATION AND TAXONOMY

3:45 **I. C. Casanovas-Vilar, J. Garcia-Porta, J. Fortuny, Ó. Sanisidro, J. Prieto, M. Querejeta, S. Llácer, J. M. Robles, F. Bernardini, D. M. Alba** OLDEST SKELETON OF A FOSSIL FLYING SQUIRREL (SCIURINAE, PTEROMYINI) ALLOWS FOR A RECALIBRATION OF THE TIME OF ORIGIN AND DIVERSIFICATION OF THE GROUP

4:00 **S. V. Robson, C. Scott, J. M. Theodor** DENTAL MICROWEAR OF NORTH AMERICAN TAENIOLABIDOID MULTITUBERCULATES

SATURDAY AFTERNOON, OCTOBER 20, 2018

TECHNICAL SESSION XIX

ALBUQUERQUE CONVENTION CENTER, BALLROOM C

MODERATORS: Kenneth Angielczyk and Savannah Olroyd

1:45 **C. P. Abbott, R. Lockwood, H. Sues** THE *DIMETRODON* DILEMMA: REASSESSING POSTURE IN SPHENACODONTIANS AND OTHER NON-MAMMALIAN SYNAPSIDS

2:00 **R. R. Reisz** *VARANODON* AND THE EVOLUTION OF VARANOPID SYNAPSIDS

2:15 **R. Fong, A. Leblanc, R. Reisz, T. Kaye, C. Sidor, M. Pittman, M. Laflamme** DENTAL HISTOLOGY OF THE DICYNODONT *LYSTROSAURUS*

2:30 **Z. T. Kulik, C. A. Sidor** THE ORIGINAL BONEHEADS: HISTOLOGICAL ANALYSIS OF THE PACHYOSTOTIC SKULL ROOF IN PERMIAN BURNETIAMORPHS (THERAPSIDA, BIARMOSUCHIA)

2:45 **M. R. Whitney, C. A. Sidor, A. R. Leblanc** A PERMANENT LIGAMENTOUS TOOTH ATTACHMENT IN GORGONOPSIANS EXPANDS THE PHYLOGENETIC AND ECOLOGICAL DISTRIBUTION OF A GOMPHOSIS IN SYNAPSIDS

3:00 **K. D. Angielczyk, B. K. Otoo, J. Benoit, C. A. Sidor, S. J. Nesbitt, R. M. Smith, J. Steyer, L. A. Tsuji** A NEW CRYPTODONT DICYNODONT (THERAPSIDA, ANOMODONTIA) WITH A NOVEL PALATAL MORPHOLOGY FROM THE UPPER PERMIAN USILI FORMATION (RUHUHU BASIN, TANZANIA)

3:15 **C. F. Kammerer** A NEW TAXON OF GORGONOPSIAN FROM THE LATE PERMIAN OF ZAMBIA, REVEALING THE ORIGINS OF THE ENIGMATIC GORGONOPSIAN GENUS *ARCTOGNATHUS*

3:30 **S. L. Olroyd, C. A. Sidor** ALLOMETRY OF BONY SOUND RECEPTION STRUCTURES: CHAMELEONS AS A POTENTIAL FUNCTIONAL ANALOG FOR HEARING ABILITY IN NON-MAMMALIAN THERAPSIDS

3:45 **B. R. Peecook, K. Jones, A. G. Sennikov, R. M. Smith, S. E. Pierce, K. D. Angielczyk** VERTEBRAL OSTEOLOGY OF *HIPPOSAURUS BOONSTRAI* (THERAPSIDA, BIARMOSUCHIA) FROM THE MIDDLE PERMIAN OF SOUTH AFRICA, WITH IMPLICATIONS FOR THE EVOLUTION OF ARCHOSAUROMORPHA

4:00 **R. M. Smith, J. Botha-Brink, C. A. Sidor, N. J. Tabor** END-PERMIAN ECOSYSTEM COLLAPSE IN SOUTHERN GONDWANA: EVIDENCE FROM SOUTH AFRICA AND ANTARCTICA

SATURDAY, OCTOBER 20, 2018

POSTER SESSION IV

ALBUQUERQUE CONVENTION CENTER, HALL 4

Authors must be present from 4:15–6:15 p.m. Saturday, October 20

Posters must be removed by 6:30 p.m.

B36 **H. R. Taruvinga, S. Tolan, C. T. Griffin** A *LUANGWA*-LIKE CYNODONT FROM NORTHERN ZIMBABWE AND ENDEMISM ACROSS THE CARNIAN OF SOUTHERN AFRICA

B60 **A. Beerlink, D. Steiner** NEW TECHNOLOGY APPROACHES FOR HIGH RESOLUTION X-RAY COMPUTED TOMOGRAPHY STUDIES OF BIOLOGICAL AND PALEONTOLOGICAL SPECIMENS

B61 **A. S. Hall, J. L. Jacobs, E. N. Smith** AUTOMATIC BONE MEASUREMENT FROM X-RAY COMPUTED TOMOGRAPHY

B62 **M. D. Celeskey, S. G. Lucas, L. F. Rinehart** A NEW EDAPHOSAUR FROM THE EARLY PERMIAN OF NEW MEXICO WITH NOVEL SPECIALIZATIONS FOR HERBIVORY

B63 **E. Bendel, C. F. Kammerer, J. Fröbisch** THE POSTCRANIAL ANATOMY OF *GORGONOPSTORVUS* (SYNAPSIDA, GORGONOPSIA) FROM THE LATE PERMIAN OF SOUTH AFRICA

B64 **K. Kato, A. K. Huttenlocker, E. Rega, C. A. Sidor** PERIOSTEAL REACTION IN A GORGONOPSIAN RADIUS: INSIGHTS INTO THE EVOLUTION OF MAMMALIAN HEALING RESPONSES

B65 **R. R. Hummel, J. D. Gardner** ORIGIN AND DISPERSAL OF GORGONOPSIA: A PHYLOGENETIC APPROACH TO PERMIAN THERAPSID BIOGEOGRAPHY

B66 **W. M. Wilson, K. D. Angielczyk, B. Peecook, G. T. Lloyd** PELYCOSAURIAN "LINEAGES": A META-ANALYSIS OF THREE DECADES OF PHYLOGENETIC RESEARCH

B67 **C. D. Shelton, O. Wings, T. Martens, S. S. Sumida, D. S. Berman** EVIDENCE OF A LARGE BIPEDAL TETRAPOD FROM THE EARLY PERMIAN TAMBACH FORMATION PRESERVED AS NATURAL BONE CASTS DISCOVERED AT THE BROMACKER QUARRY (THURINGIA, GERMANY)

B68 **J. Liu, J. Yi, G. Bever** THE FIRST COMPLETE PAREIASAUR SKULL FROM CHINA AND ITS IMPLICATIONS FOR THE TAXONOMY OF CHINESE PAREIASAURS

B69 **L. A. Cook, C. J. Flis, J. E. Flis, T. Bell, R. T. Bakker, D. P. Temple** CLEAR FORK DIVERSITY CYCLE: RICH LARGE PREDATOR - MEGAHERBIVORE FAUNA IN MID EARLY PERMIAN

B70 **J. Jung, S. S. Sumida, H. Sues** ANATOMICAL REDESCRIPTION AND PHYLOGENETIC ANALYSIS OF THE MATERIALS ASSIGNED TO THE TAXON "*CAPTORHINIKOS*" *CHOZAENSIS*

B71 **G. S. Gonçalves, B. R. Peecook, C. A. Sidor** THREE-DIMENSIONALLY PRESERVED DREPANOSAUROMORPH REMAINS FROM THE SONSELA MEMBER (CHINLE FORMATION, NORIAN) OF PETRIFIED FOREST NATIONAL PARK, ARIZONA

B72 **L. Lustri, A. B. Heckert** WHEN ECOLOGY AND PHYLOGENY ARE AT ODDS: EXTRAPOLATING RESTING AND STANDARD METABOLIC RATES OF AETOSAURS (ARCHOSAURIA, AETOSAURIA) FROM EXTANT SAURIANS

SATURDAY, OCTOBER 20, 2018
POSTER SESSION IV
(CONTINUED)

B73 **J. Desojo, M. Von Baczko, J. R. Taborda** PALEONEUROANATOMY OF THE AETOSAUR *NEOAETOSAUROIDES ENGAEUS* (ARCHOSAURIA, PSEUDOSUCHIA): FIRST NATURAL ANDDIGITAL ENDOCASTS

B74 **M. N. Hudgins, M. D. Uhen, L. N. Hinnov** THE EVOLUTION OF RESPIRATORY SYSTEMS IN THEROPODA AND PARACROCODYLOMORPHA AND THE END-TRIASSICEXTINCTION.

B75 **W. L. Holloway** A COMPARATIVE FUNCTIONAL ANALYSIS OF THREE-DIMENSIONALLY RECONSTRUCTED CRANIAL MYOLOGY IN PHYTOSAURIA AND CROCODYLIA

B76 **J. D. Fortner** PETROGRAPHIC AND ISOTOPIC ANALYSIS OF PHYTOSAUR TOOTH DENTIN REVEALS ARIDIFICATION-RELATED TRENDS IN THE DIAGENETIC ENVIRONMENT OFTHE CHINLE FORMATION

B77 **R. J. Gay, J. Uglesich, X. Jenkins, A. R. Milner** A PHYTOSAUR MASS DEATH SITE FROM THE UPPER TRIASSIC CHINLE FORMATION IN UTAH: IMPLICATIONS FOR THE ADAMANIAN–REVUELTIAN FAUNAL TURNOVER

B78 **A. J. Fitch, A. M. Kufner, M. R. Stocker, B. R. Price, D. Lovelace** NEW MATERIAL FROM THE POPO AGIE FORMATION OF WYOMING YIELDS INSIGHTS INTO BASAL PHYTOSAURS AND THE LATE-CARNIAN FAUNA OF THE WESTERN U.S.A.

B79 **C. M. Stefanic, S. J. Nesbitt** THE PRESENCE OF INTERVERTEBRAL STRUCTURES TRACK BODYSIZE IN ARCHOSAURIA, NOT PHYLOGENY, AND THE LOSS OF THE STRUCTURES IN LIVING MEMBERS OF THE CLADE

B80 **P. J. Bishop, V. R. Allen, K. T. Bates, D. M. Henderson, J. R. Hutchinson** TESTING ASSOCIATIONS BETWEEN CENTRE OF MASS, BODY PROPORTIONS, AND LOCOMOTOR HABIT INARCHOSAURIA

B81 **H. M. Avrahami, L. E. Zanno** COMPARING MORPHOMETRIC METHODS FOR QUANTIFYING SHAPE VARIATION: BEST PRACTICES FOR ARCHOSAURIAN TEETH

B82 **P. Sander, T. Wintrich** THE GIANT "MYSTERY BONES" FROM EUROPEAN RHAETIC BONE BEDS– A HISTOLOGICAL TEST OF COMPETING HYPOTHESES OF AFFINITY

B83 **B. S. Bhullar** SKULL ONTOGENY IN DINOSAURS AND OTHER ARCHOSAURS DIVERGESFROM THE ANCESTRAL REPTILIAN GROUND PLAN AND BEARS SIGNATURES OF BOTH EARLY REPATTERNING AND TERMINAL ADDITION.

B84 **S. Singh, A. Elsler, T. Stubbs, E. J. Rayfield, M. J. Benton** TURNING OVER A NEW LEAF: HERBIVOROUS TETRAPOD TROPHIC MORPHOLOGY REVEALS THEECOLOGICAL DYNAMICS OF THE TERRESTRIAL FAUNAL TURNOVERS THROUGH THE EARLY MESOZOIC.

B85 **J. A. Schwab, M. T. Young, S. Walsh, L. M. Witmer, Y. Herrera, S. L. Brusatte** A MAJOR EVOLUTIONARY TRANSITION–NEUROANATOMICAL ADAPTATIONS IN THALATTOSUCHUAN CROCODYLOMORPHS

B86 **E. T. Metz, P. S. Druckenmiller, N. R. Boone, N. P. Kelley** THALATTOSAURIAN BRAINCASE ANATOMY REVEALED THROUGH COMPLETE AND THREE-DIMENSIONAL MATERIAL OF A NEW GENUS FROM THE CARNIAN VESTER FORMATION OF OREGON

B87 **R. D. Bourque, H. C. Larsson** ENDOCAST RECONSTRUCTIONS AND COMPARISONS BETWEEN *CRICOSAURUS* SP. AND *STOLOKROSUCHUS LAPPARENTI*

B88 **B. Theurer, R. Esplin, D. J. Chure, G. F. Engelmann, R. D. Scheetz, J. M. Clark, B. B. Britt** STRANGERS IN A STRANGE LAND: THE TAPHONOMY OF 80+ SPHENOSUCHIANS (BASAL CROCODYLOMORPHA) IN THE SAINTS & SINNERS QUARRY, A LATE TRIASSIC (NORIAN OR RHAETIAN) OASIS IN THE EOLIAN NUGGET SANDSTONE OF NORTHEASTERN UTAH

B89 **A. A. Ruebenstahl, J. M. Clark** *JUNGGARSUCHUS SLOANI*: A TRANSITIONAL 'SPHENOSUCHIAN' AND THE EVOLUTION OF THE CROCODILIAN SKULL

B90 **L. J. Hart, P. Bell, S. W. Salisbury** LOWER CRETACEOUS CROCODYLIFORMS FROM LIGHTNING RIDGE, NEW SOUTH WALES, AUSTRALIA: NEW EVIDENCE OF THE BASAL EUSUCHIAN *ISISFORDIA*

B91 **S. A. Williams, C. A. Brochu, K. M. Tremaine, R. Carr, D. J. Varricchio, J. Scannella** FIRST OCCURRENCE OF *BOREALOSUCHUS* AND OTHER CROCODYLIFORM FOSSIL MATERIAL FROM THE UPPER CRETACEOUS TWO MEDICINE FORMATION OF NORTHWESTERN MONTANA

B92 **L. McCormack, C. A. Brochu** A NEW SPECIES OF *BOREALOSUCHUS* AND ITS IMPLICATIONS FOR THE EVOLUTION OF CROCODYLIA

B93 **M. Wakui, P. Pha, H. Doan Dinh, T. Komatsu, R. Hirayama, M. Nguyen, T. Tsuihiji** FIRST RECORD OF AN EARLY-DIVERGING CROCODYLOID (REPTILIA, CROCODYLIA) FROM THE PALEOGENE OF NORTHERN VIETNAM AND ITS PHYLOGENETIC RELATIONSHIP WITH *ASIATOSUCHUS*-LIKE CROCODYLOIDS

B94 **D. J. Morgan , R. E. Weems, D. C. Parris** A NEW LARGE GAVIALOID FROM THE LATE PALEOCENE OF EASTERN UNITED STATES

B95 **J. P. Rio, P. Mannion, J. E. Martin, E. Tschopp, M. Delfino** NEW DATA ON THE ANATOMY OF *DIPLOCYNODON HANTONIENSIS*, A LATE EOCENE ALLIGATOROID FROM THE UNITED KINGDOM

B96 **J. O. Farlow, N. J. Robinson, M. L. Turner, J. Black, S. M. Gatesy** FOOTFALL PATTERN OF A BOTTOM-WALKING CROCODILE (*CROCODYLUS ACUTUS*)

B97 **J. C. Kosch, A. Canoville, L. E. Zanno** ASSESSING METHODOLOGICAL BIASES ON TOOTH-AGE AND DENTIN DEPOSITION RATE ESTIMATES IN EXTINCT TAXA: A STUDY ON *ALLIGATOR MISSISSIPPIENSIS*

B98 **K. Wiersma, S. Läbe, M. Koschowitz, M. Lambertz, P. M. Sander** THE ORGANIC PHASE (EXTRACELLULAR MATRIX, OSTEOCYTE, BLOOD VESSEL) PRESERVATION IN FOSSIL TETRAPOD BONE: TEMPORAL AND ENVIRONMENTAL PATTERNS OF PRESERVATION

B99 **C. Colleary, S. O'Reilly, K. Penkman, M. Dickinson, S. J. Nesbitt** CHEMICALLY CHARACTERIZING ORGANIC PRESERVATION IN TERRESTRIAL VERTEBRATES FROM THE LATE TRIASSIC HAYDEN QUARRY (~212 MA) AT GHOST RANCH, NEW MEXICO

B100 **X. A. Jenkins, R. J. Gay** PALEOECOLOGICAL TRENDS OF THE ADAMANIAN–REVUELTIAN FAUNAL TURNOVER EVENT WITHIN THE LATE TRIASSIC (NORIAN) CHINLE FORMATION (U.S.A.)

B101 **C. V. Beightol V, W. Parker, J. W. Martz, A. D. Marsh** ESTIMATING THE STATISTICAL ERROR OF OBSERVED BIOSTRATIGRAPHIC RANGES WITHIN ADAMANIAN–REVUELTIAN VERTEBRATE ASSEMBLAGES OF THE LATE TRIASSIC CHINLE FORMATION OF ARIZONA TO TEST FOR AN ABRUPT TURNOVER EVENT

SATURDAY, OCTOBER 20, 2018
POSTER SESSION IV
(CONTINUED)

B102 **D. R. Richmond, T. C. Hunt** STRATIGRAPHIC REEVALUATION OF THE HISTORIC STOVALL DINOSAUR QUARRIES OF THE UPPER JURASSIC MORRISON FORMATION IN THE WESTERN PANHANDLE OF OKLAHOMA

B103 **L. R. King, A. B. Heckert** A PRELIMINARY ANALYSIS OF THE MOGAN SITE, A NEW LATE JURASSIC VERTEBRATE MICROFOSSIL SITE IN THE MORRISON FORMATION INNORTHEASTERN, WYOMING

B104 **T. C. Hunt, D. R. Richmond** THE AQUATIC VERTEBRATE COMMUNITY OF A BONE-DRYPOND: THE HISTORIC STOVALL QUARRY 8, MORRISON FORMATION IN THE PANHANDLE OF OKLAHOMA

B105 **S. Wright** EFFECTIVENESS OF HARVESTER ANT MOUNDS AS SAMPLE SOURCES BASED ON GEOGRAPHIC COMPARISON OF OXFORDIAN (JURASSIC) MARINE FAUNA, WYOMING, U.S.A.

B106 **J. I. Kirkland, D. D. DeBlieux, J. R. Foster, R. K. Hunt-Foster, K. C. Trujillo** THE MORRISON FORMATION IN THE WESTERN BLANDING BASIN, SOUTHEASTERN UTAH: THE POORLY DOCUMENTED TYPE AREA OF ITS HIGHLY FOSSILIFEROUS BRUSHY BASINMEMBER

B107 **J. C. Mathews, D. S. Large, S. A. Williams, K. Tremaine** TEN YEARS OF EXCAVATION AT THE LATE JURASSIC (TITHONIAN) HANKSVILLE-BURPEE DINOSAUR QUARRY, (MORRISON FORMATION, BRUSHY BASIN MEMBER) AND A POSSIBLE NEW SPECIMEN OF *TORVOSAURUSTANNERI*

B108 **J. R. Foster, D. Pagnac, R. K. Hunt-Foster** AN UNUSUAL NORTHERN BIOTA FROM THEMORRISON FORMATION (UPPER JURASSIC) OF THE BLACK HILLS OF WYOMING, U.S.A.

B109 **B. Haiar, D. Perault, N. Romine** THE USE OF GIS SOFTWARE FOR BONEBED MAPPING TO IMPROVE RESEARCH OUTCOMES

B110 **J. Warnock, J. Petricko, J. E. Peterson** NEW GEOCHEMICAL DATA SUPPORTS EPISODES OF HYPEREUTROPHY TO EXPLAIN THE TAPHONOMIC SIGNAL OF THE CLEVELAND-LLOYD DINOSAUR QUARRY, UPPER JURASSIC MORRISON FORMATION

B111 **M. Suñer, M. Marin-Monfort, A. Santos-Cubedo, R. Royo-Torres, B. Holgado, A. Gamonal, À. Galobart, C. Santisteban** TAPHONOMIC ANALYSIS OF AN UPPER JURASSIC SAUROPOD SITE FROM THE VILLAR DEL ARZOBISPO FORMATION (ALPUENTE, VALENCIA, EASTERN SPAIN)

B112 **D. M. Biasatti, H. Montgomery** PALEOENVIRONMENT OF THE SOUTHERN EXTENT OF THE LATE CRETACEOUS WESTERN INTERIOR SEAWAY: EVIDENCE FROM STABLE OXYGEN ISOTOPE ANALYSES OF THE INOCERAMID *PLATYCERAMIS PLATINUS*

B113 **M. E. Deckman, R. R. Rogers, K. A. Curry Rogers** TAPHONOMY OF VERTEBRATE FOSSILS ON A MARINE SEQUENCE BOUNDARY IN THE UPPER CRETACEOUS (CAMPANIAN) JUDITH RIVER FORMATION, MONTANA

B114 **A. M. Deans, S. G. Lucas, C. Lewis, A. B. Heckert** THE PALEOENVIRONMENT OF THE VERTEBRATE FOSSIL-BEARING ALLISON MEMBER OF THE MENEFEE FORMATION (UPPER CRETACEOUS, EARLY CAMPANIAN), EASTERN SAN JUAN BASIN, NEW MEXICO, U.S.A.

B115 **T. Lepore, K. Chin, P. Robinson, T. Culver, F. Frazier** SOFT-TISSUE IMPRESSIONS AND ORGANIC INCLUSIONS IN A LARGE THEROPOD COPROLITE DEPOSIT FROM THE LARAMIE FORMATIONOF COLORADO

SATURDAY, OCTOBER 20, 2018
POSTER SESSION IV
(CONTINUED)

B116 **A. L. Titus, J. Sertich, K. Knoll, I. Glasspool, C. A. Suarez, S. Richardson** UNIQUE TAPHONOMY OF A TYRANNOSAURID-DOMINATED BONEBED FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION, GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH

B117 **A. Pérez-García, N. Bardet, F. Gascó, R. De La Horra, M. Martín-Jiménez, P. Mocho, I. Narváez, A. Torices, R. Vullo, F. Ortega** THE SINGULAR UPPER CRETACEOUS VERTEBRATE SITES OF THE GUADALAJARA PROVINCE (CENTRAL SPAIN): NEW DATA ON THE FAUNAS FROM THE CENOMANIAN OF ALGORA AND THE UPPERMOST CRETACEOUS OF POYOS

B118 **A. T. McDonald, D. G. Wolfe** NEW DISCOVERIES OF TYRANNOSAURID, ORNITHOMIMID, AND NODOSAURID DINOSAURS FROM THE UPPER CRETACEOUS (LOWER CAMPANIAN) ALLISON MEMBER, MENEFEE FORMATION OF NEW MEXICO

B119 **M. M. Gilbert, E. L. Bamforth** A NEW DINOSAUR PARK FORMATION (CAMPANIAN, LATE CRETACEOUS) MICROVERTEBRATE LOCALITY FROM SOUTHWEST SASKATCHEWAN: IMPLICATIONS FOR PALEOENVIRONMENTAL CONTROLS ON SPECIES ALPHA DIVERSITY

B120 **H. Uno, S. Mitsuzuka, K. Horie, Y. Tsutsumi, R. Hirayama** U–PB DATING OF VERTEBRATE-FOSSIL BEARING SEDIMENT FROM THE UPPER CRETACEOUS TAMAGAWA FORMATION IN KUJI, IWATE PREFECTURE, JAPAN

B121 **A. L. Hendrix, A. M. Deans, A. Harrison, C. Lewis, S. G. Lucas, A. B. Heckert** REVISITING THE ALLISON MEMBER OF THE MENEFEE FORMATION (UPPER CRETACEOUS, EARLY CAMPANIAN), SAN JUAN BASIN, NEW MEXICO

B122 **R. L. Surprenant, R. R. Rogers, K. Curry Rogers** TAPHONOMY OF A VERTEBRATE MICROFOSSIL BONEBED IN THE UPPER CRETACEOUS (CAMPANIAN) TWO MEDICINE FORMATION OF MONTANA–A COMPARATIVE APPROACH

B123 **J. J. Captein, J. R. Moore** THE UTILITY OF PHYSICAL TAPHONOMIC CHARACTERISTICS TO RESOLVE TIME IN REWORKED MICROVERTEBRATE ASSEMBLAGES

B124 **L. Vietti** WHO'S THE BEST? A CROSS-STATE COMPARISON OF FOSSIL VERTEBRATERICHNESS, TEMPORAL COMPLETENESS, AND BIODIVERSITY IN THE U.S.A.

B125 **G. R. Williamson, H. Green, T. Walsh** PALEOENVIRONMENT INTERPRETATION OF FOSSILIFEROUS MUDROCK WITHIN THE POJOAQUE MEMBER (MIOCENE) OF THE TESUQUE FORMATION IN THE EASTERN-CENTRAL ESPAÑOLA BASIN, NEW MEXICO

B126 **E. Welsh, C. A. Boyd, D. Pagnac** EVIDENCE OF TOOTH DECAY IN AN OLIGOCENE URSIDFROM SOUTH DAKOTA AND IMPLICATIONS OF DIETARY TRENDS IN SMALL CANIFORMIA

B127 **B. P. Tanis, L. G. DeSantis, R. C. Terry** CATEGORIZING THE DIET OF TWOHYPOCARNIVOROUS BOROPHAGINE CANIDS, *CYNARCTOIDES LEMUR* AND *PHLAOCYON LATIDENS*

B128 **A. L. Atwater** A NEW OCCURRENCE OF A LARGE BOROPHAGINE CANID (CARNIVORA, CANIDAE) FROM THE MIDDLE MIOCENE SIXMILE CREEK FORMATION (BARSTOVIAN) OF MONTANA

B129 **A. R. Reynolds, K. L. Seymour, D. C. Evans** EXPANDING THE NORTHERN RANGE OF *SMILODON FATALIS* (CARNIVORA, FELIDAE): DESCRIPTION OF THE FIRST SPECIMEN FROM CANADA (LATE PLEISTOCENE; MEDICINE HAT, ALBERTA)

B130 **C. A. Shaw** IMPLIED VOCALIZATION BASED ON THE MORPHOLOGY OF THE HYOID APPARATUS IN THE SABERTOOTHED CAT, *SMILODON FATALIS* (MAMMALIA, FELIDAE, MACHAERODONTINAE) FROM RANCHO LA BREA, LOS ANGELES, CALIFORNIA

B131 **D. R. Ramoni, M. Montellano** DIRE WOLF FOSSIL RECORD IN MÉXICO

B132 **E. Johnson, J. A. Moretti** THE GEOGRAPHIC DISTRIBUTION OF *PANTHERA ATROX*(CARNIVORA, FELIDAE) REMAINS IN TEXAS, U.S.A.

B133 **T. Gabay** PALEONEUROLOGY AND INTERSPECIFIC BRAIN VARIATION WITHIN THE GENUS *SMILODON*

B134 **P. M. Anderson** BRAIN CASE EXPANSION IN COMMENSAL RACCOONS

B135 **D. V. Latorre** GATHERING BACULA TO BUILD A BACULUM MORPHOSPACE FOR THE CARNIVORA

B136 **J. Royer, W. N. McLaughlin, S. S. Hopkins** A JUVENILE BADGER, *MELES LEUCURUS*, FROM THE PLEISTOCENE–HOLOCENE OF KYRGYZSTAN

B137 **S. C. Thompson, S. H. Burch** PREY SIZE PREFERENCE DETERMINATION OF MODERN AND FOSSIL CATS USING GEOMETRIC MORPHOMETRICS

B138 **E. L. Bogner, B. W. Schubert, J. X. Samuels** DISTINGUISHING NORTH AMERICAN BLACK BEARS (*URSUS AMERICANUS*) AND BROWN BEARS (*URSUS ARCTOS*) WITH DENTAL MEASUREMENTS

B139 **W. D. Lambert** IMPLICATIONS OF DISCOVERIES OF THE SHOVEL-TUSKED GOMPHOTHERE *KONOBELODON* (PROBOSCIDEA, GOMPHOTHERIIDAE) IN EURASIA FOR THE STATUS OF THE GENUS *AMEBELODON* AND THE SPECIES *A. FLORIDANUS*

B140 **J. C. Hartley** DISTRIBUTION OF THE AMERICAN MASTODON (*MAMMUT AMERICANUM*) IN THE AMERICAN SOUTHWEST THROUGH THE PLEISTOCENE

B141 **B. J. Hart-Farrar** MANUS MORPHOLOGY OF AN EXTRAORDINARILY LARGE PROBOSCIDEAN FROM THE GRAY FOSSIL SITE OF EASTERN TENNESSEE, WITH COMPARISON TO SAUROPOD MODIFICATIONS BASED ON GIGANTISM

B142 **A. A. Bahameem, M. I. Al-Najjar, M. L. Al-Fadani, I. S. Zalmout, Y. A. Al-Mufarreh, S. A. Soubhi, A.M. Memesh, M. A. Haptari, A. N. Rountrey, D. C. Fisher** 3D MODELING OF AN *ELEPHAS RECKI* SKELETON FROM THE PLEISTOCENE OF NORTHWESTERN SAUDI ARABIA

B143 **R. Rabinovich, G. Herzlinger, R. Calvo, G. Beiner** ERQ EL AHMAR ELEPHANT SITE–A MAMMOTH SKELETON AT A RARE AND CONTROVERSIAL PLIOCENE SITE ALONG THE MAMMAL MIGRATION ROUTE OUT OF AFRICA

B144 **T. Htun, D. R. Prothero, J. Hoffman** ONTOGENETIC LONG BONE GROWTH AND DWARFISM IN PLEISTOCENE PROBOSCIDEA

B145 **A. Hastings, D. A. Hubbard, F. Grady, R. G. Vodden, B. Khameiss** NEWLY COLLECTED MATERIAL FROM STARR CHAPEL CAVE REVEALS FURTHER PRESENCE OF PLEISTOCENE FAUNA IN NORTHWESTERN VIRGINIA, U.S.A.

B146 **A. C. Dooley, Jr., E. Scott, B. S. Dooley, B. E. Stoneburg** A RANCHOLABREAN VERTEBRATE FAUNA FROM TEMECULA VALLEY, CALIFORNIA

SATURDAY, OCTOBER 20, 2018
POSTER SESSION IV
(CONTINUED)

B147 **C. M. Redman, J. Meachen** THE ABUNDANCE STRUCTURE OF LATE PLEISTOCENE MEGAFAUNA FROM NATURAL TRAP CAVE, WYOMING

B148 **F. Socki** REFINEMENT OF CHRONOLOGY OF KENNEWICK ROADCUT (WASHINGTON, U.S.A.) ALLOWS COMPARISON OF IRVINGTONIAN FOSSIL LOCALITIES ACROSS NORTH AMERICA

B149 **B. Hensley-Marschand, P. Polly** TESTING THE VARIABILITY SELECTION HYPOTHESIS: PALEOCLIMATE, PALEOENVIRONMENT, AND SUBSISTENCE OF *HOMO ERECTUS* ACROSS AFRICA AND EURASIA

B150 **K. B. Springer, J. S. Pigati, E. Scott, V. L. Santucci, M. Ferlicchi** DESERT WETLANDS RECORD A NEW PLEISTOCENE VERTEBRATE FAUNA FROM DEATH VALLEY NATIONAL PARK

B151 **R. Laker, M. Clementz** QUANTIFYING ORGANIC PRESENCE IN YOUNG FOSSIL SPECIMENS WITH RAMAN SPECTROSCOPY

B152 **R. W. Graham, M. I. Pardi, J. A. Christine** TAPHONOMY AND PALEOECOLOGICAL IMPLICATIONS OF THREE PIT CAVE DEPOSITS IN THE BLACK HILLS OF SOUTH DAKOTA

B153 **S. B. Cooke, A. Mychajliw, J. Almonte, G. Feliz, R. K. McAfee, S. Turvey, S. Lovett** A LATE PLEISTOCENE TO HOLOCENE FAUNAL COMMUNITY IN PEDERNALES PROVINCE, DOMINICAN REPUBLIC

B154 **C. Widga, J. Saunders, G. Hodgins, S. Lengyel, J. D. Walker, A. Wanamaker** STABLE ISOTOPE ECOLOGY OF MIDWESTERN PROBOSCIDEANS DURING THE LATE PLEISTOCENE: IMPLICATIONS FOR LIFE HISTORIES AND LANDSCAPE CHANGES

B155 **K. O'Brien, K. Allen, M. Biernat, D. R. Braun, A. Guerrero, A. McGrosky, D. B. Patterson, F. Torres, J. Faith** EARLY PLEISTOCENE GRASSLAND DYNAMICS AT EAST TURKANA: SPATIOTEMPORAL PATTERNS OF MESIC- AND XERIC-ADAPTED UNGULATES AND NEW INSIGHTS INTO NICHE PREFERENCES OF *EURYGNATHOHIPPUS* AND *KOLPOCHOERUS*

B156 **A. K. Behrensmeyer, J. M. Hutson, D. Gifford-Gonzalez, G. Haynes, H. Little, A. Millhouse** INTERPRETING BONE MODIFICATION PROCESSES AND AGENTS: AN INTRODUCTION TO THE SMITHSONIAN'S NATIONAL TAPHONOMY REFERENCE COLLECTION

B157 **WITHDRAWN**

B158 **M. I. Pardi, F. A. Smith** CLIMATE AND CULTURALLY MEDIATED CHANGES TO THE HUMAN NICHE ALTERED INTERSPECIFIC INTERACTIONS WITH ENDEMIC CANIDS IN NORTH AMERICA

B159 **M. A. Stegner, T. Stidham** NEW AND EXTRALIMITAL TETRAPODS FROM MIDDLE–LATE HOLOCENE PACKRAT MIDDENS ON PUBLIC LANDS IN THE BEARS EARS REGION OF SOUTHEASTERN UTAH, U.S.A.

B160 **A. M. Mychajliw, K. C. Brown, B. T. Campbell, P. Alagona, E. Lindsey** A TALE OF TWO BEARS: EMPLOYING QUATERNARY FOSSILS TO GUIDE ANTHROPOCENE CONSERVATION STRATEGIES IN CALIFORNIA

B161 **S. E. Foss** GEOETHICS IN THE FIELD: BEST PRACTICES FOR INTEGRATING ETHICAL PRINCIPLES INTO PALEONTOLOGICAL FIELDWORK

Technical Session XIX (Saturday, October 20, 2018, 1:45 PM)

THE *DIMETRODON* DILEMMA: REASSESSING POSTURE IN SPHENACODONTIANS AND OTHER NON-MAMMALIAN SYNAPSIDS

ABBOTT, Caroline P., The College of William & Mary, Williamsburg, VA, United States of America; LOCKWOOD, Rowan, The College of William & Mary, Williamsburg, VA, United States of America; SUES, Hans-Dieter, National Museum of Natural History, Washington, DC, United States of America

Historically, the "pelycosaur"-grade synapsid *Dimetrodon* has been reconstructed with sprawling body and tail-dragging posture. However, referred trackways are narrower than those of most sprawling taxa and its vertebral column exhibits limited lateral flexibility, implying that this animal was capable of some limb adduction and carried its body higher above the ground. The goal of this research is to re-evaluate the posture and locomotion of *Dimetrodon* and other non-mammalian synapsids, by comparing body and trace fossil measurements to present-day analogues.

We collected measurements (n = 57) of postcranial limb and girdle bones from the FMNH, MCZ, AMNH, and NMNH collections for *Dimetrodon*, more basal "pelycosaurs" (such as *Ophiacodon*), and various therapsids (such as the dicynodont *Aulacephalodon*). We focused on the appendicular skeleton. Pace angles were also collected from the literature for taxa with associated ichnogenera (such as *Dimetropus* for *Dimetrodon* and other sphenacodonts) where available. We compared these data with analogous measurements for some 50 extant mammalian, reptilian, and amphibian species, which were collected from museum specimens or the literature. These included *Didelphis virginiana, Pecari tajucu, Iguana iguana, Alligator mississippiensis,* and *Tachyglossus aculeatus*. These linear measurements and pace angles were analyzed via discriminant function analysis (DFA) and multiple regression analysis to predict postural grade and femoral abduction angle for *Dimetrodon* and other non-mammalian synapsids.

Preliminary DFA results suggest that *Dimetrodon* was not a sprawling "belly-dragger," but greater sample size, phylogenetic context, and more taxa are needed to fully assess the posture of this taxon. If mammalian precursors are found to have evolved more upright posture earlier than previously thought, this may offer insight into when and in which taxa these major "mammalian" traits arose.

Grant Information

We would like to thank the Smithsonian NHRE Program (NSF Grant #1062692), W&M Honors Fellowship, and the Stoffan Fund (W&M Geology Department) for funding this research.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

QUSEIR TESTUDINES REMAINS FROM THE LATE CRETACEOUS KHARGA AREA, SOUTH WESTERN DESERT, EGYPT

ABDELGAWAD, Mohamed K., Cairo University, Giza, Egypt; ABU EL-KHEIR, Gebely A., New Valley Branch, Assiut University, New Valley, Egypt

Late Cretaceous stages are less documented periods in the Egyptian Testudines record. The Quseir Formation is a Campanian, Late Cretaceous site that mainly crops out in the southwestern Desert of Egypt. The locality comprises a clastic sequence of bioturbated mudstone and sandstone intercalations, which contain rare scattered and fragmented vertebrate remains such as shark teeth, dinosaur remains, and turtle plates. These sediments indicate a supratidal marsh environment. A recent expedition found turtle remains which had been collected from the Quseir Formation east of the Kharga area. The collected specimens are housed in the Geology Department, New Valley Branch, Assuit University. All the turtle remains are isolated plates; no cranial elements. However, four well-preserved, mostly complete shells, have been recovered. Three complete plastrons with a fragmentary carapace and one shell with both carapace and plastron have been collected from the compacted mudstone at the uppermost part of the formation. This area had been described previously as Late Cretaceous, Cenomanian period. At least two new Testudines genera are recovered from the Quseir Formation, Kharga area. The new taxa fill the missing evolutionary gap from the Late Cretaceous Testudines records in Egypt and generally in Africa.

Poster Session III (Friday, October 19, 2018, 4:15 – 6:15 PM)

STRUCTURE AND EVOLUTIONARY IMPLICATIONS OF TAIL CLUBS ATTRIBUTED TO THE SAUROPOD DINOSAUR *KOTASAURUS YAMANPALLIENSIS* FROM THE EARLY TO MIDDLE JURASSIC OF INDIA

ABDUL KAREEM, Tariq, University of Michigan, Ann Arbor, MI, United States of America; WILSON, Jeffrey A., University of Michigan, Ann Arbor, MI, United States of America

Tail clubs evolved independently multiple times within amniotes, including at least twice within dinosaurs. The best known and most complex dinosaurian tail clubs evolved within ankylosaurids and consist of modified vertebrae and osteoderms forming a 'knob' and 'handle.' Structurally simpler tail clubs have been reported for basal sauropods from the Jurassic of China (*Shunosaurus*, *Omeisaurus*, *Mamenchisaurus*). Of these, only those of *Shunosaurus* and *Mamenchisaurus* were found in association with definitive postcranial remains of those taxa. Tail clubs attributed to *Shunosaurus* and *Omeisaurus* are laterally expanded, rounded structures with signs of segmentation ventrally, and partially fused caudal elements precede them. The *Mamenchisaurus* club is distinctive in its laterally compressed aspect. All three taxa possess 'forked' distal chevrons with anterior and posterior processes.

We report on tail club elements from the Kota Formation of India (Lower to Middle Jurassic), which has produced abundant but mostly disarticulated remains of the basal sauropods *Kotasaurus* and *Barapasaurus*. These remains were collected from geographically adjacent sets of localities and are housed in distinct collections. Five tail clubs were recovered among the nearly 400 bones attributed to *Kotasaurus*. These elements are bilaterally symmetrical, roughly ovoid in dorsal outline, and fairly large. Their dimensions range from 140–308 mm (greatest length), 140–211 mm (greatest width), and 8–12 mm (greatest depth). The posterior end of the club is more rounded than the anterior and bears a prominent dorsal depression. The ventral surface is partially segmented. 'Forked' chevrons and partially fused distal caudal vertebrae are present in one or both collections, suggesting that one of the two Indian basal sauropod taxa had a tail club and associated caudal structures. Conversely, presence of slender, elongated distal caudal vertebrae in both collections indicates that the other Indian taxon had a more gracile tail lacking a club. We provisionally attribute the tail clubs to *Kotasaurus*, but additional data are required to formalize this claim.

The tail clubs of *Kotasaurus* are similar in shape to those attributed to *Shunosaurus* and *Omeisaurus* and share with them ventral segmentation and a distinct posterodorsal depression, as well as 'forked' chevrons and fused distal caudal vertebrae. This raises the question of whether tail clubs and associated structures evolved once, multiple times, or were gained and then lost within basal sauropods.

Grant Information

Support for this research was provided by the American Institute of Indian Studies (JAW) and the Scott Turner Fund (TAK).

Technical Session XI (Friday, October 19, 2018, 4:00 PM)

TRENDS IN DIET, BODY SIZE, HABITAT OCCUPANCY, AND WATER DEPENDENCY ASSOCIATED WITH THE EOCENE–OLIGOCENE CLIMATE TRANSITION IN TOADSTOOL GEOLOGIC PARK, NEBRASKA

ABT, Wiley E., University of New Mexico, Albuquerque, NM, United States of America; ARMIJO, Brooklyn, University of New Mexico, Albuquerque, NM, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America

Abundant evidence shows that a global climate shift occurred across the Eocene–Oligocene boundary, with the poles cooling rapidly and a permanent ice cap forming on Antarctica. The effects of this transition (the Eocene–Oligocene Climate Transition, or EOCT) at middle and low latitudes on land are more complex to understand. To better investigate the macroecological effects of the EOCT on the terrestrial mid-latitudes, we sampled the large vertebrate fauna of the White River Group from four sites spanning the EOCT at Toadstool Geologic Park in Nebraska. The White River Group is an exceptionally fossil rich formation with good temporal and faunal representation throughout the study interval. If the EOCT was a rapid, global event, we expect to see a pronounced change in mammalian faunal structure occurring at the stratigraphic level that corresponds to the EOCT, with lesser paleoecological change in other parts of the section. Alternatively, if regional factors are driving faunal change in the White River Group (for example, the progradation of a distributive fluvial system), we would expect to see a more gradual pattern of faunal change, suggesting long term habitat evolution. To differentiate among these hypotheses, we quantified changes in the ecology of the large mammal assemblage through the ~1 million year interval sampled by our assemblages, including diet, body size (within and among taxa), preferred habitat, and degree of drinking water dependency.

Preliminary analysis of our data shows no identifiable shifts in the abundance of dietary categories, but does support a shift in the White River Group mammalian fauna to less water dependent and more drought tolerant taxa through time, indicating an upward drying trend. Consistent with this, we also see a change in the preferred habitat of taxa present from woodland to open plains and a shift to the dominance of smaller-bodied taxa. All of the trends are gradual and diachronous with similar patterns reported elsewhere in the White River Group, suggesting that global climatic effects from the EOCT were not the primary drivers of faunal change in the White River Group at this time.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A NEW VERTEBRATE LOCALITY OF MAASTRICHTIAN SUCCESSIONS OF THE DAKHLA BASIN, WESTERN DESERT, EGYPT

ABU EL-KHEIR, Gebely A., New Valley Branch, Assiut University, New Valley, Egypt; ABDELGAWAD, Mohamed K., Cairo University, Giza, Egypt; KASSAB, Walid G., Cairo University, Giza, Egypt

The Maastrichtian has a very rare record of dinosaur bones in Egypt and generally in Africa. This scarcity reduces the recognition of the evolution and extinction of the huge African reptiles in this stage. The Dakhla Basin in Egypt presents very good Maastrichtian outcrops, consisting of highly fossiliferous, calcareous siltstones and sandstone layers, rich in ammonites, bivalves (e.g., *Exogyra overwagi*, *Pycnodonta vesicularis*, Pectinids), gastropods, echinoids, corals, fossilized fruits of mangrove plants (*Nypa*) and vertebrate remains. Two well preserved humeri of different turtle species, vertebrae of marine reptiles, turtle shell fragments, shark teeth, fishbone fragments, and others are discovered from the early late Maastrichtian, Ammonite Hill member of the Dakhla Formation in the Abu Minqar area, South Western Desert, Egypt. These layers were deposited in very shallow coastal, inner neritic to littoral environments. This discovery introduces a new locality for the Maastrichtian reptiles in Egypt. It represents the second recording of Maastrichtian reptile remains from Egypt. Therefore, it reveals a unique window into the evolution and extinction of reptiles by the end of the Cretaceous Period.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A NEW EMBOLOMERE FROM THE MISSISSIPPIAN-AGED POINT EDWARD FORMATION OF NOVA SCOTIA, CANADA

ADAMS, Gabrielle R., Carleton University, Ottawa, ON, Canada; MANN, Arjan, Carleton University, Ottawa, ON, Canada; MADDIN, Hillary C., Carleton University, Ottawa, ON, Canada

Embolomerous tetrapods, a group of large, aquatic predators, form a major faunal constituent of Permo–Carboniferous tetrapod communities. Embolomeres are recognized by their distinct circular, bipartite vertebrae. Although traditionally classified as stem amniotes, the inclusion of embolomeres within the tetrapod crown group has recently been challenged. In spite of the group's phylogenetic uncertainty, embolomeres provide an important record of a long-lived tetrapod lineage, spanning 'Romer's Gap' through to the early Permian. Here we describe embolomerous tetrapod material that was collected in 1915 by W. A. Bell, currently housed in the Canadian Museum of Nature (CMN 10015). The material, comprised of numerous disarticulated cranial and postcranial elements, was discovered near Sydney, Nova Scotia, as ex situ beach-float pertaining to the Mississippian-aged Point Edward Formation. At least three individuals are represented among the material, as evidenced by the presence of three right ilia. Additionally, the possibility of different age classes is suggested by the different sizes of preserved centra; however, these may alternatively pertain to different locations along the axis. Among the material is a well preserved parietal, which possesses a mosaic of diagnostic traits,

including a wedge-like shape and a rimmed pineal foramen, common to either *Archeria* and *Proterogyrinus*, respectively. A phylogenetic analysis including CMN 10015 recovers a polytomy between it, *Proterogyrinus*, and a clade containing *Pholiderpeton* and *Archeria*. These results and the greater overall similarity between CMN 10015 and *Proterogyrinus* suggests these may be the same taxon. However, CMN 10015 differs significantly from *Proterogyrinus* in that both the pleurocentra and intercentra of CMN 10015 are completely ossified dorsally with no trace of a suture. As such, we propose CMN 10015 belongs to the genus *Proterogyrinus*, but that it represents a distinct species. CMN 10015 therefore constitutes a new tetrapod taxon for the Point Edward Formation, increasing the known diversity of the predominantly aquatic ecosystem preserved at this locality.

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

OF MICE AND MULTITUBERCULATES: ASSESSING COMPETITIVE EXCLUSION AND EXTINCTION THROUGH CRANIOMANDIBULAR BIOMECHANICS

ADAMS, Neil F., University of Leicester, Leicester, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom; COX, Philip G., University of York, York, United Kingdom; COBB, Samuel N., University of York, York, United Kingdom; CORFE, Ian J., University of Helsinki, Helsinki, Finland

Multituberculate mammals thrived during the Mesozoic, but their diversity declined from the mid-late Paleocene onwards, with last occurrences known from the late Eocene. The radiation of superficially similar eutherian rodents has been linked to multituberculate extinction through competitive exclusion. However, characteristics providing rodents with a supposed competitive advantage are currently unknown and comparative functional tests between the two groups are lacking. Here, a multifaceted approach to craniomandibular biomechanics was taken to test the hypothesis that superior skull function made rodents more effective competitors. Digital models of the skulls of four extant rodents, encompassing the three major morphotypes of rodent cranial musculature (hystricomorph, myomorph, sciuromorph), and the Upper Cretaceous multituberculate *Kryptobaatar* were constructed from CT scans. The first 3D digital reconstructions of cranial muscles for a multituberculate were also produced from preserved muscle origin and attachment sites to determine muscle forces. The skull models were then used in finite element analysis (1) to study feeding-induced stresses, (2) to calculate metrics of bite force production, and (3) to determine mechanical resistances to bending and torsional forces. Results suggest that most rodents experienced higher craniomandibular stresses and some had lower resistances to bending and torsion than the multituberculate, apparently refuting the competitive exclusion hypothesis. However, rodents optimize bite force production at the expense of higher skull stress and this may have been more functionally and selectively important. Our results therefore provide a first step to understanding the decline of multituberculates in the changing environments of the Paleogene. This research was conducted using CT data collected previously for other purposes (e.g., morphological and anatomical studies). We, therefore, advocate the open sharing of 3D morphological, phenotypic data to facilitate similar research, testing hypotheses that might not have been predicted by the original data collector.

Grant Information
Rodent data acquired with NERC grant NE/G001952/1 to EJR and PGC. EJR was also supported by NE/K01496X/1. IJC was supported by the Ella & Georg Ehrnrooth and Otto A. Malm Foundations.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A DIVERSE TURTLE ASSEMBLAGE FROM THE ARLINGTON ARCHOSAUR SITE, WOODBINE FORMATION (CENOMANIAN), TEXAS, U.S.A.

ADRIAN, Brent, Midwestern University, Glendale, AZ, United States of America; SMITH, Heather F., Midwestern University, Glendale, AZ, United States of America; NOTO, Christopher R., University of Wisconsin-Parkside, Kenosha, WI, United States of America; GROSSMAN, Aryeh, Midwestern University, Glendale, AZ, United States of America

The Arlington Archosaur Site (AAS) is a Cenomanian (93–99 Mya) fossil locality in the Woodbine Formation of Texas. Woodbine sediments form primarily terrigenous near shore and shallow marine depositional systems, including shelf, deltaic, and fluvial environments. The AAS represents the oldest Late Cretaceous unit in the Gulf Coastal Plain, and the most complete fossil ecosystem discovered in southwestern Appalachia. It preserves a freshwater or brackish wetland situated in a low lying coastal plain. The site contains a diverse fossil vertebrate fauna, invertebrates, and plants. The taphonomy of the site is complex, resulting in frequently disarticulated or broken specimens, likely due to a mixture of environmental transport, biological accumulation, and pervasive crocodyliform predation. While the dinosaurian and crocodyliform fossil record from the AAS has been documented, the taxonomic diversity and evolutionary significance of the associated turtle fauna has not. Our study documents the skulls, shells, and postcrania of an extensive turtle fauna including taxa previously unrecognized from the site.

The AAS turtle fauna expands the temporal and geographic ranges of several groups and provides new insights into the origins and evolution of turtles in North America. Identified taxa include a helochelydrid *Naomichelys*, the baenid *Trinitichelys*, the marine chelonioid *Toxochelys,* the basal cheloniid *Ctenochelys*, early records of *Adocus* and a bothremydid (cf. *Bothremys*), a trionychid (cf. *Aspideretoides*), and the nanhsiungchelydrid *Basilemys*—the earliest and easternmost record of the genus in North America. The turtles studied here sample a taxonomically diverse mixture of freshwater, marine, and terrestrial forms. Common taxa in the AAS include the freshwater semiaquatic cryptodires *Naomichelys* and *Trinitichelys*, which were present on the continent since the Early Cretaceous. *Toxochelys* and *Ctenochelys* are both basal chelonioids from the lineage that eventuates in crown Cheloniidae. With the singular pleurodire cf. *Bothremys,* they form a marine component that immigrated from Europe and Africa beginning in the Early Cretaceous. These taxa exhibit early adaptations to a marine environment such as a secondary palate, webbed feet or flippers, and relatively long manus lengths. Immigrations also occur from Asia, including freshwater aquatic trionychids and adocids, and the terrestrial nanhsiungchelyid *Basilemys*. In sum, the diverse turtle taxa occupy environmental niches consistent with reconstructions of the AAS.

Grant Information
Midwestern University faculty intramural funds.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

MORPHOGENESIS OF THE EXOSKELETON IN EARLY VERTEBRATES (OSTEOSTRACI, AGNATHA): MODES OF THE HORIZONTAL GROWTH

AFANASSIEVA, Olga B., Borissiak Paleontological Institute of Russian Academy of Sciences, Moscow, Russia

Possible modes of the horizontal growth of the exoskeleton of early vertebrates are characterized based on recently obtained original and published data on the exoskeletal structure of osteostracans (Osteostraci, Agnatha). Osteostraci is one of the most ancient groups of extinct jawless vertebrates, known from the Early Silurian to the Late Devonian. The sculpture and histocharacteristics of osteostracan exoskeletons are extremely diverse. In the case of the horizontal growth of the exoskeleton of osteostracans (increase in the absolute size of an individual) and successive deposition of dentin, different variants of the formation of hard tissues around the initial structure (tubercle, ridge, smooth site) are possible. Various combinations of initiation of anlages of dentin and bone tissues form the space of logic capability of horizontal development of hard exoskeletal structures. For the sake of convenience, following Pythagoreans, we designate a point (future tubercle) in numerical form as 1, a line (future ridge) as 2, and a plane (future smooth site of the shield) as 3. The absence of dentin (presence of bone tissue) is designated as 0. Then, the combinations of the initial and subsequent (secondary) tissue anlages are designated as (00), (01), (02), …, (10), (11), …, (20), (21), …, (30), etc. Algorithms (1), (2), and (3) designate synchronous formation of uniform dentin structures (tubercles, ridges, smooth sites) on the entire surface of the exoskeleton of an individual. For example, in *Timanaspis kossovoii*, the smooth surface is only formed on the ventral side of the cephalothoracic shield (growth algorithm (3), i.e., simultaneous formation of a smooth dentin surface of the exoskeleton), whereas on the dorsal shield side, rows of relatively large tubercles are primarily formed, with longitudinal ridges forming between them in the course of the growth (12); in *Saaremaaspis*, throughout the shield surface, small uniform-sized tubercles (1) and, probably, in places, smooth sites (3) are formed. The study of the space of logic capability of horizontal development of exoskeletal structures of osteostracan agnathans has shown that, in the development of the cephalothoracic shield with different configurations, osteostracans realize most of theoretically possible variants of horizontal formation of the armor. The exoskeleton in the osteostracans is a good model for demonstration of morphogenesis of different types of hard covers in vertebrates.

Grant Information
This research was supported by the Russian Foundation for Basic Research, project 14-04-01507.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

COMPARATIVE MORPHOLOGY OF PINNIPED (CARNIVORA, PINNIPEDIMORPHA) CRANIAL ENDOCASTS: INSIGHTS INTO SEMI-AQUATIC SENSORY SYSTEMS

ALBERDI, Madeleine, Vanderbilt University, Nashville, TN, United States of America; DARROCH, Simon, Vanderbilt University, Nashville, TN, United States of America; RACICOT, Rachel, Claremont McKenna, Pitzer, and Scripps Colleges, Claremont, CA, United States of America

Pinnipeds (Carnivora, Pinnipedimorpha) have evolved dramatic adaptations to the unique demands of living a semi-aquatic lifestyle, such as large fusiform bodies with very small surface area to volume ratios, extremely innervated vibrissae, and the most developed tapetum lucidum of any mammal. However, relatively little is known about the brains of these fascinating animals. Here, we used the new and evolving method of computed tomography (CT) scans to create virtual endocasts from which to study the internal anatomy, namely the cranial endocasts as they represent 'virtual' brains, of multiple extant and extinct pinniped species. This method is an important innovation in paleontology because it allows for observation and data extraction without the loss of information that would occur from traditional methods such as serial sectioning. Motivations for this study were to examine the possibility of unique brain morphologies of pinnipeds, mainly through features such as overall brain volume and sizes of the various brain regions related to sensory systems and higher-level cognitive function. The program VGStudioMax was used to segment the braincases to create three-dimensional 'virtual' endocasts of the brains from which data can be extracted. Three-dimensional geometric morphometric (3DGM) methods were used to quantify the differences between the endocasts and compare features of interest. Larger overall endocast volumes are observed in monachines (monk seals) with the largest volume of all samples in an extant walrus. Brain volume to body length ratios indicate similar results, although with *Erignathus* and *Cystophora* having comparable brain-to-body-length ratios to monachines and otariids. The lowest endocast volume is found in *Phoca groenlandica*. *Enaliarctos*, a stem pinniped, and *Enhydra*, a sea otter, have similar overall volumes, which may be expected given their presumed similar lifestyles. The accuracy of the brain volumes extracted from the virtual endocasts compared to known volumes in the literature suggests that this method can be useful for estimating brain sizes in rare or extinct animals.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE FIRST RECORD OF *NEOCHELYS FAJUMENSIS* (PODOCNEMIDIDAE, SIDE-NECKED TURTLE) FROM THE LATE EARLY OLIGOCENE SHUMAYSI FORMATION OF WESTERN SAUDI ARABIA

AL-FADANI, Mohammad L., Saudi Geological Survey, Jeddah, Saudi Arabia; AL-NAJJAR, Mohammad I., Saudi Geological Survey, Jeddah, Saudi Arabia; BAHAMEEM, AHMAD A., Saudi Geological Survey, Jeddah, Saudi Arabia; AL-MUFARREH, Yahya S., Saudi Geological Survey, Jeddah, Saudi Arabia; ZALMOUT, Iyad S., Saudi Geological Survey, Jeddah, Saudi Arabia; GINGERICH, Philip D., University of Michigan, Ann

Arbor, MI, United States of America; WILSON, Jeffrey A., University of Michigan, Ann Arbor, MI, United States of America

The late early Oligocene terrestrial beds of the Shumaysi Formation are very well exposed along the eastern side of the Red Sea Rift in the Makkah Region of western Saudi Arabia. In recent years, these syn-rift sediments have produced a diverse assemblage of Paleogene vertebrates that show affinities with taxa from Africa, especially those of the Jabal Qatrani Formation of the Fayum Region of Egypt. A large quarry dug at the type locality of the basal ape *Saadanius hijazensis* produced other terrestrial mammals, as well as abundant reptilian remains represented by turtle shells and crocodilian vertebrae.

In 2014, a virtually complete cranium of a side-necked turtle (SGS-UM-2014-004) was excavated from the *Saadanius hijazensis* type locality quarry. The cranium is very well preserved, with all bones of the skull intact in all aspects. The skull is relatively small (length=59.2 mm, width=38.9 mm, height=13.4 mm). This new material is referable to Podocnemididae and seems to be concordant with the morphology and size of *Neochelys fajumensis*, which is only known from the early Oligocene of the Jabal Qatrani Formation of Egypt. This Shumaysi specimen and Egyptian *Neochelys* specimens share several features, including a 'W'-shaped contact between the prefrontal and frontal, and the same degree of emargination of the posterior temporal roof, and the extensive quadratojugal exposure in lateral and dorsolateral aspects.

The new Shumaysi *Neochelys* is the first record of this taxon outside Africa in a geologically younger sedimentary formation, extending both its spatial and temporal ranges.

Grant Information
Saudi Geological Survey and University of Michigan

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A POTENTIAL DINOSAUR CLUTCH FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION (GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH)

ALGER-MEYER, Evan, Denver Museum of Nature & Science, Denver, CO, United States of America; OSER, Sara E., University of Colorado, Boulder, Boulder, CO, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America; SMITH, Elliott A., Salt Lake City, UT, United States of America

Dinosaur eggs and nesting sites are well-documented from upper Campanian localities in the northern Western Interior landmass of Laramidia. However, evidence of nesting activity in the southern portion of Laramidia during this interval is represented by a limited number of localities with isolated eggshell fragments largely documented from surface weathering and screen-washing efforts, or in transported bonebed deposits. We describe here a locally concentrated accumulation of elongatoolithid eggshell fragments interpreted as a potential clutch of eggs within the Kaiparowits Formation of southern Utah. A high percentage of concave up fragments (~69%) within the assemblage and variable fragment sizes preserved in a fine-grained matrix suggest these eggshells were preserved autochthonously or parautochthonously. The substrate, a fine silty mudstone with Osteichthyes and terrestrial pulmonate gastropod remains, is consistent with a floodplain depositional environment within the fluvially-dominated Kaiparowits Formation system. This assemblage is the first reported instance of a potential dinosaur clutch from the Kaiparowits Formation and from the Campanian of southern Laramidia. Accumulations of partial eggshells like this one may represent a more typical taphonomic mode of clutch preservation in generally wetter southern Laramidian systems exemplified by the Kaiparowits Formation and may further provide an effective search image for similar future discoveries.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

TESTUDO COSTARRICENSIS*, A PURPORTED TORTOISE FROM THE OLIGO–MIOCENE OF COSTA RICA, IS *OLIGOPHERUS LATICUNEA

ALVARADO, Guillermo I., Centro de Investigaciones Geológicas, Universidad de Costa Rica, Costa Rica; LICHTIG, Asher J., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America; LUCAS, Spencer G., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America

Testudo costarricensis was described from a single, mostly complete shell purportedly found in the Oligo–Miocene of Costa Rica. However, no rocks similar to the matrix of the fossil are found in the type area, which exposes only Eocene marine sediments and Quaternary volcanics. The unusual placement of the humeral-pectoral sulcus overlying the entoplastron, claimed to be diagnostic of *T. costarricensis*, is absent in the holotype. It was actually a preservational artifact, as shown by its continuing onto the matrix. The type publication's figures included reconstruction of areas of the shell that were not preserved, and this provided additional characters that were used to support its validity. This included the purported contact of marginal six and pleural three, which is not preserved in the specimen, but was in the reconstruction. The erosion of the anteriormost edge of the plastron does not allow us to assess with confidence whether the edge was rounded or had a gular projection. Nevertheless, we see no evidence that *T. costarricenesis* and *Oligopherus laticunea* are not synonyms. The Costa Rican specimen also greatly resembles fossils of the White River Group of the U.S.A. in preservation and matrix. Thus, the Costa Rican tortoise was likely the result of a hoax, possibly perpetrated by or against Segura, who described it, possibly collected or purchased in the U.S.A. or by U.S. workers on the Atlantic or Caribbean railroad of Costa Rica. The "new" species was presented as a unique specimen from Costa Rica, and it was used in several papers for the paleogeographic reconstruction of the Americas.

Technical Session VI (Thursday, October 18, 2018, 10:45 AM)

AN ENIGMATIC TETRAPOD FROM FIVE POINTS, OHIO (UPPER CARBONIFEROUS), FURTHER SUPPORTS AISTOPOD PLACEMENT AMONG THE TETRAPOD STEM GROUP

ANDERSON, Jason S., University of Calgary, Calgary, AB, Canada; PARDO, Jason D., University of Calgary, Calgary, AB, Canada; HOLMES, Robert B., University of Alberta, Edmonton, Canada

A specimen from the newly available collection of cannel coals from Five Points, Ohio (Westphalian D, Pennsylvanian) in the collections of the Carnegie Museum, previously identified as an embolomere by the late Don Baird, is revealed to be part of the largest aïstopod skull known. The specimen had been previously prepared by removing the infilling bone and kaolinite and latex peels produced, from which specimen drawings were made. We also constructed a virtual cast of the specimen by scanning each half in a micro-CT scanner, and infilling the empty space using Amira 5.

The specimen preserves the postorbital skull roof and most of the braincase, which permits close comparison to the recently described braincases of *Lethiscus* and *Coloraderpeton*. The skull roof, in particular the articulation between the posterolateral process of the parietal and the tabular, and locality identify the specimen as belonging to the genus *Oestocephalus*. The parasphenoid closely compares with other described aïstopods by having an anteriorly restricted basal plate, which exposes the well-ossified basioccipital with notochordal occipital articulation, in ventral view. The cultriform process is narrow, non-denticulate, and sharply keeled. Two large descending flanges of the parietals wall the braincase laterally in this region laterally. An open bucohypophyseal canal may be present at the junction of the basal plate and cultriform process, although this area has several fractures making this identification tentative. Large fenestra vestibulae are seen in lateral view, above and slightly rostral to two ossifications of the basioccipital. These structures, previously described as basal tubera, are massive and appear to end in an articular facet. Considering the lack of parasphenoid contribution to these structures, we suggest these may represent the point of articulation with the first pharyngeobranchial. Supporting this identification are grooves that represent the dorsal branchial arterial passage. Collectively, these features support a recently published phylogenetic analysis that places aïstopods deep on the tetrapod stem rather than in the crown, challenging lepospondyl monophyly but resolving extended ghost lineages in early tetrapod evolution.

Grant Information
This work supported by a Natural Sciences and Engineering Research Council of Canada Discovery Grant to JSA.

Technical Session II (Wednesday, October 17, 2018, 8:30 AM)

BONE MICROSTRUCTURE OF *STENOPTERYGIUS QUADRISCISSUS* (REPTILIA, ICHTHYOSAURIA) FROM THE POSIDONIENSCHIEFER (POSIDONIA SHALE, LOWER JURASSIC) OF GERMANY

ANDERSON, Katherine L., University of Alaska Fairbanks, Fairbanks, AK, United States of America; DRUCKENMILLER, Patrick S., University of Alaska Museum, Fairbanks, AK, United States of America; ERICKSON, Gregory M., Florida State University, Tallahassee, FL, United States of America; MAXWELL, Erin, Staatliches Museum für Naturkunde, Stuttgart, Stuttgart, Germany

Ichthyosaurians (Ichthyosauria) are a major clade of secondarily aquatic marine tetrapods that occupied several major predatory niches during the Mesozoic Era. Multiple lines of evidence including isotopic, osteohistological, body shape, and swimming modality analyses suggest they exhibited elevated growth and metabolic rates, and body temperatures. However, applications of osteohistological methods to test hypotheses regarding their physiology are few. Previous studies focused on the humeri, vertebrae, and ribs from a small number of taxa. Here, we use osteohistological methods to describe the bone microstructure of over 30 cranial and post-cranial elements from a nearly complete, articulated individual of *Stenopterygius quadriscissus* from the Posidonienschiefer (Posidonia Shale, Lower Jurassic) of Germany. The specimen shows highly vascularized primary and secondary bone in its limbs, suggesting an overall shift to a lighter spongious structured skeleton was achieved through multiple developmental mechanisms. The modified perichondral ossification in elements of the limbs distal to the stylopodium informs our understanding of functional morphology, including hydrodynamic forces on the paddles. The ribs show variation in cortical thickness and degree of vascularization along their length. Cyclical growth is inferred from changes in vascularization and osteocyte density as well as the presence of annuli in primary fibrolamellar bone. Cranial elements, due to their relative density and better preservation of growth marks, may prove to be of particular importance in future skeletochronological studies of post-Triassic ichthyosaurians. We infer and corroborate hypotheses of elevated growth rates and metabolic rates in ichthyosaurians, and the potential for thermoregulation similar to extant homeothermic ectotherms.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

BRAIN CASE EXPANSION IN COMMENSAL RACCOONS

ANDERSON, Peter M., East Tennessee State University, Johnson City, TN, United States of America

Dramatic anthropogenic environmental changes present modern animals with a uniqueset of challenges. While some taxa are in steep decline, others—such as *Procyon lotor* (the common raccoon) —are plainly thriving in spite of these radical changes. Many raccoon populations live their entire lives in cities and even breed there, and have been doing so for a long enough period of time to suspect measurable adaptations. The present study sought to characterize the differences in craniodental morphology between urban and rural raccoons. Specimens from modern collections at four museums were measured for analysis. Statistically significant differences were found between the two sets. Urban raccoons tended to possess a larger brain case relative to body size. Several possible evolutionary mechanisms that might have led to this encephalization are discussed.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

STEGOSAUR PLATE FUNCTION: THERMOREGULATION VS. DISPLAY, AND A NOVEL NEW HYPOTHESIS

ANDUZA, Danny, Badlands Dinosaur Museum, Dickinson, ND, United States of America; LOMBARDO, Matthew D., Bozeman, MT, United States of America

Stegosaurs, being a charismatic group of ornithischian dinosaurs well-known for their elaborate osteoderms, have been the subject of much discussion and speculation, largely centered on the function of their dorsal plates. While explanations such as defensive armor have mostly been discounted in recent years, such proposed functions as display and thermoregulation remain in vogue to this day. We set about testing these hypotheses. In a

review of the stegosaur literature, we summarized what is known about the morphology and arrangement of dorsal plates across Stegosauria. Using digital sculpting software, we created 3D models of multiple stegosaur taxa in order to estimate and quantify the ratio between plate surface area and body volume, demonstrating that this ratio varies significantly between taxa. This, as well as the diversity of plate size and form within Stegosauria, argues against a primary thermoregulatory function for stegosaur plates. A display function, however, seems consistent with morphological evidence. For *Stegosaurus* in particular, the staggered alignment of dorsal plates is a highly unusual arrangement for paired structures in an otherwise bilaterally symmetrical animal, and its selective advantage remains mostly undiscussed. For this, we propose a novel explanation in the phenomenon known as "motion dazzle." Modern zebras (*Equus quagga*) have been suggested to employ motion dazzle, induced by their characteristic stripes, to confuse or deter predators. Through 3D modeling, we demonstrate that a staggered plate arrangement, with the appropriate coloration, is capable of producing a motion dazzle effect. We propose that this effect, used in concert with the defensive spikes of the tail, could have served as selectively advantageous visual warning against predators. This new hypothesis yields thought-provoking implications not only for the biology of stegosaurs and the function of their plates, but may also furnish insight into the evolution of novel structures throughout Dinosauria.

Technical Session XIX (Saturday, October 20, 2018, 3:00 PM)

A NEW CRYPTODONT DICYNODONT (THERAPSIDA, ANOMODONTIA) WITH A NOVEL PALATAL MORPHOLOGY FROM THE UPPER PERMIAN USILI FORMATION (RUHUHU BASIN, TANZANIA)

ANGIELCZYK, Kenneth D., Field Museum of Natural History, Chicago, IL, United States of America; OTOO, Benjamin K., University of Chicago, Chicago, IL, United States of America; BENOIT, Julien, Evolutionary Studies Institute, Johannesburg, South Africa; SIDOR, Christian A., University of Washington, Seattle, WA, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; SMITH, Roger M., Evolutionary Studies Institute, Johannesburg, South Africa; STEYER, Jean-Sebastien, Museum National d'Histoire Naturelle, Paris, France; TSUJI, Linda A., Royal Ontario Museum, Mississauga, ON, Canada

Cryptodont dicynodonts were among the most successful Permiandicynodonts, and many were characterized by byzantine facial ornamentation. Although they did not survive the Permo-Triassic extinction, cryptodonts have been reported from most major basins preserving upper Permian tetrapods (e.g., southern and eastern Africa, Scotland, European Russia, China). Recent phylogenetic analyses differ on whether Cryptodontia is a clade or paraphyletic grade at the base of Bidentalia. Here, we describe a new cryptodont from the upper Permian (Lopingian) Usili Formation of Tanzania, and use it to further investigate the potential paraphyly of Cryptodontia.

The new taxon is represented by a partial skeleton of a sub-adult; the inferred ontogenetic stage is based on its relatively small size and incompletely ossified articular surfaces of the limb elements. The skull displays a mosaic of characters found in other cryptodonts. For example, the parietals are widely exposed dorsally and the postorbitals are vertical and concave laterally, similar to geikiids, whereas the snout has a low profile resembling *Tropidostoma*. The secondary palate morphology is autapomorphic: the premaxillary palatal rim is rounded and flares anteriorly; the palatal surface of the premaxilla is gently concave with a midline groove; and anterior palatal ridges are absent. The caniniform process is bluntly rounded with a prominent longitudinal groove on its medial surface. The dentary symphysis is very broad, but its dorsal surface is damaged, obscuring the details of the triturating surface that occluded with the uniquely structured secondary palate. The anterior surface of the premaxilla bears prominent round foramina, raising the possibility of unusual facial innervation. X-ray micro-CT data reveal that the nasopalatine canal bends upwards toward the external naris, similar to the condition in *Oudenodon* and *Lystrosaurus*. Unfortunately, metallic inclusions make it impossible to ascertain whether the foramina on the snout were supplied by the nasopalatine canal, the plesiomorphic state for dicynodonts, or by the maxillary canal as in other bidentalians.

Our updated phylogenetic analysis recovers a paraphyletic Cryptodontia, with the new taxon near the base of the grade. However, this result seems to be influenced by the juvenile status of the specimen. The new taxon appears to be endemic to the Ruhuhu Basin, but lived alongside cosmopolitan cryptodonts such as *Rhachioephalus*, *Oudenodon*, and *Geikia*.

Grant Information
NSF EAR-1337569, NSF EAR-1337291, National Geographic Society CRE 7787- 05, National Geographic Society CRE 8962-11, National Geographic Society CRE 9606- 14

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

DINOSAURS OF THE NORTHERN INTERIOR MOUNTAINS OF BRITISH COLUMBIA, CANADA, INCLUDING A NEW HIGH LATITUDE LEPTOCERATOPSID

ARBOUR, Victoria, University of Toronto, Toronto, ON, Canada; EVANS, David C., Royal Ontario Museum, Toronto, ON, Canada; SIMON, Jade, University of Toronto, Toronto, ON, Canada; CULLEN, Thomas, The Field Museum, Chicago, IL, United States of America

Orogenic events in North America during the Cretaceous produced voluminous sedimentary wedges in the Western Interior Basin that have well-documented and diverse terrestrial faunas. In contrast, fossils from temporally equivalent sediments within the Cordillera are poorly known. The Sustut Group in the Northern Interior Mountains of British Columbia exposes 2000 m of Barremian through Maastrichtian-aged sediments over more than 9000 km^2; much of this rugged terrain is accessible only by helicopter, and so this vast Cretaceous terrestrial fossil record is largely unexplored. Geographically the Sustut Basin bridges vertebrate fossil localities in Alaska, Yukon, northeast British Columbia, and Alberta, and represents an important new data point for assessing Laramidian faunal provinciality, dispersal corridors between Asia and North America, and diversity dynamics during the terminal Cretaceous.

A 2017 expedition to the confluence of the Sustut River and Birdflat Creek attempted to relocate the original collection site for a partial dinosaur skeleton discovered in 1971, providing new geological context for this specimen and new vertebrate and plant fossils. Palynomorphs indicate that the site is Maastrichtian in age, equivalent to the lower Hell Creek Formation in Montana and the unconformity between the Battle and Horseshoe Canyon formations in Alberta. Originally described as an indeterminate neornithischian, the skeleton is here reinterpreted as a leptoceratopsid ceratopsian, making this the northernmost occurrence of the clade. The forelimbs are more gracile than in *Leptoceratops*, the proportions of the pedal digits suggest affinities with *Montanoceratops*, and the coracoid has a distinctive sharply pointed ventral process. Together, these features suggest the Sustut leptoceratopsid represents a new taxon. Preliminary phylogenetic analyses are consistent with our identification of the specimen as aleptoceratopsid.

Also recovered at the Sustut River site were the remains of a *Basilemys*-like turtle, the first record of the Nanhsiungchelyidae from this region and the northernmost occurrence of this clade. Finally, previously unreported fossils discovered at high altitude sites in the more northern Spatsizi Plateau during botanical and mycological collecting efforts include a tyrannosauroid tooth and large ornithischian limb bones; these currently lack geological age constraints. Overall there is great potential for future significant fossil finds in the Sustut Basin with focused prospecting efforts.

Grant Information
Funding was provided by the Natural Sciences and Engineering Research Council, the National Geographic Society, and the Dinosaur Research Institute.

Technical Session XII (Friday, October 19, 2018, 3:15 PM)

CRANIAL OSTEOLOGY AND SYSTEMATICS OF *HELAGRAS PRISCIFORMIS* AND THE EARLY EVOLUTION OF CROWN MACROSTOMATAN SNAKES.

ARMFIELD, Roxanne E., University of Cambridge, Cambridge, United Kingdom; WILLIAMSON, Thomas E., New Mexico Museum of Natural History, Albuquerque, NM, United States of America; HEAD, Jason J., University of Cambridge, Cambridge, United Kingdom

Macrostomata is the most diverse major snake clade, with taxa united by cranial specialisations that produce increased jaw mobility and gape size. Despite their modern diversity, there is no current consensus on the interrelationships within the clade, biogeographic origins or the timing and acquisition of macrostomatan characters. Cretaceous fossils have been ambiguously referred to Macrostomata, but the early history of the crown clade is mostly unknown, due primarily to a paucity of Palaeogene records that include diagnostic cranial material. *Helagras prisciformis* was first described on the basis of isolated precloacal vertebral elements from the early Palaeocene (Torrejonian) Nacimiento Formation of New Mexico. The taxon has been alternately considered a boiid, erycine, or a madstoiid snake based on vertebral morphology, but the evolutionary implications of the taxon for inferring crown Macrostomatan history have not been previously explored. Recently discovered specimens of *Helagras* include partial skulls and provide the first opportunity to resolve its interrelationships. Segmentation of microCT data reveals anatomy of the braincase, parietal, stapes, supratemporal, maxilla, vomer, pterygoid, palatine, compound bone, and dentary, as well as vertebrae and ribs. Phylogenetic analysis based on morphological datasets recovered a position stemward of Booidea within crown Macrostomata, based on skull roof morphology. Addition of a molecular scaffold recovered the first anatomical support for the molecular phylogenetic hypothesis of synonymy of Alethinophidia with Macrostomata by joining *Helagras* with *Anilius scytale* and tropidophiids, based on stapedial and palatomaxillary morphologies. Phylogenetic analysis combined with the occurrence of *Helagras* in the Palaeocene of the San Juan Basin provides the oldest unambiguous evidence for the dispersal of crown Macrostomata into Northern continents, and indicates dispersal connectivity of the Americas between the Late Cretaceous and early Palaeogene.

Grant Information
Wellcome Trust/Issac Newton Trust ISSF Joint Grant to JJH

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

LARGE MAMMAL TAXONOMIC RESPONSE TO THE EOCENE–OLIGOCENE CLIMATE TRANSITION IN NORTHWESTERN NEBRASKA

ARMIJO, Brooklyn D., University of New Mexico, Albuquerque, NM, United States of America; ABT, Wiley, University of New Mexico, Albuquerque, NM, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America

The Eocene–Oligocene sediments of northwestern Nebraska provide an exceptional record of faunal change associated with the global cooling event that occurs at the end of the Eocene and beginning of the Oligocene (the Eocene–Oligocene Climate Transition, or EOCT). To investigate the impact of the EOCT on the taxonomic composition of the large mammal fauna of the White River Group, we surface collected >2500 identifiable vertebrate specimens from four sites spanning ~500,000 years on either side of the Eocene–Oligocene boundary in and around Toadstool Geologic Park, NE. All collected specimens were identified, and a range of taphonomic data were collected from each in order to ensure that any patterns of taxonomic change were ecologically driven, rather than an artefact of preservation. In total, 1246 specimens were taxonomically identifiable, representing at least 23 different genera. Changes in species richness and evenness were examined through the study interval, as were changes in the proportional abundances of the common taxa to reveal any climate change related faunal response.

Multivariate analyses of the preserved patterns of taphonomic modification among the four assemblages showed no variation likely to bias our diversity estimates, giving us confidence that any observed differences in diversity/abundance are ecologically driven. When accounting for sample size differences, no significant changes in diversity were observed throughout the study interval, but significant changes in abundance were found for *Eumys*, *Ischyromys*, *Megalagus*, *Mesohippus*, and *Poebrotherium*. These abundance shifts were gradual throughout the studied section and not focused at or immediately after the EOCT, so it appears that they are being driven by processes other than this climate change. This argues that the environmental shift associated with the EOCT was not large enough to produce a significant response among the large White River mammals. These results provide important context for understanding organisms' response to climate change in the past, and hence studying responses to present day climate change.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

EVIDENCE FOR A SECOND LAMBEOSAUR FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION (GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH)

ARMOUR SMITH, Elliott, Denver Museum of Nature & Science, Denver, CO, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America; ALGER-MEYER, Evan, Denver Museum of Nature & Science, Denver, CO, United States of America; SARTIN, Catherine, Front Range Community College, Westminster, CO, United States of America

Lambeosaurine hadrosaurids are common components of many western North American biotic communities during the Campanian, often including members of Parasaurolophini and/or Lambeosaurini. Intensive field reconnaissance of the upper Campanian Kaiparowits Formation of southern Utah has recovered a rich dinosaur biota that includes abundant remains of the genus *Parasaurolophus*, though remains of other lambeosaurines, common in contemporaneous northern faunas, have not been documented. Two recently recovered partial skeletons display several morphologic features of their postcranial and cranial skeletons that differentiate these individuals from *Parasaurolophus*. Isolated, fragmentary cranial roof elements preserve key differences between these remains and *Parasaurolophus* including: a weakly inclined fronto-parietal platform, a weakly interdigitate fronto-parietal suture, and an absence of fusion between the prefrontal and the premaxilla. Several unique features of the ilium further differentiate these remains from *Parasaurolophus,* including: a shallow iliac body; an arcuate dorsal margin of the preacetabular process; a vertically oriented margin of the preacetabular process; and a delicate and elongate pubic peduncle. The degree of fusion of vertebrae, and the presence of a completely ossified obturator foramen, suggests a high degree of skeletal maturity and indicate that these individuals were significantly smaller than comparably mature *Parasaurolophus*. Generally, cranial roof fragments resemble *Hypacrosaurus altispinus*, in which the premaxillae and nasals are weakly fused to the fronto-parietal platform, though the Kaiparowits lambeosaur lacks the distinctly tall dorsal neural spines of *H. altispinus*. The pendant ischial foot is markedly expanded, similar to *H. altispinus* and differentiating it from *Lambeosaurus* and *Corythosaurus*. Though the absence of relatively complete cranial remains complicates a full evaluation of the taxonomic affinity of these new remains, they provide strong evidence for the presence of a previously undocumented, small-bodied lambeosaur taxon from the Kaiparowits Formation.

Technical Session VI (Thursday, October 18, 2018, 8:45 AM)

PERTURBING *HOX* GENE EXPRESSION DOMAINS PRODUCE NEW AND ANCESTRAL CRANIAL MORPHOLOGIES IN EXTANT AMPHIBIANS

ATKINS, Jade, Carleton University, Ottawa, ON, Canada; REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada; MADDIN, Hillary C., Carleton University, Ottawa, ON, Canada

The fossil record reveals the pattern of morphological transformations throughout evolution. However, understanding the underlying developmental processes that drove these transformations requires a more integrated approach. Such approaches have improved our understanding of certain transformations (e.g., fin-to-limb) and their underlying developmental processes, whereas others, such as the evolution of the skull-neck boundary in tetrapods, remain poorly understood. The skull-neck boundary is important as this boundary is key to identifying the posterior limit of the skull. It is widely accepted that the location of the skull-neck boundary seen in extant amphibians is ancestral for tetrapods and that a posterior shift of the skull-neck boundary took place in the origin of amniotes. In contrast, recent work synthesizing paleontological and developmental data yields a different hypothesis, wherein the extant amphibian condition is the product of an anterior shift in the location of the skull-neck boundary took place in that lineage. Here we aim to further understand the mechanistic basis of this transformation through the experimental manipulation of factors regulating the location of the skull-neck boundary in amphibians. The application of exogenous retinoic acid (RA) and an RA inhibiter to salamander (*Ambystoma mexicanum*) and frog (*Xenopus laevis* and *X. tropicalis*) embryos results in the translocation of the skull-neck boundary anteriorly and posteriorly, respectively. These experiments reveal a similar capacity in both salamanders and frogs to respond to changes in late-stage axial patterning. These experimental phenotypes are consistent with homeotic transformations of the skeleton leading to a change in the location of the skull-neck boundary. Additionally, we hope to also show that these phenotypical changes are accompanied by shifting expression of *Hox* genes along the anterior-posterior axis. Significantly, details of the resulting phenotypes, from skeletal, muscular and nervous tissue perspectives, mimic variation observed among living tetrapods. This suggests such homeotic transformations, and their underlying genetic basis, may have played a role in the evolution of the tetrapod skull.

Grant Information
Ontario Graduate Scholarship to Jade Atkins and NSERC Discovery Grant RGPIN-2015-04633 to Hillary Maddin

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A NEW OCCURRENCE OF A LARGE BOROPHAGINE CANID (CARNIVORA, CANIDAE) FROM THE MIDDLE MIOCENE SIXMILE CREEK FORMATION (BARSTOVIAN) OF MONTANA

ATWATER, Amy L., Museum of the Rockies, Bozeman, MT, United States of America

The subfamily Borophaginae is a diverse monophyletic group of canids that is only known from the middle to late Tertiary of North America. These bone-crushing 'dogs' are well represented in the fossil record and are frequently the most common predators in middle to late Miocene localities. Barstovian-aged vertebrate fossil localities in southwestern Montana are limited in exposure and dispersed throughout the intermontane valleys, which poses challenges in establishing reliable biochronology in the region and correlation elsewhere. The Sixmile Creek Formation of southwestern Montana contains a diverse Barstovian fauna, including the type specimen of a hypercarnivorous borophagine, *Aelurodon montanensis* (MOR 1724), as well as a complete skull and mandible of an undescribed borophagine (MOR 8673).

A character analysis of MOR 8673 suggests it may represent one of three recognized taxa: *Paratomarctus temerarius*, *Paratomarctus euthos*, or *Protepicyon raki*. It differs from *Paratomarctus temerarius* in having a moderately widened palate, unshortened lower premolars, and is larger in cranial and dental measurements. MOR 8673 differs from *Paratomarctus euthos* in having unshortened lower premolars and a ramus without a symphyseal flange. Measurements of *P. euthos* and MOR 8673 overlap. MOR 8673 differs from *Protepicyon raki* in lacking an inflated bulla and a tubular auditory meatus, and having an unexcavated masseteric fossa. The M1 paracone of MOR 8673 is subequal to the metacone, and the p4 is not disproportionally enlarged relative to the p3. MOR 8673 is smaller than *Protepicyon raki* in all measurements. MOR 8673 appears to most closely resemble *P. euthos*, and may indicate a range expansion for this species. Alternatively, MOR 8673 may represent a new taxa as some characters show similarities to other genera such as *Epicyon* or *Aelurodon*, or it may simply illustrate a greater degree of individual variation within the borophagine family than previously recognized.

While correlating the intermontane valley formations of Montana remains challenging, describing new fossils such as the borophagine MOR 8673 represents a critical step in determining local and regional biochronology. The Tertiary faunas of Montana are crucial for understanding paleogeography as the Columbia Plateau and Great Basin are situated to the west and the Great Plains to the east. New fossils from Montana continue to provide significant contributions in our understanding of the middle Miocene.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

COMPARING MORPHOMETRIC METHODS FOR QUANTIFYING SHAPE VARIATION: BEST PRACTICES FOR ARCHOSAURIAN TEETH

AVRAHAMI, Haviv M., North Carolina State University, Raleigh, NC, United States of America; ZANNO, Lindsay E., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America

Isolated teeth often constitute the majority of vertebrate remains from microvertebrate fossil localities, and are therefore ideal indicators of biodiversity. However, without associated skeletal material, taxonomic referrals can be tenuous. For example, although generally considered homodont, the dentition of some theropod dinosaurs display underappreciated morphological disparity within the tooth row. A number of studies have conducted multivariate statistical analyses, utilizing series of linear measurements, in order to discriminate between tooth morphologies for the purpose of taxonomic identifications. The traditional method of using linear measurements has proven relatively effective at parsing out tooth morphotypes; however, this approach often fails to account for a number of morphological tooth features predicted to be important indicators of similarity. For example, characteristics such as curvature, regions of convexity and concavity, cariana orientation, and other nuances of shape are usually excluded from these analyses, or may require additional calculations and arbitrary measurements that may not be homologous across all samples. In contrast, geometric morphometrics offers the ability to statistically compare the shape of teeth with more refinement, potentially improving taxonomic identifications. Unfortunately, geometric morphometric analysis of isolated teeth is challenged by the simplicity of archosaurian teeth, which yield few discrete homologous points and the often diminutive size of specimens has proven difficult to capture in 3D. We characterized the shape of 32 archosaurian (theropodan, phytosaurian, mosasaurid, mesocrocodillian) and two osteichthyan teeth using traditional linear measurements, 2D and 3D geometric morphometrics, as well as combinations of these techniques, and analysed shape data using various multivariate techniques. We compare the effectiveness of these various protocols based on accuracy (correct placement of teeth in known taxonomic groups), data discrimination (ability to reduce convex hull overlap, identify ontogenetic differences, and account for preservation quality), and time, labor, complexity, and investment required to perform. Although data collection effort is significantly higher, we find optimum accuracy and data discrimination of isolated archosaurian teeth when traditional methods are combined with geometric methods, especially when linear measurements are combined with 3D landmarks.

Grant Information
Canyonlands Natural History Association Discover Pool to LEZ 2014, 2015

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

DESMOSTYLIANS FROM THE 'TOPANGA' FORMATION OF ORANGE COUNTY, CALIFORNIA, WITH COMMENTS ON TOOTH ONTOGENY OF PALEOPARADOXIIDS

AWALT, Katrina M., California State University Fullerton, Fullerton, CA, United States of America; PARHAM, James F., California State University Fullerton, Fullerton, CA, United States of America; VELEZ-JUARBE, Jorge, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America

The 'Topanga' Formation of Orange County is an informally recognized middle Miocene marine unit with an approximate age of upper Burdigalian to lower Langhian (between 16.5–14.5 Ma). Although a diverse marine mammal assemblage has been noted, few specimens have been figured or described. We present data on desmostylians from the 'Topanga' Formation, including specimens referable to *Desmostylus* and Paleoparadoxiidae. The presence of paleoparadoxiids in this unit differentiates it from the potentially contemporaneous Round Mountain Silt of Kern County (including Sharktooth Hill, 15.9–15.2 Ma), which so far lacks reports of paleoparadoxiids. This difference in the marine mammal assemblage is further emphasized by the presence of an undescribed new species of the pinniped *Allodesmus* and two species of the earliest otariid, *Eotaria* (*E. crypta, E. citrica*), in the 'Topanga.' The paleoparadoxiid specimens include a complete right dentary of a large adult with a completely preserved set of premolars and molars (LACM 131889). Because it is the only known specimen with an erupted third molar, we interpret this specimen to be the most ontogenetically advanced paleoparadoxiid with a complete dentition yet described. In LACM 131889, the morphology of premolars posterior to the premolar diastema differs from that of the holotype of *Neoparadoxia cecilialina*. In *N. cecilialina* four premolars are present, p1 (the 'snagging tooth') and three that are posterior to a premolar diastema. In LACM 131889, just three premolars are preserved, p1 and two that are posterior to the premolar diastema. We interpret these teeth to be p3 and p4 based on the similarity to their corresponding teeth in *N. cecilialina*, implying that p2 was lost. This interpretation reconciles competing hypotheses about the identity of the first post-snagging tooth (p2 or p3) by suggesting that it depends on the ontogenetic stage of the individual. Finally, if *N. cecilialina*, *Paleoparadoxia tabatai*, and

LACM 131889 are considered to represent subsequent ontogenetic stages then we can assume that the eruption of m3 occurs after the loss of p2.
Grant Information
This work was facilitated by a National Science Foundation grant for Collections in Support of Biological Research (NSF grant #CSBR-1349430).

Technical Session XV (Saturday, October 20, 2018, 10:15 AM)

GATEWAY TO THE FOSSIL RECORD: THE SKELETAL ASSEMBLAGE OF DOÑANA NATIONAL PARK, SPAIN

BADGLEY, Catherine, University of Michigan, Ann Arbor, MI, United States of America; DOMINGO, Soledad, Doñana Biological Station, Seville, Spain; MARTÍN-PEREA, David, Doñana Biological Station, Seville, Spain; NEGRO, Juan J., Doñana Biological Station, Seville, Spain

Modern ecosystems offer critical insights about early stages in the formation of the fossil record, especially when depositional processes are prevalent. In 2017, we initiated a taphonomic monitoring program of the skeletal assemblage in Doñana National Park, a Mediterranean ecosystem in southern Spain. The park lies at the confluence of the Guadalquivir River and the Atlantic Ocean and contains the largest wetland in western Europe. Eighteen species of mammals and 25 species of birds over 1 kg in body weight reside in the park. Since the extirpation of the wolf in the 1950s, no major predators have been present in Doñana National Park. The park contains nine habitats that vary in substrate, vegetation, and hydrology; Five habitats—marsh, pond, riverbank, dunes, and beach—are active depositional environments that correspond to common sedimentary environments in the fossil record.

We established 19 transects in all nine habitats and documented all vertebrate material on the surface, noting taxonomic identity, skeletal part, bone-modification features, and degree of completeness and burial. We found nearly 2000 individual elements, dominated by five species of wild and feral ungulates, with minor presence of smaller mammals, marine vertebrates, and birds. Most specimens occurred in association with other elements from the same skeleton. Bones showed low frequencies of damage, reflecting low predation pressure. The frequency of chewed, fractured, and scattered bones was correlated with the abundance of wild boar, which is the principal mammalian scavenger. The highest abundance of skeletal remains occurred in the pond margin and the ecotone between marsh and woodland. The greatest proportion of buried bones occurred in pine wood, marsh, and riverbank. Trampled bones were notable along pond margins where feral cattle congregate during the dry season. The relative abundance of ungulate remains among habitats tracked preferred habitats and activity patterns of the living populations throughout the year. The active depositional environments contained fewer bones and carcasses than other habitats, with the exception of pond margins, which had a high concentration of skeletal remains and the highest frequency of trampled, partially buried remains. This habitat should produce the richest fossil assemblages.

The Doñana bone survey becomes another case study of taphonomic and ecological monitoring with special significance from the depositional processes throughout the area.
Grant Information
This work is supported by a Marie Curie Fellowship to Soledad Domingo.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

3D MODELING OF AN *ELEPHAS RECKI* SKELETON FROM THE PLEISTOCENE OF NORTHWESTERN SAUDI ARABIA

BAHAMEEM, Ahmad A., Saudi Geological Survey, Jeddah, Saudi Arabia; AL-NAJJAR, Mohammad I., Saudi Geological Survey, Jeddah, Saudi Arabia; AL-FADANI, Mohammad L., Saudi Geological Survey, Jeddah, Saudi Arabia; ZALMOUT, Iyad S., Saudi Geological Survey, Jeddah, Saudi Arabia; AL-MUFARREH, Yahya A., Saudi Geological Survey, Jeddah, Saudi Arabia; SOUBHI, Saleh A., Saudi Geological Survey, Jeddah, Saudi Arabia; MEMESH, Abdullah M., Saudi Geological Survey, Jeddah, Saudi Arabia; HAPTARI, Mohammed A., Saudi Geological Survey, Jeddah, Saudi Arabia; ROUNTREY, Adam N., University of Michigan, Ann Arbor, MI, United States of America; FISHER, Daniel C., University of Michigan, Ann Arbor, MI, United States of America

Excavation of Pleistocene vertebrate fossils from the Ti's al Ghadha locality, near the southwestern edge of the Nafud Desert, northwestern Saudi Arabia, has produced a partial skeleton of a proboscidean that is best attributed to a single individual. Based on dental and skeletal characters, we identify this specimen as *Elephas recki*, an extinct species of elephant that occupied East Africa, the Levant, and parts of the Arabian Peninsula during the Pliocene and Pleistocene. The remains of this individual are of great interest because of their excellent preservation and relative completeness, as the specimen now represents almost 65% of the skeleton. Material currently in hand includes the lower jaw, most of the vertebral column, most of the rib sequence (left and right), and relatively complete fore and hind limbs (left and right replicates of many elements). To document the osteology of this elephant, a nearly full-grown, adult male, we have used a laser scanning digitizer (Artec Space Spider) to capture surface data for 85 essentially complete bones, more than ten times the number of models we have reported on previously. These models (saved as *.PLY files) are now being assembled to form an articulated 3D skeleton. Missing contralateral elements will be generated by reflecting models of existing elements. Missing axial elements represent more of a problem, but we intend to develop provisional models by scaling elements from different individuals (and if necessary, different taxa). The pelvis and cranium are the most conspicuous cases that may require such treatment. In parallel, we intend to return to the original locality and extend our excavation in a further effort to recover these elements for this individual. For dissemination of our results, we will make both individual bone models and our articulated skeleton available on the University of Michigan UMORF website, where they can be conveniently manipulated, viewed, and even measured in a custom viewer. Following publication of our work, downloading of model data will also be supported. The goal of our study is to use this individual as an osteological reference, permitting us to accomplish refined identification of conspecific material from other localities in the region. This will be critical for detailed taphonomic analyses, in which instances of post-mortem bone modification are compared against data on original morphology. Refined characterization of osteology may also help address some of the systematic issues involving this taxon, assigned by some workers to the genus *Palaeoloxodon*.
Grant Information
Saudi Geological Survey and University of Michigan

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

BIOSTRATIGRAPHY AND DIVERSITY OF PALEOGENE PERISSODACTYLS FROM THE ERLIAN BASIN OF INNER MONGOLIA, CHINA

BAI, Bin, IVPP, Chinese Academy of Sciences, Beijing, China; WANG, Yuan-Qing, Beijing, China; LI, Qian, Beijing, China; MENG, Jin, American Museum of Natural History, New York, NY, United States of America

Extant perissodactyls (horses, rhinos, and tapirs) compose a small portion of living mammals; however, perissodactyl fossils have a great diversity and commonly dominate faunas during the Paleogene. But the components and distribution of Paleogene perissodactyls in China remain controversial and unclear, which further hampers their correlation with those from other localities and continents. Here we clarify the temporal and spatial distribution of Paleogene perissodactyls at species-level from the Erlian Basin based on all published specimens, archives, and our recent fieldwork. The strata of the Erlian Basin range are nearly continuous from the late Paleocene to early Oligocene, and almost all of the Eocene Asian Land Mammal Ages (ALMA) were based on the corresponding faunas from the Erlian Basin. Mainly based on the biostratigraphy of perissodactyls and lithostratigraphy, we revised the correlation of the deposits at Erden Obo (=Urtyn Obo), the most important and complete section in the Erlian Basin, with other type formations/faunas in the basin. Further, the middle Eocene Arshantan, Irdinmanhan, restricted Sharamurunian, and restricted Ulangochuian ALMAs can be roughly correlated to North American Bridgerian, early and middle Uintan (Ui1-2), late Uintan (Ui3), and Duchesnean, respectively, mainly based on closely related perissodactyl fossils from both continents. The fauna from the Baron Sog Formation is correlative to late Eocene Ergilian and North American Chadronian. Finally, the general decrease of perissodactyl diversity from middle Eocene to late Eocene is probably attributed to a general cooling trend of global climatic change. The diversity of perissodactyls prominently declined during the Eocene–Oligocene Transition, when the temperature considerably dropped.
Grant Information
National Natural Science Foundation of China (No. 41672014, 41572021) and Youth Innovation Promotion Association CAS

Technical Session VII (Thursday, October 18, 2018, 3:30 PM)

A NEW SPECIMEN OF ENANTIORNITHINE FROM THE LOWER CRETACEOUS XIAGOU FORMATION WITH PRESERVATION OF AN UNUSUAL MINERALIZED TISSUE

BAILLEUL, Alida, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; O'CONNOR, Jingmai, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; YOU, Hailu, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; LI, Daqing, Gansu Geological Museum, Lanzhou, China; ZHOU, Zhonghe, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

The Changma locality of the Lower Cretaceous Xiagou Formation in Gansu Province, northwestern China, is largely dominated by specimens referable to the derived non-ornithurine ornithuromorph *Gansus yummenensis*. In the present study, we report on the seventh enantiornithine described from this locality (after *Feitianius*, *Qiliania*, *Dunhuangia*, and three indeterminate enantiornithines). The new specimen (GSGM-06-CM-012), consisting of the articulated remains of the caudal half of the skeleton (part of the vertebral column, pelvic girdle and limbs), is distinct from previously described taxa. In addition to contributing to the growing number of enantiornithines uncovered from this important locality, the new specimen also preserves a large, thin sheet of unusual mineralized tissue not observed in any other of the dozens of specimens collected from this locality, or any of the thousands of collected Jehol birds. The mineralization, located in the abdominal region, extends from the second preserved thoracic vertebrae to roughly the level of the pubis, ending cranial to the pygostyle and appearing to be entirely contained within the limits of the body. Interpretation as the sternum can be ruled out based on size and the absence of sternal features (e.g., no coracoidal sulci, caudal trabeculae, or keel). We investigated the microstructure of this unusual mineralization through a battery of analyses including micro-computed tomography, standard paleohistological methods, newly developed histochemical techniques, and Energy Dispersive Spectrometer (EDS). Preliminary results indicate it is composed of roughly four thin layers separated from each other by irregular borders, with an averaged total thickness of 300μm. Their arrangement suggests that this structure was three-dimensional and consisted of two layers *in vivo* that collapsed on themselves post-mortem. These layers are vitrous, avascular, acellular (although a few dark, round structures can be identified and may potentially represent some type of cell lacunae), and possess a few mineral inclusions. This histology differs from that of bone and cartilage, the two most abundant mineralized skeletal tissues of vertebrates, suggesting it might be the remnant of soft-tissues that were secondarily mineralized post-mortem. This interesting specimen has the potential to shed light on unusual modes of soft-tissue preservation in the Changma locality, and in well-preserved Cretaceous birds in general.
Grant Information
Chinese Academy of Sciences; National Natural Science Foundation of China (Grant No. 41688103)

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

FEEDING, AND THE FORM-FUNCTION-BEHAVIOR RELATIONSHIP IN RAPTORS

BAINES, Alec E., University of South Florida, Tampa, FL, United States of America; SELLES DE LUCAS, Victor, University of Hull, Hull, United Kingdom; COBB, Samuel N., University of York, York, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom; BRIGHT, Jen, University of South Florida, Tampa, FL, United States of America

Raptorial birds are polyphyletic, with the diurnal raptors formed primarily by two non-sister families: the Accipitridae (the larger group, including hawks, eagles, kites, and Old World vultures), and the Falconidae (including falcons and caracaras). Abundant examples of dietary convergence may be recognized between these families, yet the relationship between morphology and diet in raptor skulls has recently been shown to be relatively weak. Part of the reason for this may be due to observable differences in feeding behavior between the two families. Although representatives from both groups capture prey with their talons, accipitrids kill by squeezing with the talons, whereas falcons deliver a killing bite with the beak (and have correspondingly higher bite forces). Despite similarities in the birds' ecologies, these differences in behavior and associated performance criteria may be reflected in shape differences in the feeding apparatus. We tested the functional performance of the feeding apparatus in equal-sized representatives from both families, the Eurasian sparrowhawk (*Accipiter nisus*) and the common kestrel (*Falco tinnunculus*) using 3D finite element analysis derived from computed tomography. When scaled to an equivalent bite force/surface area, we found that stresses between the two families were similar, despite the falcon's broader, shorter beak. This suggests that the morphological differences between the two birds are likely a result of the falcon's need to accommodate a greater muscle volume to achieve its higher bite force, rather than the falcon being optimized for relatively better stress resistance. This has two paleontological implications: firstly, that while it is generally recommended that paleontological finite element models without well-known and validated input parameters should be scaled to only compare relative performance, workers must keep in mind that this practice may obscure biological relevant variables. Secondly, we recommend that those inferring predatory behavior in extinct birds must take care to consider arguments based not only on form, but also on explicitly measured performance metrics, and with as much consideration of the behavior of close extant relatives as is possible.
Grant Information
BBSRC Grants BB/I011668/1 and BB/I011714/1

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

AGE AND GROWTH OF *PACHYRHIZODUS CANINUS* (TELEOSTEI, CROSSOGNATHIFORMES) FROM THE LATE CRETACEOUS WESTERN INTERIOR SEAWAY

BAIR, Mark A., Columbus State University, Columbus, GA, United States of America; NEWBREY, Michael G., Columbus State University, Columbus, GA, United States of America; MARTIN-ABAD, Hugo J., Universidad Autonoma de Madrid, Madrid, Spain; MAISEY, John, American Museum of Natural History, New York, NY, United States of America

Despite *Pachyrhizodus caninus* being the largest crossognathiform and one of the larger teleosts within the Western Interior Seaway, very little is known about its development and growth. In this study, growth cessation marks recorded within the vertebral centra are used to calculate the age and estimate the growth rate of two taxa, *Pachyrhizodus caninus* (12 specimens) and the elopiform *Megalops atlanticus* (39 specimens). *Megalops atlanticus* was selected as an extant standard of comparison because it is likely the closest living relative of *Pachyrhizodus*. The growth curve of *Pachyrhizodus* shows linear growth up to age 17, the age of the oldest available specimen. In contrast, the growth curve of *Megalops* is linear only up to age 12, after which growth begins to slow. Although both taxa present a similar growth rate, *Pachyrhizodus* specimens continue growing at the same rate after *Megalops* growth has slowed. With these data in consideration, the large size of *Pachyrhizodus* in comparison to related taxa such as *Megalops* could be attributed to longevity and a prolonged stable growth period, rather than rapid growth.

Romer Prize Session (Thursday, October 18, 2018, 11:00 AM)

CLIMATE AS MODULATOR OF THE MACROEVOLUTIONARY RATCHET: DIVERSIFICATION AND TURNOVER IN NORTH AMERICAN FOSSIL CANIDS

BALISI, Mairin, University of California, Los Angeles, Los Angeles, CA, United States of America

How traits influence species outcomes is a fundamental question in ecology and evolution. Specifically, the trait combination of large body size and hypercarnivory has received much attention; carnivory is costly, and the appearance of large-bodied hypercarnivores in a lineage is linked to an irreversible 'macroevolutionary ratchet' by which species march to their inevitable demise. While modern ecosystems harbor few large hypercarnivores, this specialization repeatedly marks the fossil record, permitting exploration of how it may correlate with extinction in a world before human effects.

Here, I track diversification in North American fossil dogs (Canidae), a family of over 130 species spanning a range of ecomorphologies including iterative occurrences of large-bodied hypercarnivory. Because broad resource use may enable species to weather disturbance over long timescales, canids of average size and mesocarnivory might exhibit longer durations than specialized larger or smaller species. Accounting for varying preservation through time, I recover a non-linear relationship between species duration and carnivory: species at either end of the carnivory spectrum tend to have shorter durations than mesocarnivores. Over 40 million years, however, extinction victims and survivors are similar in size and diet—except at the end-Pleistocene (10 ka), when all extinct canids were large and hypercarnivorous—suggesting that large-bodied hypercarnivory little elevates extinction risk. Per-subfamily extinction rates increase and longevities decrease starting approximately at the origination of each subfamily's first large hypercarnivore, but diversification rates largely overlap across size and carnivory.

How do we reconcile the apparent contradiction between reduced durations and overlapping rates for large hypercarnivores and other canids? When diversification rates are analyzed alongside climate as an alternative hypothesis for canid patterns, negative relationships emerge between large-hypercarnivore extinction rate and both temperature and atmospheric CO_2, and between subfamily diversification rates and temperature. Environment has long been considered secondary to competition to explain divergence among carnivores, whose high trophic position might insulate them from climatic effects. These results suggest that environment, likely mediated by predator-prey dynamics, interacted significantly with the 'macroevolutionary ratchet' to shape the diversification trajectory of carnivorous mammals.
Grant Information
American Museum of Natural History Theodore Roosevelt Memorial Grant, National Science Foundation Doctoral Dissertation Improvement Grant DEB-1501931

Podium Symposium (Wednesday, October 17, 2018, 9:15 AM)

TRIASSIC TERRESTRIAL VERTEBRATE COMMUNITY STRUCTURE AND THE EMERGENCE OF MEGAFAUNAL-DOMINATED COMMUNITIES

BALK, Meghan A., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; LYONS, S. Kathleen, Lincoln, NE, United States of America; CARRANO, Matthew T., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America

Changes in community structure affect ecosystem functioning. Research is beginning to focus on the consequences to ecosystem functioning after the late Quaternary megafaunal (i.e., over 44 Kg) extinction in terrestrial mammals, especially in light of current anthropogenic climate change. However, it is still not well understood how communities in megafauna-dominated systems form in general or how their structure might shift as the identity of the largest member changes. Here, I use a deep-time, assemblage perspective to ask how community structure changes: (1) as the taxonomic identity of the largest member changes; and (2) across different environments? Specifically, I focus on the emergence of megafaunal-dominated communities in the Triassic Period. Beginning with a data set of non-marine tetrapods derived from the Paleobiology Database, I filtered for the lowest available stratigraphic resolution (typically member) and minimum community size (18 distinct taxa) to generate a final data set of 18 communities. To this data, I added estimates of body size based on available osteological data, using mean generic values for specimens only identifiable at this level and approximate modern analogues where no usable data were available. Finally, all taxa were assigned to broad ecological groups (herbivore or carnivore). Using this data, I quantified the moments of each community's body size distributions and tested for similarity between distributions using Kolmogorov-Smirnov Wilcoxon Signed-Rank tests. These data show that body size distributions remained markedly similar across the Triassic, regardless of differences in environment or taxonomic composition. Triassic communities show mostly normal body size distributions. This has interesting differences to modern mammal community body size distributions, and it seems likely that different life-history strategies between mammals and reptiles explain this shift. More generally, these tools can be used to further explore community structure over time and space.
Grant Information
Meghan A. Balk is supported by the Peter Buck Postdoctoral Fellowship.

Technical Session IV (Wednesday, October 17, 2018, 2:15 PM)

LARGE-SCALE SPATIAL BETA DIVERSITY PATTERNS IN THE UPPER CAMPANIAN (LATE CRETACEOUS) DINOSAUR PARK FORMATION OF WESTERN CANADA

BAMFORTH, Emily L., Royal Saskatchewan Museum, Eastend, SK, Canada; GILBERT, Meagan, University of Saskatchewan, Saskatoon, SK, Canada

Understanding paleobiodiversity patterns is of critical importance in discerning the drivers of evolution, diversification, and extinction that have shaped life on Earth. Spatial beta ('among-site') diversity analyses elucidate patterns that exist among coeval biological communities across geographical regions, and are often difficult to study in the fossil record. The Campanian-aged Dinosaur Park Formation (DPF) is one of the most productive dinosaur-bearing units in the world. The formation has been well-studied in Alberta, Canada, where temporal beta diversity patterns are well documented. However, given the restricted geographical size of the Albertan DPF outcrops, spatial beta diversity is far less well understood. Saskatchewan, the province to the east, contains Canada's most northeastern exposures of DPF, although these are rarer and less well studied than Alberta's. Herein, we describe the first large-scale spatial beta diversity analysis of DPF paleocommunities across the two provinces, a spatial scale of ~400 km. Three well-sampled DPF microvertebrate sites from Saskatchewan, and five coeval sites from Alberta, were included in this preliminary study. In these occurrence-based diversity analyses, each microvertebrate assemblage represents a single paleocommunity ('point'). Non-metric multidimensional scaling was used to ordinate the points, which were then transposed onto a spatial (geographical) plane. Weighted minimum spanning networks were plotted to better identify patterns. The results were unexpected. Although paleocommunities in the two provinces contain many of the same taxa, there was strong intra-provincial clustering among points, with notable interprovincial dissimilarity. Similar results were found using Principal Coordinate Analysis and nearest-neighbor cluster analysis. These results imply a high degree of provinciality in DPF paleocommunities, based on geographical location. Saskatchewan was closer than Alberta to the coastline of the Western Interior Sea. The DPF stratigraphic record in this province demonstrates a prevalence of estuarine environments with frequent marine inundations. Marine influence may therefore have been a major driver of this spatial heterogeneity. Future research, including increasing the sample size from Saskatchewan, will help to elucidate why east–west spatial heterogeneity exists in the DPF, and may identify which groups or guilds are most affected by it and why.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

THE FEMMES OF STEM: AN INTERSECTIONAL, INTERDISCIPLINARY PODCAST AND WEB RESOURCE EXPLORING THE HISTORY OF WOMEN IN SCIENCE

BARBOZA, Michelle University of Florida, Gainesville, FL, United States of America

The Femmes of STEM project was created to combat the false narrative that women and minorities are newcomers to the world of science, technology, engineering, and mathematics (STEM) by presenting research that shows we have always been a part of the past—the problem is that simply that we have not always been a part of history.

Research in the fields of women's studies, the philosophy of science, science and technology studies, and the history of science provide background to this issue, but most remains trapped behind paywalls and generally inaccessible to the public. The Femmes of

STEM pairs peer-reviewed publications with popular science writings, historical archives, and personal narratives to produce an intersectional, interdisciplinary web based project. Key to the project is the establishment of two open access, searchable databases featuring entries of historical women in all STEM fields and important dates in STEM history showcasing women and minorities. Beyond presenting data, the Femmes of STEM project also produces weekly blog posts and biweekly podcast episodes featuring biographies, open access resources, and guest articles from fellow scientists and scholars thinking about the intersection of feminism, history, and science.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

CARBON ISOTOPE ANALYSIS OF MAMMALIAN HERBIVORE TEETH FROM A 10-MILLION-YEAR TIME SPAN IN FLORIDA INCLUDING THE MID MIOCENE CLIMATIC OPTIMUM

BARBOZA, Michelle, University of Florida, GAINESVILLE, FL, United States of America

Analysis of carbon and oxygen isotopes from fossil teeth is well established as a proxy for understanding paleodiet, paleoecology, and paleoclimate. This study examines over 150 unique specimens of terrestrial herbivores from Florida in a ten-million-year time span covering the Mid Miocene Climatic Optimum (MMCO), a global climate event that is well established by deep sea oxygen isotope records, but lacking interpretation based terrestrial isotope records. Specimens have been analyzed from seven faunas from Florida, ranging from late early Miocene (Hemingfordian) through middle Miocene (Clarendonian) age, or about 18 Ma to 9.5 Ma. Two well-studied Florida fossil localities anchor the study on either end—the Thomas Farm locality at 18 Ma and the Love Site at 9.5 Ma. The span of this study allows for a view of terrestrial ecology in a state preceding the warming, during the warming, and in response to the warming. Preliminary results show a mean of less than a 2‰ change in either carbon or oxygen isotopes from the sites throughout this period, but the data do follow a trend indicating a warming event. The carbon isotope composition of herbivore teeth are used as a proxy for understanding the plant life ecosystems of middle Miocene Florida. Given that the majority of data reflect $\delta^{13}C$ values of well below -8‰, this supports evidence of a purely C_3 diet for terrestrial herbivores. The oxygen data reflect a more complex combination of signals, including temperature, aridity, and local meteoric water, which will be explored further. In summary, the study reveals evidence for the impact of the MMCO on land and provides new isotope data for the paleoecology and climate of the southeastern U.S.

Grant Information
Funding by the National Science Foundation (1115210, 1547229) in support of the Integrated Digitized Biodiversity Collections (iDigBio) project at the University of Florida

Podium Symposium (Friday, October 19, 2018, 9:30 AM)

BEST PRACTICES FOR CAPTURING AND ANALYZING HIGH DIMENSIONAL SHAPE DATA: AN AMPHIBIAN CASE STUDY

BARDUA, Carla, Natural History Museum, London, United Kingdom; FELICE, Ryan N., Natural History Museum, London, United Kingdom; WATANABE, Akinobu, New York Institute of Technology, New York City, NY, United States of America; GOSWAMI, Anjali, Natural History Museum, London, United Kingdom

Recent advances in scanning technology have created an explosion of high dimensional digital data, offering high resolution visualisations of the anatomy of both fossil and extant organisms. These have the potential to transform our understanding of morphological evolution across the vertebrate tree of life. However, methods to compare diversity have struggled to fully utilise this data. The use of sliding and surface semilandmarks to complement anatomical landmarks offers a potential solution, sampling morphology over entire surfaces. 'Big data' does however impose analytical constraints. To alleviate these, anatomical structures can be partitioned into modules (strongly correlating groups of traits). Modules reflect developmental and genetic interactions between traits, allowing us to assess how development influences morphological evolution. We can analyse modules individually, increasing statistical power and revealing localised evolutionary rates, disparity, and influences on morphology.

We have collected CT and laser scans of ca. 2000 tetrapod species, sampling all major clades and a range of 330 million years. Our study of cranial morphology across all 33 genera of Gymnophiona (Amphibia) illustrates our approach for comparing disparate morphologies. We defined 16 cranial regions using 53 anatomical landmarks and 343 sliding semi-landmarks, followed by a semi-automated placement of 729 surface semi-landmarks across the regions. Our shape data were iteratively subsampled down to 10% and models of modularity were assessed using a Maximum Likelihood approach ('EMMLi' R package).

We found highest support for a ten-module model, with the skull more integrated posteriorly. Phylogeny had a greater influence anteriorly, whilst allometry influenced more posterior modules. The quadrate and occipital modules were the only modules without strong phylogenetic signal ($K_{mult} = 0.58, 0.66, p > 0.05$), but exhibited the highest allometric constraints ($R^2 = 0.24, 0.37, p < 0.001$), and two of the three strongest influences of fossoriality ($R^2 = 0.19, 0.17, p < 0.01$). However, whilst the quadrate was the most disparate module, the occipital was the least, revealing variable morphological responses to these influences. Evolutionary rate varied across the modules, with the quadrate evolving the fastest ($\sigma^2_{mult} = 34.6$ or 8). Our study allowed a detailed investigation of localised morphological influences across the caecilian skull, and demonstrates the potential of this method to quantify and compare morphology across disparate clades.

Grant Information
ERC grant STG-2014-637171

Technical Session IV (Wednesday, October 17, 2018, 2:30 PM)

NON-AVIAN DINOSAURS WERE NOT IN TERMINAL DECLINE DURING THE EARLY LATE CRETACEOUS

BARRETT, Paul M., Natural History Museum, London, United Kingdom; BONSOR, Joseph A., Imperial College London, London, United Kingdom; COOPER, Natalie, Natural History Museum, London, United Kingdom

The tempo and mode of non-avian dinosaur extinction remains contentious, and several different interpretations of this event have been proposed. These scenarios are all based on the same basic data sets, but differ primarily in the methods applied to investigate this phenomenon. Nevertheless, a broad consensus had been reached with respect to the timing of this extinction, with many studies converging on a relatively rapid demise. By contrast, a recent analysis of speciation/extinction rates using phylogenetic generalized linear mixed models (GLMMs) within a Bayesian framework proposed that non-avian dinosaurs were in decline well before the K-Pg boundary, with their terminal decline commencing during the early Late Cretaceous. To test this hypothesis, we reassessed speciation/extinction events using a published dinosaur supertree containing 420 taxa (time-scaled according to the midpoint time of each terminal stratigraphic range) and examined speciation/extinction rates under three GLMMs, implemented in the R package 'MCMCglmm': a null model, a 'speciation slowdown' model, and a 'slowdown to asymptote' model. Best model fits were determined by calculating the Deviance Information Criterion (DIC) value. In the majority of cases (6 of 8 models have a DIC difference greater than 4 units favoring the 'slowdown to asymptote' model), our results indicate that although dinosaur evolutionary rates reached asymptotes prior to the K-Pg boundary (0–17 Ma in advance depending on the method used) the proposed early Late Cretaceous decline was not supported. This is consistent with the high levels of taxonomic diversity observed in many late occurring dinosaur communities and other results deduced from sampling based techniques, such as rarefaction. Our results caution against making broad evolutionary generalizations when fitting large sets of complex models that display a diversity of results.

Grant Information
NHM Earth & Life Sciences Departmental Investment Funds

Technical Session IX (Friday, October 19, 2018, 10:15 AM)

WHAT (IF ANYTHING) IS A BARBOUROFELID? RE-EVALUATING THE NUMBER OF CARNIVORAN SABERTOOTH LINEAGES WITH TOTAL-EVIDENCE BAYESIAN TECHNIQUES

BARRETT, Paul Z., University of Oregon, Eugene, OR, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America

A total of five mammalian lineages have explored sabertooth craniodental adaptations (i.e., elongated and compressed canine teeth, and increased gape of the lower jaw). These mammalian sabertooth groups span marsupials, "creodonts," and crown group placental carnivorans. Some of the most extreme sabertooth adaptations are found within the carnivoran family Barbourofelidae, currently classified as an independent case of sabertooth acquisition relative to the Nimravidae (Eocene to Oligocene 'false sabertooth cats') and machairodontine felids (true sabertooth cats such as *Smilodon*). However, the evolutionary origins of the Barbourofelidae have been uncertain for more than 170 years. Here we present a novel approach to assessing the phylogenetic placement of barbourofelids (and the validity of three independent sabertooth clades within Carnivora) by examining the relationships of all major stem and crown families across Carnivoramorpha. We implemented a total-evidence Bayesian analysis, using the fossilized birth-death (FBD) model, incorporating morphological data (231 characters), nuclear and mitochondrial molecular data (37 genes), and stratigraphic occurrence data. We performed our analysis in Beast2, employing tip-dating and cranial/postcranial partitions for morphological data, while designating gene partitions and site models as determined by PartitionFinder2 for molecular data. Our results place barbourofelids as terminal members of the Hoplophoneini within the Nimravidae, a hypothesis contrary to prior analyses, which recovered barbourofelids as a separate subfamily of the Nimravidae or a unique family with a non-sabertooth carnivoran ancestor within the Feliformia. This relationship is strongly supported via both topology metrics and number of synapomorphies (0.97 posterior probability, 6 synapomorphies). Furthermore, machairodontine felids were recovered as a monophyletic group, sister to extant felids, while the entirety of the Nimravidae (inclusive of barbourofelids) was recovered as a stem member of the Feliformia, a result counter to analyses of the past six years, which placed them as the sister clade to the crown group Carnivora. These results display the potential for total-evidence analyses to inform on the evolutionary history of complex groups (inclusive of extant and fossil taxa), while bringing together molecular and morphology- based data sets that have traditionally been analyzed separately.

Grant Information
This work was supported by NSF grant (DEB-1256897).

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

EQUUS*: WHERE IS THE GENUS? PHYLOGENETIC ASSESSMENT OF *HARINGTONHIPPUS FRANCISCI* (PERISSODACTYLA, EQUIDAE) AND OTHER HORSES TRADITIONALLY ASSIGNED TO *EQUUS

BARRON-ORTIZ, Christina I., Royal Alberta Museum, Edmonton, AB, Canada; JASS, Christopher N., Royal Alberta Museum, Edmonton, AB, Canada; BRAVO-CUEVAS, Victor M., Universidad Autonoma del Estado de Hidalgo, Pachuca, Mexico

A recent molecular and morphometric study concluded that *Equus francisci*, a Pleistocene equid characterized by slender metapodials, falls outside of the crown group of *Equus*. As a result, a new genus, *Haringtonhippus*, was proposed for this taxon. The two lineages were estimated to have diverged during the late Hemphillian or earliest Blancan. However, the taxonomic sampling of that study did not take into consideration Hemphillian and Blancan taxa that were referred to *Equus* in previous phylogenetic studies (e.g., *Equus (Plesippus) simplicidens* and *"Dinohippus" mexicanus*). In our study, we examined and scored character data from the holotype and paratypes of *Haringtonhippus francisci*. We also evaluated specimens of *Equus ferus*, as representatives of the crown group, and *Equus conversidens*, a Pleistocene equid thought to be closely related to *Haringtonhippus francisci*. For specimens of these three species, we evaluated 34 cranial, dental, and postcranial characters and combined those data with a previous study that investigated 15 taxa of the tribe Equini of Clarendonian to Blancan age, including species of *Pliohippus*, *Astrohippus*, *Dinohippus*, and *Equus*. We analyzed the data using maximum likelihood phylogenetic methods. The analysis identified *"Dinohippus" mexicanus* as sister taxon to the *Equus* plus *Haringtonhippus* clade (79% bootstrap), a result consistent with previous phylogenetic studies. Within this clade, *Equus (Plesippus) simplicidens* was recognized as the most basal member (74% bootstrap). *Haringtonhippus francisci* and *Equus*

conversidens were identified by the analysis as the sister group of *Equus ferus*, with bootstrap values of 78%. Based on these results, we recognize two alternative scenarios for the taxonomy of *Equus*: 1) *Haringtonhippus* is recognized as a junior synonym of *Equus*; or 2) *Haringtonhippus* is regarded as a distinct genus, and then *Equus (Plesippus) simplicidens* and *Equus conversidens* should each receive a different generic name: *Plesippus* could be given generic rank and *Equus conversidens* assigned to a new genus or to *Haringtonhippus*.

Technical Session I (Wednesday, October 17, 2018, 9:45 AM)

OSTEOHISTOLOGY REVEALS INDIVIDUAL VARIATION IN GROWTH AMONG A LARGE SAMPLE OF THE TRIASSIC THEROPOD DINOSAUR *COELOPHYSIS BAURI* FROM GHOST RANCH, NEW MEXICO

BARTA, Daniel E., American Museum of Natural History, New York, NY, United States of America

Metabolic changes often characterize major evolutionary transitions, such as the evolution of endothermy among the ancestors of mammals and birds. A high degree of developmental plasticity (variation in size for a given age) within a population, traditionally considered a hallmark of growth in ectotherms, was subsequently hypothesized to be decoupled from growth and metabolic rates, especially at early stages of evolutionary transitions to endothermy. However, these hypotheses are difficult to test for extinct taxa. Fortunately, bonebeds provide a rare opportunity to assess growth and variation in fossil populations of taxa occupying key phylogenetic positions.

Since the discovery of the *Coelophysis* bonebed at Ghost Ranch, New Mexico, its numerous articulated specimens of *Coelophysis bauri* have proved important to studies of early dinosaurs. However, the bone histology of these specimens has not yet been broadly sampled nor their absolute ontogenetic ages thoroughly assessed.

To test whether a high degree of individual variation in bone histology and growth patterns is present among Ghost Ranch *C. bauri*, I thin sectioned 17 tibiae and 12 corresponding fibulae of these specimens near their midshafts. Collectively, these specimens span the predominant size range of individuals in the bonebed.

All examined *C. bauri* tibiae exhibit woven to parallel-fibered bone matrix with abundant longitudinal to reticular vascular canals. Where observable, fibula growth mark counts mostly agree with those of the tibiae. Growth marks are frequently expressed as annuli rather than lines of arrested growth, though both types are present. Assuming all growth marks were deposited annually, the sampled individuals range from less than one year to at least three years of age. No specimens exhibit an external fundamental system, suggesting that none had reached skeletal maturity. Therefore, the body size, morphology, and longevity of skeletally mature *C. bauri* likely remain unknown. Data supporting developmental variability in *C. bauri* include substantial variance in tibia circumferences within each age class, despite a broadly positive correlation with age. Additionally, a decrease in vascularity towards the periosteal surface in specimens of varying ages indicates that growth was slowing at different ages in different individuals. In exhibiting relatively rapid growth in conjunction with a moderate degree of developmental plasticity, *Coelophysis* provides further evidence of a decoupling of growth rate and growth canalization among early dinosaurs.

Grant Information
NSF DDIG #DEB-1601315, Geological Society of America Student Research Grant, Richard Gilder Graduate School Fellowship, AMNH Division of Paleontology

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

NEUROCRANIAL ANATOMY OF THE EARLY PERMIAN REPTILIOMORPH *SEYMOURIA*

BAZZANA, Kayla D., University of Toronto at Mississauga, Mississauga, ON, Canada; GEE, Bryan, University of Toronto at Mississauga, Mississauga, ON, Canada; REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada

Seymouriamorphs are a group of reptiliomorphs known from Permian localities throughout Laurasia, including the unique early Permian karst deposits of Richards Spur, Oklahoma, and are considered to be relatives of amniotes. The external cranial anatomy of *Seymouria* has been extensively studied, but there is very little known regarding the structures of the internal braincase, otic capsule, or cranial nerves. Here, we report on two partial skulls of *Seymouria* from Richards Spur, a juvenile and a subadult, with preservation of critical parts of the braincases, including the stapes. Analysis of these specimens through neutron tomography provides a unique opportunity for detailed reconstruction of the internal anatomy of *Seymouria*. This improves the characterization of less well-studied structures and more broadly offers insights regarding current interpretations of neurocranial evolution among stem amniotes.

Analysis of the tomographic data reveals the presence of an ossification of the synotic tectum (the supraoccipital bone of amniotes) underneath the postparietal bone and a single, ventrally keeled sphenethmoid positioned above a concave cultriform process, features which are typically seen in amniotes. However, other parts of the braincase are very unusual in that the laterally extending parasphenoid, together with the opisthotic and the prootic, forms an otic tube that positions a large fenestra ovalis far laterally, near the otic notch. The space between the large fenestra ovalis and the otic notch is spanned by a small, delicate stapes. The stapes lacks a distinct footplate, and its medial terminus is much smaller in cross-sectional profile than the fenestra ovalis. In addition, the tomographic data reveal the presence of a prominent dorsal process of the stapes that may have contacted a flange on the prootic. All of these features suggest that the hearing system seen in *Seymouria* may have evolved independently from other tetrapods, and its configuration also suggests that it may have evolved an impedance matching system for terrestrial audition.

Grant Information
This research is supported by a NSERC Canada Graduate Scholarship-Master's.

Technical Session XI (Friday, October 19, 2018, 1:45 PM)

BIOGEOGRAPHIC IMPLICATIONS OF AN INSULAR CLADE OF GONDWANAN METATHERIANS FROM THE EOCENE PONTIDE TERRANE, NORTH-CENTRAL ANATOLIA

BEARD, K. Christopher, University of Kansas, Lawrence, KS, United States of America; METAIS, Gregoire, Muséum National d'Histoire Naturelle, Paris, France

The middle Eocene Uzunçarsidere Formation (UCF.) in the Orhaniye Basin of north-central Turkey was deposited in a retroarc foreland basin created by collisional tectonics between the Pontide terrane and Gondwanan microcontinents to the south. Fossil mammals documented previously from the UCF. comprise a unique assemblage of Laurasian and Gondwanan taxa, including multiple species of the pleuraspidotheriid "condylarth" *Hilalia*, one or more palaeoamasiid embrithopods, a herpetotheriid metatherian, an omomyid primate, a palaeochiropterygid bat, and the phylogenetically enigmatic metatherian *Anatoliadelphys maasae*. Notably absent from the UCF. mammal fauna are multiple placental mammal clades (including Rodentia, Perissodactyla, Carnivora, Creodonta, and Artiodactyla) that are otherwise ubiquitous across Laurasia by the middle Eocene. Available geological and paleontological data indicate that the Pontide terrane was a Tethyan island during the Eocene, which explains the extreme degree of endemism shown by its mammalian fauna.

Fieldwork during 2017 yielded multiple specimens of a new metatherian taxon, which becomes the third metatherian documented to date from the UCF. The new metatherian is intermediate in size between the previously known herpetotheriid and *Anatoliadelphys maasae*. It shares multiple dental synapomorphies with *Anatoliadelphys*, including bunodont lower molars with weakly cuspidate entoconids that become progressively exodaenodont posteriorly, a hypertrophied protoconid on M_4, and upper molars with narrow stylar shelves on which StB and StD are enlarged and closely approximated with the paracone and metacone, respectively. Phylogenetic analysis indicates that *Anatoliadelphys* and the new Turkish metatherian are sister taxa that are nested within basal polydolopimorphians, an otherwise Gondwanan clade known from Peru, Argentina, and Australia. We hypothesize that this insular clade of Anatolian polydolopimorphians colonized the Pontide terrane by rafting across Tethys during the early or middle Eocene from Africa, even though polydolopimorphians have not yet been documented from the African Paleogene.

Grant Information
Funded by INSU-2011 CT4 Interrvie, Action Transversale Muséum (2012), National Geographic Society (grants 9215-12 & W296-13), and National Science Foundation EAR-1543684

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

NEW TECHNOLOGY APPROACHES FOR HIGH RESOLUTION X-RAY COMPUTED TOMOGRAPHY STUDIES OF BIOLOGICAL AND PALEONTOLOGICAL SPECIMENS

BEERLINK, Andre, YXLON International GmbH, Hamburg, Germany; STEINER, Dirk, YXLON International - COMET Technologies U.S.A., Inc., Hudson, OH, United States of America

X-ray computed tomography (CT) goes light years beyond regular 2-D X-ray technology to deliver accurate three-dimensional images of scanned objects, including their inner morphology and areas of differing density. It has become one of the most important and powerful non-destructive testing (NDT) methods—an achievement resulting from the continuous improvement of CT scanning and reconstruction methods, the enabling of increased precision and specimen resolution, the access to higher power and consequently higher scanning speed, and finally innovative concepts allowing for highest user friendliness to simplify the execution of successful CT experiments with high quality results.

The study of biological and paleontological specimens by using modern x-ray CT provides us with a wealth of information about life on earth. However, these fragile samples are often incomplete due to erosion and it becomes hard to extract all the specimen has to offer, as conventional methods are often destructive, costly, and time-consuming. But now, through the power of high resolution micro computed tomography, getting a holistic look into the past, present, and future of life sciences has never been easier.

We will present representative application examples that show how modern digital x-ray CT inspection systems help to render any sample from small to large scale in 3D offering highest detail visibility on the micron scale, making it possible to develop models and fill in the biotic blanks to bring each specimen to life. In times where the digitization of the huge natural history museum collections all over the world is of highest priority, x-ray CT has become an extremely valuable tool in the preservation of these precious life science specimens for the future.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

TAXONOMIC AND PHYLOGENETIC IMPLICATIONS OF THE LOWER MOLAR STRUCTURAL ORGANIZATION OF THE MIOCENE APE *RUDAPITHECUS HUNGARICUS*

BEGUN, David R., University of Toronto, Toronto, ON, Canada; [illegible] Institute of Human Origins, Tempe, AZ, United States of America; [illegible], Université Toulouse III - Paul Sabatier, Toulouse, France

We used non-invasive X-ray tomographic imaging to characterize the lower molar structural signature of the [illegible] ape *Rudapithecus*. We compared these results with those of fossil apes from Miocene apes (*Dryopithecus* and *Ouranopithecus*) from Eurasia and Asian Miocene *Sivapithecus*, and with extant hominids. We assessed the [illegible] proportions through indices such as the percent of crown dentine area (PCDA), average and relative enamel thickness (3D AET and 3D RET), and explored the enamel thickness distribution patterns (rendered by chromatic scale cartographies). In addition, besides the virtual exploration of the dentine morphology, we performed geometric morphometric analyses of the enamel-dentine junction (EDJ).

Withdrawn

Rudapithecus Vcdp/Vc is lower than in *Dryopithecus* and extant African apes, and closer to *Pongo* and *Sivapithecus*. The 3D AET and 3D RET values of the *Rudapithecus* m1s and m2s are low, similar to *Dryopithecus* and *Pan*, while the other taxa have thicker enamel. The geometric morphometric analysis discriminates the extant hominids. The Miocene apes all plot close to each other and overlap with *Pongo*. When extant apes are excluded, *Rudapithecus* overlaps with *Dryopithecus* and *Ouranopithecus*, all of which are discriminated from *Sivapithecus*.
Rudapithecus has moderately thick enamel similar to *Pongo*, thicker than in *Dryopithecus* and extant African apes, but thinner than in *Ouranopithecus* and extant humans. The diversity in enamel thickness does not have a clear phylogenetic signal. The geometric morphometric analysis shows that the Miocene apes overlap with *Pongo* but not extant hominines. This suggests that *Pongo* retains primitive features in its EDJ shape, whereas African apes are derived in having higher cusps and *Homo* is derived in cuspal pattern. Among Miocene apes alone, all the European taxa plot close to each other and are discriminated from the Asian ape *Sivapithecus*. This suggests closer phylogenetic affinities among *Rudapithecus*, *Dryopithecus,* and *Ouranopithecus* (purported hominines) than with *Sivapithecus* (pongine.) Additionally, of the two specimens of *Rudapithecus* included, RUD 14 plots closest to *Ouranopithecus* and closer to *Dryopithecus* than to RUD 212. The differences between the Rudabánya specimens are greater than the difference between *Rudapithecus* and *Dryopithecus*. This is consistent with previous observations of differences in size and morphology and suggests that more than one ape taxon may be present at Rudabánya.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

INTERPRETING BONE MODIFICATION PROCESSES AND AGENTS: AN INTRODUCTION TO THE SMITHSONIAN'S NATIONAL TAPHONOMY REFERENCE COLLECTION

BEHRENSMEYER, Anna K., Smithsonian Institution, Washington, DC, United States of America; HUTSON, Jarod M., Smithsonian Institution, Washington, DC, United States of America; GIFFORD-GONZALEZ, Diane, University of California, Santa Cruz, Santa Cruz, CA, United States of America; HAYNES, Gary, University of Nevada, Reno, NV, United States of America; LITTLE, Holly, Smithsonian Institution, Washington, DC, United States of America; MILLHOUSE, Amanda, Smithsonian Institution, National Museum of Natural History, Washington, DC, United States of America

Taphonomy is essential for understanding biological, physical, and chemical processes that control the "transition of organic remains" from death to burial to fossilization. Interpreting causes of bone accumulations and the processes involved in preservation can be difficult because different processes may leave similar evidence. For example, tooth marks, trampling scratches, and human inflicted cutmarks can have similar features, and distinguishing them is an ongoing challenge in paleoanthropology. The same applies to patterns of weathering, breakage, dissolution, and abrasion, all of which can be hard to assign to particular agents or processes. Just as taxonomic identifications need comparative osteological collections, taphonomic interpretations need well-documented reference collections that link specific bone modification features to known processes and ecological contexts. Experimental specimens bearing direct evidence of taphonomic cause and effect as well as specimens that record the signatures of particular agents and processes of biotic and abiotic bone modification should be the "backbone" of such a comparative collection. The newly established National Taphonomy Reference Collection (NTRC) at the National Museum of Natural History, Smithsonian Institution consists of modern and fossil vertebrate specimens that document a wide range of bone modification processes. The collections include naturally occurring and experimental modern bones (macro and micro) collected by Behrensmeyer and colleagues in modern African ecosystems and North American fluvial systems as well as fossils representing different types of preservation from various depositional contexts and ages in East Africa and North American. A recent addition consists of ~5,000 modern specimens assembled by Gifford-Gonzalez and Haynes from decades of experimental, ethno-archaeological, and landscape-scale taphonomic research. The NTRC specimen catalogue, along with supporting field notes and photographs, will be available via a searchable online database on the Smithsonian Institution's Department of Paleobiology collections website. The NTRC provides paleontologists, paleoanthropologists, zooarcheologists, and forensics specialists with a comparative resource for interpreting the taphonomy of fossil and modern bones. It is the first global taphonomy repository and is designed to grow with future additions of modern and fossil bones that document known or inferred taphonomic processes.

Grant Information
National Science Foundation Collections Grant 1145777 to Gifford-Gonzalez and Haynes

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

ESTIMATING THE STATISTICAL ERROR OF OBSERVED BIOSTRATIGRAPHIC RANGES WITHIN ADAMANIAN-REVUELTIAN VERTEBRATE ASSEMBLAGES OF THE LATE TRIASSIC CHINLE FORMATION OF ARIZONA TO TEST FOR AN ABRUPT TURNOVER EVENT

BEIGHTOL V, Charles V., University of Washington, Seattle, WA, United States of America; PARKER, William, Petrified Forest National Park, Petrified Forest National Park, AZ, United States of America; MARTZ, Jeffrey W., Houston, TX, United States of America; MARSH, Adam D., Petrified Forest National Park, Petrified Forest National Park, AZ, United States of America

Upper Triassic deposits of the Chinle Formation have been heavily collected for vertebrate fossils over the past century, yielding numerous specimens from diverse terrestrial ecosystems. These deposits preserve temnospondyls, dicynodonts, sphenodontians, and an array of archosauromorphs, especially pseudosuchians and rare avemetatarsalians. Two locations primary for recovering these tetrapods in northeastern Arizona are the *Placerias* Quarry and Petrified Forest National Park (PEFO). Recent detailed stratigraphic data from PEFO place the boundary between the Adamanian and Revueltian estimated holochronozones, defined by the first appearance of pseudopalatine phytosaurs, within the middle of the Sonsela Member. This level is demarcated by a red silicified organic marker bed termed the 'persistent red silcrete,' which presently approximates the Adamanian–Revueltian boundary. Detailed biostratigraphic work suggests that the observed stratigraphic ranges of many Adamanian taxa end before this datum, including non-pseudopalatine leptosuchomorph phytosaurs, desmatosuchine aetosaurs, non-shuvosaurid poposaurs, and dicynodonts. It has been postulated that these disappearances represent a synchronous local extinction event. The range terminations are not simultaneous given the observed data, but the ranges have not been statistically validated based on sample size. Here we use a non-parametric method of stratigraphic range estimations to determine error at the 50%–95% confidence levels. Several taxa such as dicynodonts, trilophosaurs, and desmatosuchine aetosaurs have observed stratigraphic ranges confined to the Adamanian, but low sample sizes extend potential ranges into the Revueltian. Although no pseudopalatine phytosaurs have been found below the persistent red silcrete, our results suggest a potential range extension below this horizon, which would decouple the base of the Revueltian from the silcrete. Some taxa with ranges that span the Adamanian and Revueltian boundary are the aetosaurs *Typothorax coccinarum* and *Paratypothorax*, the archosauromorph *Vancleavea campi*, the pseudosuchian *Revueltosaurus callenderi*, shuvosaurid poposaurs, and theropod dinosaurs. Detrital U–Pb zircon data bound the persistent red silcrete to be near contemporaneous with increasing aridity and the Manicouagan impact event (215 Ma), but an exact causal mechanism of the faunal turnover is still elusive. Given resultant confidence intervals, a synchronous extinction for Adamanian taxa is possible but cannot be verified.

Technical Session X (Friday, October 19, 2018, 9:00 AM)

REVISED AGE AND PALAEOECOLOGY OF THE DINOSAUR-BEARING GRIMAN CREEK FORMATION AT LIGHTNING RIDGE, NSW, AUSTRALIA

BELL, Phil, University of New England, Armidale, Australia; FANTI, Federico, Alma Mater Studiorum - Università di Bologna, Bologna, Italy; HART, Lachlan, University of New England, Armidale, Australia; MILAN, Luke, University of New England, Armidale, Australia; CRAVEN, Stephen, Macquarie University, North Ryde, Australia; BROUGHAM, Tom, University of New England, Armidale, Australia; SMITH, Elizabeth, Australian Opal Centre, Lightning Ridge, Australia

Terrestrial vertebrates are poorly known from the Australian Cretaceous, limited to only a handful of formations continent wide. The Griman Creek Formation (GCF.), which crops out in north-central New South Wales near the town of Lightning Ridge, is noteworthy for the unusual opalized preservation of its fauna as well as being the only dinosaur-bearing terrestrial unit in the state. New U-Pb age dating of detrital zircons extracted from a layer of distal volcanic ashfall, immediately overlying the main fossil-bearing layer revise the maximum depositional age to early- to mid-Cenomanian, rather than late Albian as was previously thought. The new date provides a reliable context for the GCF. fauna for the first time, placing it temporally within the fossiliferous portion of the Winton Formation in central Queensland. More specifically, the Lightning Ridge exposures of the GCF. sit between (with some very minor overlap) the older Albian (Isisford and Longreach sites) and younger Cenomanian to Turonian (Lark Quarry, Bladensburg, and Eromanga) sites within the Winton Formation. These new constraints also permit more meaningful comparisons between the GCF. and Winton faunas. A review of the GCF. vertebrate fauna exposes a diversity of dipnoans, chelid and possible meiolaniform turtles, leptocleidid-like and possible elasmosaurid plesiosaurians, anhanguerian pterosaurs, titanosauriform sauropods, megaraptoran theropods, ankylosaurians, iguanodontians, crocodylomorphs, and rare elements of aspidorhynchid teleosts, lamniform chondrychthians, enantiornithine birds, stem and true monotremes, and a possible indeterminate synapsid, making it one of the most diverse mid-Cretaceous terrestrial vertebrate faunas in Australia.

Grant Information
Australian Research Council Discovery Early Career Researcher Award (project ID: DE170101325)

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE POSTCRANIAL ANATOMY OF *GORGONOPS TORVUS* (SYNAPSIDA, GORGONOPSIA) FROM THE LATE PERMIAN OF SOUTH AFRICA

BENDEL, Eva-Maria, Museum fur Naturkunde Berlin, Berlin, Germany; KAMMERER, Christian F., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; FRÖBISCH, Jörg, Museum für Naturkunde, Berlin, Germany

Gorgonopsia is one of the most iconic clades of synapsids (the mammalian lineage of amniotes) and includes the top predators of the late Permian. It is yet amongst the most obscure: even more than a hundred years after the establishment of the group, only little research has been done on the palaeobiology of this group. Although some recent descriptions of cranial material have been published to establish the ground work for taxonomic work, the postcranium of gorgonopsians remained mostly understudied. In this study, we are delivering the first thorough comparative investigation of the postcranial anatomy of *Gorgonops torvus* based on SAM-PK-K10591, housed at the Iziko South African Museum in Cape Town. Gorgonopsians are characterized by a notoriously conservative anatomical bauplan. This has been assumed for their crania for the most part of the last century until a few studies recently have hinted otherwise. This very subtle but nevertheless present variation in South African gorgonopsians is confirmed for the postcranial morphology as well, supported by our insights on postcranial specializations of SAM-PK-K10591 compared with other gorgonopsian specimens. This is mirrored for instance in a range of different grades of robustness of appendicular bones as well as diverse morphologies of pectoral and pelvic features. The almost complete and articulated medium-sized skeleton of SAM-PK-K10591 shows typical specializations (i.e., strong forelimbs and more gracile hind limbs, adaptations for a quick pounce towards prey) to a predatory lifestyle, similar to more distantly related sabre-toothed taxa such as the extinct metatherian *Thylacosmilus*. In addition, however, our analysis of SAM-PK-K10591 reveals distinct autapomorphies of this taxon, including two posterior grooves on the medial side of the ilium as well as the first account of a pristine and complex multi-part sternum.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

THE EURASIAN *EQUUS* DATUM AND EARLY EVOLUTION OF THE GENUS IN EURASIA

BERNOR, Raymond L., Howard University, Washington, DC, United States of America; CIRILLI, Omar, University of Florence, Florence, Italy; JUKAR, Advait M., Smithsonian Institution, Fairfax, VA, United States of America; POTTS, Richard, Smithsonian Institution, Washington, DC, United States of America; ROOK, Lorenzo, University of Florence, Florence, Italy; SUN, Boyang, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; WANG, Shi-Qi, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

The *Equus* Datum has been traditionally viewed as a single immigration event of a North American *Equus* species into Eurasia at the base of the Pleistocene (2.58 Ma.) This hypothesis has yet to be rigorously tested taxonomically within a geochronologically well resolved context. Toward a better understanding of the taxonomic content of the Old World *Equus* Datum, and evolutionary diversification following the datum, we have undertaken the current review. We have recognized a very large *Equus*, *E. livenzovensis* together with *E. stenonis* near the *Equus* Datum in the Italian record. *Equus stehlini* appears soon thereafter in Italy. It is not until 1.6 Ma that a new, smaller *Equus*, *E. altidens* occurs in Italy. In the Indian Subcontinent, *Equus sivalensis* is first seen at ~2.58 Ma and co-occurs with a smaller species of *Equus* later in the early Pleistocene. In China, the early Pleistocene has a robust sample of a large *Equus*, *E. eisenmannae* from Longdan, Linixia Basin occurring unchanged from 2.55 to 1.8 Ma. *Equus sanmeniensis* is another common large early Pleistocene species from China. *Equus qingyangensis* and *E. teilhardi* are two smaller *Equus* species from Qingyang, Gansu. *Equus qingyangensis* is particularly remarkable for its elongate slender limbs. Our current understanding is that *E. sanmeniensis, E. teilhardi,* and *E. qingyangensis* overlapped in their age range in China and are correlative with the Nihowanian mammal age. *Equus yunnanensis* has been reported from Burma and is similar in its morphology to *E. teilhardi.* Remarkable is the similarity between *E. qingyangensis* and *E. simplicidens* from the 3.3 Ma Hagerman, Idaho quarry and, in turn, their dissimilarity with Italian Villafranchian *E. stenonis.* It has been further proposed that Chinese *E. sanmeniensis* and *E. stenonis* are plausibly descendants of Chinese *E. eisenmannae. Equus* first appears later in East Africa with the earliest occurrence being the Omo Shungura Member G, 2.2 Ma. *Equus* is rare in the East African record until Olduvai Bed I, ca. 1.8 Ma, where *E. oldowayensis* has been identified. Here, using cranial, dental, and postcranial elements, we compare and contrast the morphologies between these different early Pleistocene Old World lineages of *Equus.* We aim to understand the taxonomic content of the Old World *Equus* Datum, whether it was likely a single taxon event or multiple taxa emigrated from North America. Ultimately, we would like to discover the origin of modern *Equus* lineages across Eurasia and Africa.

Technical Session III (Wednesday, October 17, 2018, 1:45 PM)

MARINE MAMMAL FEEDING DIVERSITY THROUGH TIME

BERTA, Annalisa, San Diego State Univ, San Diego, CA, United States of America; LANZETTI, Agnese, San Diego State Univ, San Diego, CA, United States of America

Key ecologic (e.g., competition, predator-prey changes), productivity (diatom diversity), and climatic (e.g., ^{18}O, ^{13}C) factors have driven patterns of marine mammal diversity through time. In this study, we investigated feeding diversity using fossil marine mammal temporal distributions derived from the Paleobiology Database. We divided feeding strategies of marine mammals into four categories: biting, suction, filter, and grazing and considered habitat (e.g., pelagic, coastal, riverine), prey types (e.g., squid, fish, benthic invertebrates, zooplankton, tetrapods, sea grasses), and tooth pattern and cusp shape (e.g., homodont, heterodont, pointed, rounded, filter, or edentulous). These variables were then related to various marine mammal clades and their changes through time examined.

In agreement with earlier reports, updated generic counts reveal that the greatest diversity of pinnipedimorphs, cetaceans, desmostylians, and sirenians occurred during the middle Miocene following the Mid-Miocene Climatic Optimum. During the late Oligocene, the earliest whales employed a biting strategy feeding on fish, whereas the earliest sirenians grazed on sea grasses. Suction feeding of benthic invertebrates was the principal prey capture strategy in the late Oligocene for cetaceans and Pliocene for pinnipedimorphs. Bulk filter feeding in mysticetes became dominant beginning in the early Miocene. Sea otters arose during the late Pliocene feeding on hard-shelled benthic invertebrates, thereby filling a niche occupied during the late Miocene by the aquatic bear *Kolponomos*. Examination of climate variables indicates that pinnipedimorphs are only correlated with diatom diversity (productivity), while cetaceans are correlated with diatom diversity and ^{18}O (temperature). Sirenians and desmostylians are correlated with neither ocean temperature nor productivity. Evidence for ecologic replacement among herbivores is indicated by disappearance of desmostylians after the Messinian coinciding with the appearance of the sirenian *Hydrodamalis* lineage in the North Pacific. Convergent evolution of herbivory in aquatic sloths was limited to the South Pacific during the late Miocene through Pliocene. Combined, these results show that many factors likely influenced marine mammal feeding diversity patterns in the past and a historical framework enables analysis of present day trophic structure and predictions of future changes in marine ecosystems.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

"BONE HUNTERS": THE HISTORY OF WOMEN IN VERTEBRATE PALEONTOLOGY BOOK PROJECT

BERTA, Annalisa, San Diego State University, San Diego, CA, United States of America; TURNER, Susan, Queensland Museum, Brisbane, Queensland, Australia

Women have been pioneers in vertebrate paleontology from Mary Anning in the early 19th century to the present day, with an increasing presence in the last 50 years. We celebrate women vertebrate paleontologists all over the world and delve into their lives and work examining how the lure of our discipline has spread and shaped our understanding of the history of life on Earth. Gaining professional employment came slowly, with few women recognized before the late nineteenth to early twentieth century, but over time the fossil discoveries and scientific contributions of women scientists paved the way for later generations to pursue careers in paleontology. Our principal aims are to develop a definitive list of women in VP, both past and present, and to create a history that highlights the important roles and the challenges they have overcome to gain degrees and employment, as well as attain leadership positions in professional societies and international research projects.

We launched a Go Fund Me project (www.gofundme.com/women-in-vp-videographer-at-svp) that will enable us to videotape interviews of a cross-section of SVP members at the Albuquerque meeting to provide diverse perspectives of their experiences. Now more than 700 women strong (and counting!), our on-line database of Women in Vertebrate Paleontology (see Research Gate project www.researchgate.net) is available for review, revision and updates. We need your help in our search for the names, photos, and contributions of women VPers that have collected, taught, or pursued research in our discipline. To provide a framework for collecting and evaluating diversity data going forward, in our poster and forthcoming book, we review long-term gender trends, identify strategies that are working, and highlight additional actions needed to ensure diversity and inclusion, thus broadening the reach of SVP and our science.

Grant Information

We are grateful to Go Fund Me donors for our video session.

Technical Session XVIII (Saturday, October 20, 2018, 1:45 PM)

ENDOCRANIAL SHAPE VARIATION WITHIN THE SQUIRREL-RELATED CLADE AND THEIR FOSSIL RELATIVES USING 3D GEOMETRIC MORPHOMETRICS: CONTRIBUTIONS OF LOCOMOTION AND PHYLOGENY TO BRAIN SHAPE

BERTRAND, Ornella C., University of Toronto, Scarborough, Toronto, ON, Canada; SILCOX, Mary T., University of Toronto, Scarborough, Toronto, ON, Canada

Three-dimensional geometric morphometrics has been used by paleontologists to examine the relationship between skeletal elements and variables such as phylogeny and ecology. These methods have rarely been employed to understand the possible association between these variables and endocranial shape. Endocasts are the imprint of the brain against the inner part of the cranium and are the best proxy for investigating brain shape and size in fossil mammals. The goal of this study is to examine the endocranial morphology of the squirrel-related clade by using three-dimensional geometric morphometrics. This clade is taxonomically and ecologically diverse, and includes tree squirrels, the mountain beaver, and dormice. Virtual endocasts for Ischyromyidae, a primitive group of rodents likely to be related to the squirrel-related clade, were also included. A total of 30 landmarks were taken on 32 extant and fossil specimens.

The results show that endocranial shape and size are significantly correlated in this sample in that smaller endocasts are wider laterally than larger endocasts. The principal component analysis (PCA) reveals that endocranial shape is clearly distinct for Sciuridae, Aplodontidae, Gliridae, and Ischyromyidae. Endocranial shape variation is associated with changes in the development of the neocortex, cerebellum (including the paraflocculi), and olfactory bulbs. The K*mult* test shows that endocranial shape reflects phylogenetic relationships among the four families and within Sciuridae. In the PCA analysis, flying squirrels show the most distinct endocranial morphology among squirrels, overlapping the least with other tribes and subfamilies. This result suggests that gliding may have imposed specific constraints on cranial shape and indirectly on endocranial shape. The endocasts of fossil and modern fossorial Aplodontidae have a similar shape to those of Ischyromyidae. This finding could be the result of convergence related to fossorial specializations in later occurring Aplodontidae, as previously hypothesized. In an example of mosaic evolution, extant Sciurini retain primitive cranio-dental and postcranial features but are distinct in endocranial shape from the early Sciurini *Protosciurus*. From the data gathered, phylogeny and locomotion both have an impact on endocranial shape in our rodent sample.

Grant Information

NSERC Discovery Grant to MTS and support from the Office of Vice Principal/Dean, University of Toronto, Scarborough to MTS

Romer Prize Session (Thursday, October 18, 2018, 8:45 AM)

DIETARY ECOLOGY OF PTEROSAURS USING QUANTITATIVE 3D TEXTURAL ANALYSIS OF TOOTH MICROWEAR

BESTWICK, Jordan, University of Leicester, Leicester, United Kingdom

Pterosaurs were integral components of Mesozoic terrestrial and coastal ecosystems, yet their feeding ecology remains poorly constrained. Postulated pterosaur diets include insectivory, piscivory, carnivory, and frugivory, but many dietary hypotheses are little more than speculation based on scant evidence and untestable analogies. We have developed a more robust approach based on quantitative analysis of the micron-scale 3D textures of worn pterosaur tooth surfaces—dental microwear textural analysis—never before applied to pterosaurs. Microwear, produced as scratches and chips generated by food items, creates characteristic surface textures on teeth that vary according to diet. These textures can be quantified using International Organization for Standardization roughness parameters to determine if surface textures significantly differ between taxa from different dietary guilds. This technique therefore provides direct evidence of the nature of what has been consumed, and analysis does not rely on assumptions of a close relationship between the morphology and inferred functions of teeth.

Dietary analysis was based on microwear from non-occlusal tooth surfaces of 13 species of pterosaur. This was compared with data from extant taxa with known diets (bats, monitor lizards and crocodilians, including insectivores, piscivores, carnivores, and omnivores). The first axis of a Principal Component Analysis (PCA) of 14 texture parameters which significantly differed between extant taxa explained 70.9% of the variation in surface textures and negatively correlated with the percentage of vertebrates in the diet ($p=-0.2798$, $p=0.0367$). It positively correlated with the percentage of invertebrates in the diet ($p=-0.469$, $p=0.0003$) and degree of dietary generalism ($p=0.2982$, $p= 0.0256$). Projecting pterosaur microwear texture data into this multivariate space allows robust inference of respective diet. Microwear from *Dimorphodon* for example, previously hypothesised as a piscivore, indicates a diet of vertebrates and invertebrates. Microwear from *Darwinopterus*, disputed as a carnivore or a piscivore, instead provides evidence of insectivory. Dietary analysis from microwear provides new evidence and novel insights into the ecological roles of pterosaurs and pterosaur dietary evolution.

Grant Information
Funded by NERC studentship through the Central England NERC Training Alliance [reference 1642701] and Palaeontological Association Sylvester-Bradley Award PA-SB201701.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

EVOLUTION OF EARLY EUPRIMATE LOCOMOTOR AGILITY AND HEARING SENSITIVITY: INSIGHTS FROM THE INNER EAR OF *CANTIUS* SP. (BIGHORN BASIN, WYOMING, EARLY EOCENE, WASATCHIAN NALMA)

BHAGAT, Raj, University of Toronto Scarborough, Scarborough, ON, Canada; SILCOX, Mary T., University of Toronto Scarborough, Scarborough, ON, Canada

Measurements of aspects of the inner ear are informative about agility level (i.e., jerkiness of movement) and hearing sensitivity. Animals with larger semicircular canals (SCCs) relative to body mass have faster, jerkier locomotion compared to animals with smaller SCCs. Dimensions of the cochlea and oval window correlate with low- and high-frequency hearing sensitivities, respectively. In this study, agility and hearing sensitivities are reconstructed from the inner ear of the adapoid primate *Cantius* sp. based on DMNS EVP 124767 from the early Eocene (Wa5) of the Bighorn Basin, Wyoming. DMNS EVP 124767 comprises associated dental and neurocranial fragments including the right ear; lateral and posterior SCCs as well as the cochlea are preserved and were segmented from microCT data using Avizo 9.0.1.

The only previously studied specimen of the genus, pertaining to *Cantius nuniensis*, yielded an agility score of 2.9 (slow-medium slow), in the range of European *Adapis*. The North American notharctids *Smilodectes* and *Notharctus*, which have been reconstructed as having exhibited better developed leaping adaptations than *Cantius*, have relatively higher scores, in the medium slow-medium range. DMNS EVP 124767 has an agility score of 3.1 (slow-medium slow), which is in line with the reconstruction of *Cantius nuniensis.* This supports previous speculations that the genus had lesser propensities for leaping than other notharctids. However, it is surprising considering the postcrania of the genus show some adaptations for leaping, a relatively agile locomotor mode. Existing data on hearing sensitivities mostly come from the European *Adapis* while previous data for notharctids are limited to the low-frequency thresholds. The hearing sensitivities for DMNS EVP 124767 are reconstructed as 38.8 dB for low-frequency sounds (250 Hz) and 25.2 dB for high-frequency sounds (32 kHz). This provides the first reconstruction of high-frequency hearing sensitivity for notharctids. Overall, the reconstructions are in the range of other adapoids, including high-frequency sensitivity. These data support the idea that with the evolution of early euprimates, low-frequency hearing sensitivity increased while high-frequency hearing-sensitivity decreased relative to stem primates. In sum, these reconstructions provide additional context to the ecology and evolution of early euprimates.

Grant Information
Supported by an NSERC Discovery Grant to MTS

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

SKULL ONTOGENY IN DINOSAURS AND OTHER ARCHOSAURS DIVERGES FROM THE ANCESTRAL REPTILIAN GROUND PLAN AND BEARS SIGNATURES OF BOTH EARLY REPATTERNING AND TERMINAL ADDITION.

BHULLAR, Bhart-Anjan S., Yale University, New Haven, CT, United States of America

The heads of living birds and crocodiles could, in many ways, not be more different. Avian skulls are lightweight and thin-boned, adapted to contain organs modified for flight and maintenance of the highest metabolisms in the animal world. Crocodylian skulls are heavy and thick, able to withstand great forces and shaped to facilitate amphibious ambush predation. Both skull types derive from the ancestral archosaurian condition, which is similar to neither in adulthood. Here I use new CT data from a range of taxa from ancestral reptiles to modern archosaurs, including ontogenetic series of nonavian dinosaurs, in order to trace the evolutionary and ontogenetic trajectories of the archosaurian skull. The archosaurian skull is tall and narrow, featuring an expanded gape and elaboration of the paranasal sinuses, as well as rearrangement of the jaw adductor musculature. Early stem crocodiles show a trend toward increased thickness of cranial bones, which continues into the crown. Stem birds, including nonavian dinosaurs, demonstrate the opposite tendency—toward lightening of the cranium. The overall shape of the embryonic archosaurian head is remarkably similar to that of early archosauromorphs. This suggests that derived archosaurian characters were added to the later part of ontogeny, a process sometimes known as terminal addition. Facial bones, including the premaxilla and maxilla, show crocodile-specific and bird-specific features, including modifications to fenestration, upon ossification, indicating that many facial changes owe to early patterning alterations instead of terminal addition. The skull roof, however, goes through a stereotyped series of alterations, and the most notable features of calvarial development stem from peramorphosis in extant crocodiles and paedomorphosis along the stem of birds. In general, many crocodylian-specific features are added late in ontogeny, after ossification or chondrification, which suggests terminal addition. Bird-specific features are in many cases present from the beginning of ossification, which suggests earlier repatterning.

Grant Information
Funded by Yale University and the Yale Peabody Museum of Natural History

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PALEOENVIRONMENT OF THE SOUTHERN EXTENT OF THE LATE CRETACEOUS WESTERN INTERIOR SEAWAY: EVIDENCE FROM STABLE OXYGEN ISOTOPE ANALYSES OF THE INOCERAMID *PLATYCERAMIS PLATINUS*

BIASATTI, Dana M., University of Notre Dame, Notre Dame, IN, United States of America; MONTGOMERY, Homer, University of Texas at Dallas, Richardson, TX, United States of America

Bulk and serial oxygen isotope compositions of the inoceramid bivalve *Platyceramis platinus* were determined to examine the paleoecology of this extinct taxon and to evaluate regional seasonality and paleoclimate in the southern extent of the Late Cretaceous Western Interior Seaway (WIS). Proxy paleoenvironmental examination of the WIS is important for the understanding of marine vertebrate evolution in this region. The specimens were collected in the Big Bend region of Texas, from the uppermost Boquillas Formation San Vicente member (late Coniacian), which is a 132 m thick limestone, chalk, and marl sequence that was deposited in a outer shelf environment at the confluence of the Late Cretaceous WIS and Tethys ocean. X-ray fluorescence (XRF) and Fourier-transform infrared spectroscopic (FTIR) analyses of the specimens and O-isotope analysis of the surrounding matrix support good preservation of the original shell material. Serial $\partial^{18}O$ values of the shells range from -3.0 to -5.6 ‰, with a mean delta value of -3.6 ‰, suggesting a shallow marine environment with freshwater influence. Contributions of meteoric water from precipitation/continental runoff is supported by the sedimentology of the collection locality. However, planktonic forams and radiolarians are present while benthic forams are absent from the sequence, suggesting either a deep ocean or dysaerobic bottom waters, or both. Because inoceramids and planktonic microfossils are known from benthic sedimentary sequences deposited under low oxygen conditions, it is possible that this was a shallow dysaerobic shelfenvironment. Temperature reconstructions range from 13.0 to 24.4°C, with a mean annual temperature of 15.4°C, which is consistent with previous proxy studies of the WIS at similar latitudes. Seasonal variations in $\partial^{18}O$ values and temperature reflect evaporation/precipitation dynamics at the ocean surface and indicate increased freshwater input during warming events.

Technical Session V (Thursday, October 18, 2018, 10:45 AM)

A MULTIPROXY APPROACH TO TRACKING ARIDITY ACROSS AUSTRALIAN LANDSCAPES USING BRUSHTAIL POSSUMS (MARSUPIALIA, PHALANGERIDAE, *TRICHOSURUS*)

BIEDRON, Eva M., Vanderbilt University, Nashville, TN, United States of America; DESANTIS, Larisa, Vanderbilt University, Nashville, TN, United States of America

Australia's geological and paleontological record shows long-term aridification, making it a particularly interesting system to assess long-term responses to climate change. Geochemical analysis of tooth enamel as well as dental microwear texture analysis (DMTA) can provide a proxy for the vegetation an organism encountered and consumed and the climate it occupied across its range. The particular climatic or environmental signal captured in a taxon's dentition may differ based on its drinking behavior, physiology, and food source. Therefore, it is first necessary to examine relationships between climatic variables and both isotopic and DMTA signals recorded on or in teeth in modern organisms. Small arboreal marsupials were abundant during the Miocene when Australian forests were more widely distributed and declined with the opening up of the landscape. Most dental analyses in Australia have focused on ground dwelling marsupials; however, much can be learned from arboreal taxa. Here, we analyzed stable carbon and oxygen isotope data from incisor enamel and DMTA of the cheek teeth of two small, arboreal, primarily folivorous marsupials, *Trichosurus Vulpecula,* and *Trichosurus caninus*. We find that relative humidity, maximum mean annual temperature (Max. MAT) and mean annual precipitation (MAP) best predict *Trichosurus* stable oxygen values ($R = 0.454$, $p < 0.001$), while Max. MAT is positively correlated with and best predicts stable carbon isotope values of the two taxa ($R = 0.331$, $p < 0.001$). MAP is the best predictor of complexity (Asfc; $R = 0.216$, $p = 0.006$), suggesting that in areas with increased precipitation, *Trichosurus* consumes harder objects (e.g., fruit and seeds or woody browse). Max. MAT best predicts anisotropy (epLsar; $R = 0.158$, $p = 0.045$), indicating tougher food may be preferentially consumed in warmer regions. When specimen complexity and anisotropy data is compared to monthly climate data corresponding to the month of collection (best representing climate during the time of dental microwear formation), only Max. MAT is positively correlated with complexity ($R = 0.215$, $p = 0.021$). These results suggest that while stable oxygen isotopes are positively correlated with relative aridity similar to kangaroos and koalas, diet is largely a function of local resources and only weakly related to temperature. A combined approach utilizing both stable isotopes and DMTA can provide complementary paleoecological data, allowing for a more complete understanding of ancient environments and the ecology of resident mammals.

Grant Information
NSF 1455198 (to DeSantis); Geological Society of America Graduate Student Research Grant (to Biedron); Vanderbilt University

Technical Session V (Thursday, October 18, 2018, 11:45 AM)

INTRA-BASINAL HETEROGENEITY OF MAMMALIAN COMMUNITIES IN THE TURKANA BASIN BETWEEN ~2.0 AND 1.4 MA

BIERNAT, Maryse D., Arizona State University, Tempe, AZ, United States of America; BRAUN, David R., The George Washington University, Washington, DC, United States of America; PATTERSON, David B., University of North Georgia, Dahlonega, GA, United States of America; REED, Kaye E., Arizona State University, Tempe, AZ, United States of America

The Plio-Pleistocene fossil record of eastern Africa is generally characterized by increasing aridity and expansion of C_4 grasslands. Between ~2–1.4 Ma, paleolake Lorenyang in the Turkana Basin regressed in response to climate cycling, potentially restructuring the surrounding ecosystems. Using faunal abundance of mammalian communities from the Koobi Fora, Nachukui, and Shungura formations around paleolake Lorenyang, we investigated trends in ecosystem dynamics in response to this geomorphic change. The geographic locations of these formations (to the east, west, and north of Lake Lorenyang) are ideally positioned to investigate the spatial and temporal dynamics of mammalian communities of the Turkana Basin. Specifically, the paleoenvironments of the Shungura Formation (Fm.) have been hypothesized as a buffer for mesic-adapted taxa during cycles of increased aridity in the Basin. We test this hypothesis by investigating the relative abundances of mesic and arid-adapted fauna within each formation. If the Shungura Fm. acted as a buffer for mesic-adapted taxa, we would expect to see an increase in the prevalence of mesic taxa in this formation during increased aridity and lake recession.

We included cranial and post-cranial elements attributed to the families Bovidae (n > 4,000), Suidae (n > 1,500), and Equidae (n > 500) in the analysis. During the time of maximum lake recession (~1.8–1.5 Ma), an increase in the number of mesic-adapted Reduncini (Bovidae) fossils were identified from the Shungura Fm., while the Koobi Fora and Nachukui fms. display an increase of arid-adapted Alcelaphini (Bovidae). Furthermore, *Kolpochoerus*, a suid genus attributed to mixed habitats, are most abundant in the Shungura Fm. at this period, while *Metridiochoerus*, an arid-adapted suid, dominated the Koobi Fora and Nachukui fms. Finally, *Eurygnathohippus* (Equidae) persisted in the Shungura Fm. during periods of decline and even extirpation in the other two formations. These data suggest that *Eurygnathohippus* may be more mesically-adapted than previously recognized. Our results indicate that the Shungura Fm. was likely a buffer zone for mesic-adapted taxa during periods of fluctuating lake size and aridity. Finally, correspondence analysis also supports differences in habitats between these three regions of the Turkana Basin.

Grant Information
Research was supported by the U.S. NSF, OISE awards 1358178 and 1358200, and a NSF Doctoral Dissertation Improvement and Wenner-Gren Dissertation Fieldwork grants to DBP.

Technical Session III (Wednesday, October 17, 2018, 4:00 PM)

A REASSESSMENT OF VARIATION IN DENTAL AND MANDIBULAR CHARACTERS OF BASAL ODOBENIDS

BIEWER, Jacob, California State University Fullerton, Fullerton, CA, United States of America; PARHAM, James F., California State University Fullerton, Fullerton, CA, United States of America; VELEZ-JUARBE, Jorge, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America

If few specimens of each taxon in a clade are known, then characters that vary individually within a species may confound the recognition of taxa and phylogenetic analysis. It is possible to develop assumptions about the variation of characters by studying variation in extant lineages, but in some cases the morphology of the fossil forms are different enough to make this difficult. Walruses (odobenids) are an example of a clade with taxa that are known from few specimens and lack good modern analogs for some character complexes. Basal odobenids (defined as those phylogenetically outside the "dusignathine" + odobenine clade) are transitional between enaliarctine-like morphology (double rooted complex teeth) and the highly specialized condition seen in the extant *Odobenus rosmarus* (single rooted, peg-like teeth, loss of teeth). Most of the characters that distinguish basal odobenids from one another, and are used in phylogenetic analyses, are from this character complex. Excluding the very early walruses, *Proneotherium reppeningi* and *Neotherium mirum*, all other basal odobenids (n = 9) are represented by just 0–2 (1.11 mean) described skulls and 0–2 (0.67 mean) described mandibles. Here we report on six new specimens (five skulls, six mandibles) of a new species of basal odobenid with partial to complete dentitions from the 'Monterey' Formation of Aliso Viejo (Orange County, Southern California, U.S.A.). Eleven of the 32 (34%) dental and mandibular cladistic characters that distinguish basal odobenids vary within the Aliso Viejo species. Eight of these 11 characters segregate between males and females within the Aliso Viejo sample, but the pattern of putative sexual dimorphism does not hold when compared to other taxa where males and females are known. The variation in the Aliso Viejo samples suggests that we should expect more variation in dental and mandibular characters in more poorly known taxa if more specimens are found. This variation must be considered when diagnosing new species and delineating OTUs for phylogenetic analyses, which is especially important given the high number of undescribed specimens of basal odobenids.

Grant Information
This work was facilitated by a National Science Foundation grant for Collections in Support of Biological Research (NSF grant #CSBR-1349430).

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

TRAINING THE NEXT GENERATION OF SCIENTIFIC RESEARCHERS IN BOTH RESEARCH METHODS AND PUBLIC COMMUNICATION AT RANCHO LA BREA—A MELTING POT OF CURRENT AND ANCIENT DIVERSITY

BINDER, Wendy J., Loyola Marymount University, Los Angeles, CA, United States of America; DESANTIS, Larisa G., Vanderbilt University, Nashville, TN, United States of America; LINDSEY, Emily, Los Angeles, CA, United States of America; MEACHEN, Julie, Des Moines University, Durham, NC, United States of America; O'KEEFE, F. R., Marshall University, Huntington, WV, United States of America

The Rancho La Brea tar pits are famous for the quantity, quality, and diversity of fossil organisms they contain, and they span a critical time in Earth's history (the past 50,000 years), which saw major climatic fluctuations, the arrival of humans in North America, and the end Pleistocene extinction event that wiped out more than two-thirds of the large mammals on the continent. Moreover, this fossil site is located in the middle of Los Angeles and is visited by millions of 'future scientists' that reside locally or have trekked across the globe to visit this unique fossil site. Our NSF-funded project entitled "Collaborative Research: RUI: Chronology and Ecology of Late Pleistocene Megafauna at Rancho La Brea" has the objective of understanding how climate change over the terminal Pleistocene influenced the diets and morphology of large herbivores and carnivores, and to characterize its role in the end-Pleistocene extinction. As critical as the scientific research is the training of the next generation of scientists in both scientific methods and public communication. As part of this project, we are training cohorts of undergraduate students to do both dedicated summer research full time, along with continuing collaborative research during the school year where they can gain a depth of knowledge, learn how to do independent research, and work to present their research to their peers and the public. As many of these students are the future face of science, it is critical that they also learn to effectively communicate their science to visitors. Through their summer training, they work 'on exhibit' in the Museum's Fishbowl lab, and emerge each day to interface with the public (on the other side of the window), communicating the scientific data collection methods and broader impacts of their research to the public. Doing this on a regular basis and from the onset of training allows the scientific tasks and broader impact activities to blend and become one and the same. As part of formal student training, mentors will prepare students to discuss scientific concepts with a public that comprises a huge diversity of ages, origins, and viewpoints. Students also test teacher workshop activities communicated at the SVP Educators Workshop, providing feedback on what worked, what needs to be revised, and what they would do differently. The early immersion of science and broader impacts in student training helps prioritize the need for both; a paradigm shift has occurred within the sciences that must then be transferred to the nextgeneration.

Grant Information
NSF EAR - Sedimentary Geology and Paleobiology

Technical Session IX (Friday, October 19, 2018, 10:30 AM)

OLFACTION WRITTEN IN BONE: USING THE CLOSE LINK BETWEEN CRIBRIFORM PLATE AND OLFACTORY RECEPTOR GENE REPERTOIRE SIZE TO PREDICT OLFACTORY ABILITY IN *SMILODON FATALIS*

BIRD, Deborah J., University of California Los Angeles, Los Angeles, CA, United States of America; FOX-ROSALES, Lester, University of California Los Angeles, Los Angeles, CA, United States of America; VAN VALKENBURGH, Blaire, UCLA, Westwood, CA, United States of America

Nearly every mammal is assumed to have a keen sense of smell. Yet, mammalian olfactory systems have undergone losses as well as gains throughout evolutionary history, resulting in a wide diversity of olfactory morphologies and olfactory receptor (OR) gene repertoires across all orders. One clue to the evolution of mammalian olfaction lies deep within the skull in a small, cryptic, perforated bone that separates snout from brain, called the cribriform plate (CP). The CP is the only passageway for axons from sensory neurons in the olfactory epithelium as they cross from the snout to the olfactory bulb of the brain and for this reason offers an osteological record of the relative olfactory innervation an animal invests in smelling. Olfactory nerves passing through the CP are projections from multiple neuron subpopulations, each of which expresses a single OR gene in the animal's genome. Because each functional OR gene is represented by a distinct population of some thousands of neurons, all of which leave their imprint in the CP bone early in development, we hypothesized that losses and expansions in OR gene repertoires are reflected in smaller and larger CP morphology, respectively. To test this, we used CT scans and 3D imaging to analyze relative CP size of 27 species with known OR gene repertoires. Results showed that across all mammalian superorders, from dolphin to elephant, CP size correlates closely with the number of functional OR genes in a species genome. The regression equation from this correlation allowed us to predict a possible OR gene repertoire of an extinct mammal, the sabertooth cat (*Smilodon fatalis*), for which only the imprint of olfactory tissue in the CP bone remains. Using the surface area of *Smilodon's* well-preserved CP, as measured from a CT scan, we estimated that this extinct felid's OR gene repertoire may have been comparable to, but slightly smaller than, that of the extant domestic cat. The close link we found between CP morphology and OR gene number points to an underlying developmental intersection of genes, neuroanatomy, and skull morphology along the peripheral olfactory pathway from nose to brain. Because OR gene number is known to be linked with odorant discrimination ability, these results reinforce relative CP size as a stand-alone metric of olfactory function that can be applied to extinct species from which molecular data can no longer be extracted.

Grant Information
NSF Graduate Research Fellowship Program grant DGE-1144087; NSF grants: IOS-1119768, IOS-1457106, BCS/IOS-0924592, BCS-1231350, BCS-1231717, BCS-0959438

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

MORPHOLOGICAL SIMILARITY IN THE DENTITION OF RODENTS, MULTITUBERCULATES, AND PLESIADAPIFORMS DURING THE LATE PALEOCENE IN NORTH AMERICA

BIRLENBACH, David M., University of Minnesota, Minneapolis, MN, United States of America; FOX, David L., University of Minnesota, Minneapolis, MN, United States of America

During the late Paleocene epoch, species of Rodentia emigrated out of Asia across holarctic pathways into North America and Europe. The timing of their arrival and subsequent radiation in North America and Europe coincided with decreasing species richness of endemic Multituberculata and several lineages of stem Primates (plesiadapiforms). The inverse pattern between rodent and multituberculate and plesiadapiform taxonomic richness has been suggested to be evidence of competition between the groups. However, for competition to occur, rodents must have had niches that overlapped with those of multituberculates and plesiadapiforms. One aspect in which competitors are predicted to overlap is in their diets, which is reflected in their tooth morphology. To test for overlapping dietary niches and to examine whether the dietary niches of the endemic clades changed with the arrival of rodents, we quantitatively analyzed the morphology of isolated teeth and partial and complete tooth rows (43 specimens total) of rodents, multituberculates, and plesiadapiforms from late Paleocene localities in the Bighorn Basin, WY that were deposited before and after the immigration of rodents (Tiffanian and Clarkforkian North American Land Mammal ages, respectively). 3D surface models of the teeth were constructed from microCT scans and a series of linear, 2D, and 3D shape descriptors previously shown to reflect dietary category in extant North American rodents were collected at multiple tooth positions (p3–m3). We natural log-transformed all data and used pairwise Wilcoxon rank-sum tests to test for changes in mean values of the groups both within and between faunas. For the Clarkforkian sample, rodent molars are not statistically distinct from those of multituberculates or plesiadapiforms for any of the individual measures, suggesting some degree of overlap in dietary niche among species of all three groups. However, neither multituberculates nor plesiadapiforms exhibit statistically significant changes in mean values from the Tiffanian to the Clarkforkian fauna, suggesting that little or no character displacement, hence no dietary niche displacement, occurred in the incumbent taxa in the immediate aftermath of the immigration of rodents. Our initial results suggest that immigrant rodent taxa may indeed have been ecologically similar to North American species of multituberculates and plesiadapiforms and that niche overlap and competition may have factored into the eventual extinction of the incumbent groups.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

TESTING ASSOCIATIONS BETWEEN CENTRE OF MASS, BODY PROPORTIONS, AND LOCOMOTOR HABIT IN ARCHOSAURIA

BISHOP, Peter J., Royal Veterinary College, Hatfield, United Kingdom; ALLEN, Vivian R., Royal Veterinary College, Hatfield, United Kingdom; BATES, Karl T., University of Liverpool, Liverpool, United Kingdom; HENDERSON, Donald M., Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; HUTCHINSON, John R., Royal Veterinary College, Hatfield, United Kingdom

Archosauria contains many species with divergent locomotor habits, ranging from quadrupedal through facultatively and habitually bipedal forms, in both the pseudosuchian and ornithodiran lineages. Locomotor ability is influenced by numerous factors, including body mass, limb size and proportions, and the location of the whole-body centre of mass (COM). In particular, COM position has frequently been estimated and used to evaluate locomotor habits in extinct terrestrial archosaurs. Here, we synthesize previously published digital volumetric estimates of mass and COM with estimates of gross body proportions (glenoacetabular distance, femur length, and hindlimb vs forelimb length ratio) in 65 species of extant and extinct archosaurs. In addition, new modelling results are derived for two previously unstudied taxa, the ornithopod *Muttaburrasaurus* and the pseudosuchian *Batrachotomus*, to test their hypothesized locomotor habit. Phylogenetically-informed principal component (PC) analysis is used to test associations between anatomical parameters and the consensus locomotor habit for each taxon ('bipedal', 'quadrupedal', 'facultative bipedal', or 'unknown'). We find a very strong distinction between bipedal and quadrupedal taxa in PC space, as indicated by both one-way, non-parametric, multivariate analysis of variance ($F_{2,62} = 8.8955$, $P < 0.001$) and minimal overlap of their respective morphospaces (< 4% by volume). These findings are robust to alterations in assumed phylogenetic relationships between taxa. Facultatively bipedal taxa neatly bridge between the bipedal and quadrupedal groups, and both *Muttaburrasaurus* and *Batrachotomus* are found to likely be quadrupeds. No PC is strongly loaded by COM in isolation of the other parameters; in particular, the first PC is also markedly loaded by femur length and limb length ratio. These results highlight the utility that a holistic, multivariate approach can bring to quantitative assessments of locomotor habit in extinct archosaurs. Interestingly, despite being largely distinct from quadrupeds in PC space, bipeds still show high variance in the first two PCs, which account for > 65% of total data variance. This suggests that bipedal archosaurs may have had fewer constraints on body dimensions compared to quadrupedal archosaurs, which may underlie their proliferation and radiation throughout the Mesozoic era.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

RESEARCH EXPERIENCE IN PALEONTOLOGY CHANGES ATTITUDES, IMPROVES SCIENCE COMMUNICATION, AND INSPIRES HIGH SCHOOL STUDENTS TO PURSUE STEM CAREERS

BITTERMAN, Kathleen, Des Moines University, Des Moines, IA, United States of America; TOMIYA, Susumu, Des Moines University, Des Moines, IA, United States of America; REDMAN, Cory M., Drake University, Des Moines, IA, United States of America; CAIN, Kacia, Des Moines Central Campus, Des Moines, IA, United States of America; MEACHEN, Julie, Des Moines University, Des Moines, IA, United States of America

Despite rising emphasis on STEM education, public high-school students typically receive minimal exposure to historical biology/geology in school, and opportunities to participate in hands-on paleontological research and collections care are rare. We believe greater access to such opportunities will improve the public's scientific literacy on biodiversity under global change, raise awareness about the foundational role of natural history collections in science, and increase the diversity of workers in paleontology. Additionally, these experiences will allow the high-school students to more effectively engage in scientific discussions with peers and others in the scientific community as well as with business and government leaders.

Outreach at the high-school level is uniquely valuable because many students are exploring their career paths. In conjunction with an ongoing NSF-funded research program on fossils from Natural Trap Cave (NTC), Wyoming, and in partnership with Des Moines Public Schools Central Campus, we designed and offered a weekly after school program in paleontology for 11–12th grade students. In this semester-long, lab-based program, students were introduced to identification and curation of fossil specimens from NTC, as well as a variety of current paleontological questions and methods. They then analyzed skeletal element representations at NTC to investigate the mode of bone accumulation, and they presented their findings in professional formats at science fairs and at the Governor's Future Ready Iowa Summit where they explained their projects and the importance of the fossil record to the Governor of Iowa.

In a post-project survey, students reported that the program deepened their understanding of the scientific method and fundamentally changed their perception of paleontology as a field that was doing "much more relevant and significant work in the science community" than they had realized. Their comments underscore the importance of (1) drawing connections between the study of past biota and modern ecological issues and (2) presenting a balanced portrayal of paleontological experiences to reach a broader student audience than the field has traditionally succeeded. We think that similar, research-driven programs can be implemented at other institutions. In all cases, formal program recognition with course credit and sharing of suitable materials among a network of researchers will be key to their success.

Grant Information
NSF EAR/SGP Grant No. 1425059

Technical Session XV (Saturday, October 20, 2018, 10:30 AM)

THE OVERT THEMATIC COLLECTIONS NETWORK: 3D ANATOMICAL DATA FOR NEARLY EVERY LIVING VERTEBRATE GENUS

BLACKBURN, David C., University of Florida, Gainesville, FL, United States of America; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; LUO, Zhe-Xi, University of Chicago, Chicago, IL, United States of America; STANLEY, Edward L., University of Florida, Gainesville, FL, United States of America; TAKANO, Oona, University of Florida, Gainesville, FL, United States of America

The oVert (openVertebrate) Thematic Collections Network—funded by the US National Science Foundation—is a new collaborative initiative among museums across the U.S. that aims to CT-scan ~20,000 fluid-preserved vertebrate specimens, representing over 80% of the approximately 10,500 extant genera. This project is generating free, publicly available three-dimensional anatomical data housed in the online MorphoSource database. We will also generate contrast-enhanced scans to reveal soft tissues and organs for a majority of the living vertebrate families. Our network of leading U.S. vertebrate collections is developing best practices and guidelines for high-throughput CT-scanning, including efficient workflows, preferred resolutions, and archival formats that optimize the variety of downstream applications. Using digitized collections data via iDigBio, we are locating data-rich specimens (with geocoded locality data, associated tissues and/or media files) in U.S. museum collections representing type species of extant genera. We then loan relevant specimens to one of six participating institutions serving as imaging centers for the TCN. To date, we have CT-scanned >2,300 fluid-preserved specimens that represent more than 2,100 extant genera in 500 vertebrate extant families. For the paleontological community, these provide a rich resource for comparative and functional anatomy and reference libraries for identifying fossils, including from screenwash. The oVert TCN will provide a collection of digital imagery and three-dimensional volumes that is open for exploration, download, and use by the neontological and paleontological communities.

Grant Information
Supported by NSF DBI-1701714.

Technical Session XI (Friday, October 19, 2018, 2:45 PM)

IMPLICATIONS OF IMMIGRANT ARRIVAL TIMES DURING THE PALEOCENE–EOCENE THERMAL MAXIMUM FOR MAMMAL HABITAT SPECIFICITY

BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; MORSE, Paul E., Florida Museum of Natural History & Department of Anthropology, University of Florida, Gainesville, FL, United States of America; VITEK, Natasha, Florida Museum of Natural History & Department of Biology, University of Florida, Gainesville, FL, United States of America; BOYER, Doug M., Department of Evolutionary Anthropology, Duke University, Durham, NC, United States of America; WING, Scott L., Department of Paleobiology, National Museum of Natural History, Smithsonian Institution, Washington, DC, United States of America

Fieldwork in sections spanning the Paleocene–Eocene boundary in the southern Bighorn Basin, Wyoming, has yielded 22,691 mammal fossils from 1,324 localities tied into a high-resolution stratigraphic framework. Three distinct phases of the Paleocene–Eocene Thermal Maximum (PETM) are recorded by paleosols, fossil plants, and isotopes: a sudden 'onset' with prominent negative carbon isotope excursion associated with warmer climate; a sustained 'body' of hot, seasonally dry climate lasting ~100 kyr; and a more gradual 'recovery' when climate shifted back to cooler, wetter conditions.

The PETM onset includes the first appearances of perissodactyls and artiodactyls and a poorly preserved flora dominated by palms. The body is characterized by dry-tolerant plants that extend their ranges northward from the Gulf Coast Plain and southern Rockies, and the staggered first appearances of euprimates, amphilemurid insectivores, miacid carnivores, and hyaenodontid creodonts. These immigrants from Eurasia comprise ~20% of North American PETM mammalian diversity. The recovery period records the first appearances of plants known from the Paleocene of Eurasia, but no new intercontinental mammalian immigrants.

If the immigrant mammals were tracking specific habitats, their intercontinental dispersal would imply continuity of biomes across Holarctica. In that case, intercontinental mammal and plant immigrants should appear concurrently. Instead, mammalian immigrants crossed through high latitude belts of warm temperate forest and then appeared in the Bighorn Basin during peak PETM conditions, when plant fossils suggest a dry tropical forest. Warm temperate Eurasian plants don't appear in the Bighorn Basin until the recovery phase, but the rapid return of temperate forest does not coincide with an abrupt change in mammalian community structure. The arrival of intercontinental mammalian immigrants ahead of the floras suggests that PETM mammalian biogeographic patterns are not simply the result of expanded habitat previously restricted to lower latitudes. Instead, mammals took advantage of a broad range of habitats with different resources and seasonal cycles as they dispersed between continents.

Grant Information
Supported by NSF grants EAR-0640076, EAR-0719941, EAR-0717892, EAR-0718740, EAR-0720268, BCS-1440558, BCS-1440742

Podium Symposium (Wednesday, October 17, 2018, 11:00 AM)

THE INFLUENCE OF CROSS-TROPHIC ASSOCIATIONS ON COMMUNITY STRUCTURE AT THE END OF THE QUATERNARY

BLOIS, Jessica L., University of California—Merced, Merced, CA, United States of America; FITZPATRICK, Matthew C., University of Maryland Center for Environmental Science, Frostburg, MD, United States of America; WILLIAMS, John W., University of Wisconsin—Madison, Madison, WI, United States of America; MAGUIRE, Kaitlin Clare, College of Idaho, Caldwell, ID, United States of America; NIETO LUGILDE, Diego, University of Cordoba, Cordoba, Spain; WILLIAMS, J. Eric, University of California—Merced, Merced, CA, United States of America

Climate influences the structure of both mammal and plant assemblages across space and time, seen most clearly in the emergence of no-analog mammal and plant assemblages coincident with no-analog climates at the end of the Pleistocene. Prior work has examined separately the influence of climate on mammals and plants, without consideration of how these two taxonomic groups are integrated with and co-dependent on one another—for habitat, dispersal, resources, and other important interactions. Including both assemblages within ecological models may be necessary to capture a fuller set of processes influencing spatiotemporal changes in species distributions and community structure. In this study focused on assemblages occurring in eastern North America over the last 21,000 years, we used datasets of faunal and plant data from the Neotoma Paleoecology Database and general dissimilarity modeling to examine whether including cross-trophic associations, in

addition to climate, as predictors in community-level models improved the explained amount of assemblage variation across space and time. We found that including mammals in models of spatial plant assemblage structure influenced the amount of variation explained, and vice versa. We further explore the magnitude of this effect, and which components of the mammal or plant assemblages most strongly influenced variation in community structure.

Grant Information
This work was supported by the U.S. National Science Foundation (DEB-1257033 to J.L.B., DEB-1257164 to M.C.F., and DEB-1257508 to J.W.W.).

Technical Session III (Wednesday, October 17, 2018, 2:45 PM)

NEW FOSSILS FROM THE OLIGOCENE OF SOUTH CAROLINA CLARIFY THE IDENTITY OF "*SQUALODON*" *TIEDEMANI* AND THE POSTCRANIAL EVOLUTION OF EARLY ODONTOCETES

BOESSENECKER, Robert W., College of Charleston, Charleston, SC, United States of America; CHURCHILL, Morgan, University of Wisconsin Oshkosh, Oshkosh, WI, United States of America; BUCHHOLTZ, Emily, Wellesley College, Wellesley, MA, United States of America; BEATTY, Brian L., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; GEISLER, Jonathan H., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America

The genus *Squalodon* has historically been treated as a wastebasket for heterodont odontocetes, with many species now reassigned to other clades (Allodelphinidae, Kekenodontidae, Waipatiidae, Xenorophidae) based on discoveries of more complete material. One such taxon is "*Squalodon*" *tiedemani*, a partial rostrum of uncertain age dredged from the Wando River (Charleston, SC). Newly collected material including a partial skull and skeleton (CCNHM 103) and an isolated skull (CCNHM 220) indicate that "*Squalodon*" *tiedemani* is a stem odontocete with close affinities to 'Genus Y', an unnamed *Agorophius*-like giant dolphin from the Oligocene Ashley (29.0–26.57 Ma) and Chandler Bridge Formations (24.7–23.5 Ma) of the Charleston area. CCNHM 103 includes a large cranium (CBL = 100 cm) with prominent nuchal crests, distinct intertemporal constriction, large temporal fossae, incipient polydonty (13 upper teeth), limited heterodonty, and thickened cementum. Postcranial elements, including 90% of the vertebral column, numerous ribs, sternum, and much of the right flipper, shed critical light onto the poorly understood postcranial osteology of early odontocetes. Standard measures indicate that most vertebrae are nearly equidimensional similar to mysticetes, archaeocetes, and physeteroids (= Pattern 1 of Buchholtz) indicating undulation of the entire torso. Caudal vertebrae indicate the presence of a tail fluke, but wide mid-caudal vertebrae suggest the peduncle was poorly developed. The forelimb preserves well-ossified carpals and an unusual degree of fusion in the wrist; metacarpals and phalanges are elongate and cylindrical as in archaeocetes, suggesting a less rigid flipper than in extant Odontoceti. Digital articulations are convex and smooth, indicating synovial finger joints. These new discoveries highlight the stepwise evolution of the cetacean bauplan and gradual shift in locomotor ability in early odontocetes.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A MEADOWLARK, A CASSOWARY, AND A PUFFIN WALK INTO A BAR: A CASE STUDY FOR IDENTIFYING CLAW SPECIALIZATION IN EXTINCT ANIMALS

BOISVERT, Colin, UC Davis, Davis, CA, United States of America; THOMSON, Tracy J., Davis, CA, United States of America; LOPEZ-CARRANZA, Natalia, UC Davis, Davis, CA, United States of America

Vertebrates use their claws for different functions. Some animals have a single, highly modified claw which differs functionally and morphologically from other claws on the same limb. This trait, which we term claw specialization (CS), can be directly observed in extant animals, such as birds, reptiles, and mammals. However, function cannot be directly observed in extinct animals; other aspects (e.g., size, shape) must be used to infer function and identify CS. A methodology for quantitatively assessing CS independent of function is fundamental for identifying this trait in fossil taxa.

As a preliminary analysis, we chose three bird species for which CS is known via direct observation: a meadowlark (*Sturnella magna*), a puffin (*Fratercula cirrhata*), and a cassowary (*Casuarius casuarius*). Shape difference between specialized and non-specialized claws was examined using a geometric morphometric (GM) approach and analyzed using exploratory and statistical methods. Size difference was investigated by measuring four distances: between flexor and extensor tubercles, from flexor tubercle to apex, from extensor tubercle to apex, and from flexor tubercle to apex. Average values of these measurements for each claw group were calculated and differences in these values compared to evaluate size difference.

Size data show a large difference between claw groups in the meadowlark. However, GM analysis showed no clear separation in shape space between them. Cassowary claws have size differences greater than the meadowlark, and GM analysis distinguished between claw groups as well as claw digit numbers. In the puffin, claws show tighter grouping by digit number in shape space than the cassowary and, although the specialized claws do group together, the non-specialized claws do not show a distinct cluster like the cassowary. The puffin shows the least size difference between claw groups.

These results are preliminary but promising. Increasing both number of taxa and the number of claws will further resolve size/shape differences, providing a robust methodological framework for quantitatively assessing CS. Using only size or shape is insufficient for identifying CS in extinct animals, since it may not offer enough resolution to differentiate between specialized and non-specialized claws. When both methods are integrated, the probability of confidently identifying CS is greater. Once it can be confidently identified in extinct animals, we can begin to understand the evolutionary mechanisms behind CS and the selection pressures driving it.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ADDITIONS TO THE VERTEBRATE FAUNA OF JEAN AND RIC EDELMAN FOSSIL PARK, INCLUDING TEMPORAL RANGE EXTENSIONS ACROSS THE K/PG BOUNDARY

BOLES, Zachary M., Rowan University, Glassboro, NJ, United States of America; ULLMANN, Paul, Rowan University, Glassboro, NJ, United States of America; PUTNAM, Ian, Edelman Fossil Park, Glassboro, NJ, United States of America

Jean and Ric Edelman Fossil Park (formerly known as the Inversand site) in Mantua Township, New Jersey, exposes one of the best outcrops of the Cretaceous–Paleogene boundary in the Atlantic Coastal Plain. Near the base of the Hornerstown Formation at this site is a rich K/Pg bonebed, the Main Fossiliferous Layer (MFL), consisting of a variety of marine vertebrate and invertebrate fossils. This formation, and the MFL in particular, have been excavated and studied for decades. However, recent excavations and microsieving of sediments across the MFL have recovered the remains of several taxa new to the locality. Here, we provide an updated faunal list for Edelman Fossil Park that includes expansion of the geographic and temporal ranges of several neoselachian and actinopterygian taxa. Because the fossil record of several represented species now crosses the K/Pg boundary, our findings therefore also elucidate patterns of marine vertebrate survivorship after the end-Cretaceous mass extinction event.

New additions to the fauna of Edelman Fossil Park include osteichthyans (*Enchodus gladiolus*, *Saurocephalus lanciformis*, *Atractosteus* sp., Dercetidae indet.) and chondrichthyans (*Pseudocorax affinis*, *Notidanodon brotzeni*, *Heptranchias howellii*, *Weltonia ancistrodon*, *Palaeogaleus vincenti*, and *Squalus* sp.). The fossil record of the phyllodontid fish *Paralbula marylandica* is extended back into the late Maastrichtian, indicating that it survived the K/Pg mass extinction event. The fossil records of *Saurocephalus lanciformis*, *Pseudocorax affinis*, the chimaeriform *Ischyodus bifurcatus*, and the pycnodontid fish *Anomoeodus phaseolus* are extended across the K/Pg boundary into the earliest Danian. The recovery of a single *Saurocephalus* at Edelman Fossil Park also extends the geographic range of this taxon into northeastern North America. A complete tooth of the synechodontiform shark *Sphenodus* cf. *lundgreni* was also recovered from the MFL, providing only the second known occurrence of this species in North America and the first with definitive stratigraphic provenance. Other notable discoveries include a tooth of the rare crocodilian *Bottosaurus harlani*, a nearly complete pterygoid of *Mosasaurus hoffmanni*, and an as yet undescribed avian tarsometatarsus.

Technical Session III (Wednesday, October 17, 2018, 3:00 PM)

CRANIAL ANATOMY AND SYSTEMATICS OF THE EXTINCT RIVER DOLPHIN *PARAPONTOPORIA* AND RECONSTRUCTION OF THE ANCESTRAL HABITAT OF ODONTOCETE CETACEANS

BORCE, Bridget, San Diego State University, SAN DIEGO, CA, United States of America; LANZETTI, Agnese, El Cajon, CA, United States of America; BERTA, Annalisa, San Diego, CA, United States of America

Parapontoporia is a common Miocene–Pliocene (7.2–1.8 Ma) fossil river dolphin from California and Baja California, Mexico. There are currently three recognized species of *Parapontoporia*: *P. sternbergi*, *P. wilsoni*, and *P. pacifica*. Though it is abundant in the fossil record, the evolutionary history of *Parapontoporia* remains largely uncertain.

Previous studies have differed in their placement of *Parapontoporia*. Conflicting evidence shows it to be the sister taxon of the La Plata river dolphin, the Chinese river dolphin, or the South Asian river dolphin. Furthermore, the three currently recognized species of *Parapontoporia* were established based on qualitative descriptions of cranial morphology and have yet to be verified by modern standards for species delimitation. One goal of this study was to resolve the uncertainty of the phylogenetic placement of *Parapontoporia* and to verify the validity of the three purported *Parapontoporia* species.

In order to reveal species-level distinctiveness and phylogenetic placement of *Parapontoporia*, a character matrix was constructed using 71 cranial morphology characters. The taxon sample included *Parapontoporia*, seven extant odontocetes, three extinct crown odontocetes, and one stem odontocete. Parsimony analyses were executed using six *Parapontoporia* specimens as individual operational taxonomic units (OTUs) to examine species level distinctiveness among the specimens. Another analysis included *Parapontoporia* specimens as combined OTUs to examine the placement of *Parapontoporia* within Odontoceti. The results of this study supported the presence of two valid *Parapontoporia* species and the South Asian river dolphin as the sister taxon of *Parapontoporia*.

Another goal of this study was to examine the habitat of ancestral odontocetes to provide an ecological context based on phylogenetic position. Two different phylogenetic hypotheses were used to perform an ancestral state reconstruction, which identified specific odontocete ancestors that initiated occupation of freshwater habitats. One hypothesis placed *Parapontoporia* as the sister taxon to the South Asian river dolphin and the other placed *Parapontoporia* as sister to the Chinese river dolphin. In both analyses, the ancestral state reconstruction explained the current diversity of river dolphins as the result of two independent freshwater invasions. However, only the analysis that placed *Parapontoporia* as sister to the South Asian river dolphin could identify a definitive freshwater ancestor of the South Asian river dolphin.

Grant Information
Lerner-Gray Fund for Marine Research

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW MATERIAL OF TURTLES (TESTUDINES) FROM THE UPPER CRETACEOUS MENEFEE FORMATION OF NEW MEXICO

BORST, Jennifer, University of Arizona, Tucson, AZ, United States of America; MCDONALD, Andrew T., Western Science Center, Hemet, CA, United States of America; WOLFE, Douglas G., Zuni Dinosaur Institute for Geosciences, Springerville, AZ, United States of America

Recent field work in the Upper Cretaceous (lower Campanian) Allison Member of the Menefee Formation of the San Juan Basin of New Mexico has produced a great deal of new vertebrate material. These finds have been made possible by the combined efforts of the Western Science Center, White Mountain Dinosaur Exploration Center, University of Pennsylvania, and Southwest Paleontological Society. Numerous turtle specimens, representing three taxa, have been collected. An indeterminate trionychid is known from several partial shells and many fragments that all exhibit abundant shallow pits on the external surface.
Two baenids are represented in the sample. One is known from a single shell fragment that has a nodular, wavy texture with light pitting, similar to *Denazinemys nodosa* and *Scabremys ornata* from the upper Campanian Kirtland Formation of New Mexico. This shell fragment has a maximum thickness of approximately 6 mm, and a minimum thickness of 3 mm. The other baenid is known from a nearly complete shell. The carapace has a smooth, finely-ridged external surface texture and slight scallops along its caudal margin, similar to *Neurankylus baueri* from the Kirtland Formation. The turtle fauna of the Allison Member appears to be similar to that of the Kirtland Formation, though more study and more material are necessary to fully characterize these turtles and to place them in a broader phylogenetic and paleobiogeographic context.

Technical Session IX (Friday, October 19, 2018, 9:45 AM)

CHANGES IN HYAENODONT DIVERSITY DURING THE CARNIVORAN INVASION OF AFRO-ARABIA
BORTHS, Matthew R., Ohio University, Athens, OH, United States of America; STEVENS, Nancy J., Ohio University, Athens, OH, United States of America
Throughout the Paleogene, the only terrestrial mammalian carnivores in Afro-Arabia belonged to the extinct clade Hyaenodonta. Near the Paleogene–Neogene boundary, the first species from the order Carnivora dispersed to the island continent. Coincident with the arrival of carnivoran lineages, hyaenodonts diversified, exhibiting ecomorphological adaptations unknown in the clade during the Paleogene. In this study, new specimens from the early Miocene of Kenya are referred to Neogene hyaenodonts that illustrate apparent ecological accommodation of the newly arrived carnivorans. Many early Miocene taxa are only known from upper or lower dentitions. Using a series of regression equations constructed for this study, we refer isolated dentition to species known only from occluding material. We refer lower dentition to *Leakitherium hiwegi*, a large species previously known from a few upper molars. The new material reveals *Leakitherium* had well- developed molar talonids and a massive p4 that is nearly as mesiodistally long as it is buccolingually wide. We also refer new upper dental specimens to jackal-sized *Dissopsalis pyroclasticus* and *Buhakia*, demonstrating the shift in these lineages from mesocarnivorous dentition in the Paleogene to hypercarnivorous dentition in the Neogene. Finally, we refer upper dental specimens to weasel-sized *Exiguodon pilgrimi*. With this new material, we performed a Bayesian phylogenetic analysis, demonstrating the Paleogene–Neogene boundary was a time of increased diversification in Hyaenodonta. Using Bayesian ancestral state reconstruction, we show this period of taxonomic diversification is accompanied by morphological diversification as taxa increase the surface area of the premolars relative to the molars, and hyaenodont body size becomes more disparate as some lineages dramatically increase in body size (e.g., *Megistotherium*) and others become significantly smaller in the early Miocene (e.g., *Exiguodon*). The phylogenetic and morphological diversity of hyaenodonts during the early Neogene suggests the arrival of Carnivora did not drive the incumbent lineage to extinction, but rather to specialization. The Miocene in Afro-Arabia was an interval of significant climatic and environmental change and specialization may have left hyaenodonts more vulnerable to extinction than carnivorans. These patterns of morphological accommodation and extinction can now be used to investigate similar changes in carnivore guilds during the Neogene on other continents and in modern ecosystems.
Grant Information
Supported by the Explorers Club, the Society for Integrative and Comparative Biology, and the US NSF grants BCS-1638796, DEB-1311354, and DBI-1l2062

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

AIRWAY VARIATION AND ACOUSTIC SIGNALING IN THE CREST OF PARASAUROLOPHINE HADROSAURIDS (DINOSAURIA: ORNITHOPODA) BASED ON SPECIMENS FROM SOUTHERN UTAH
BOURKE, Jason M., NYITCOM at A-State, Jonesboro, AR, United States of America; GATES, Terry A., North Carolina State University, Raleigh, NC, United States of America; BIRTHISEL, Tylor A., University of Utah, Salt Lake City, UT, United States of America; EVANS, David C., Royal Ontario Museum, Toronto, ON, Canada; WITMER, Lawrence M., Ohio Univ, Athens, OH, United States of America; RIDGELY, Ryan C., Ohio University, Athens, OH, United States of America; DITTO, William, North Carolina State University, Raleigh, NC, United States of America; ZANNO, Lindsay, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America
The elongated cranial crest of *Parasaurolophus* garners substantial interest due to the much expanded nasal passage coursing through it. This convoluted nasal passage has been hypothesized to function in acoustic communication for this and other lambeosaurine species. Previous studies found that the nasal passages of *P. walkeri* were capable of producing low-pitched audible frequencies around 48 Hz, whereas *P. cyrtocristatus* produced a higher pitched 75 Hz frequency. Variation in the recovered frequencies is due to the different morphology of the crests adorning these two *Parasaurolophus* species. Here we present data on an unnamed species of parsaurolophine hadrosaurid from the Kaiparowits Fm. in southern Utah. This unnamed species is known from five partial-to-complete skulls that we used to reconstruct the complete crest and nasal passage. Our composite revealed a crest shape intermediate between *P. walkeri* and *P. cyrtocristatus*. Soft-tissue reconstructions of the nasal passage found that the airway was substantially more constricted by soft tissues in the rostral-most 18% of the nasal cavity, with mucosa and other soft tissues filling 60% of the available space. The airway comprised a larger portion of the nasal passage postorbitally, suggesting that the rostral-most portion of the nasal passage may have functioned more in air conditioning. Most notably, our reconstruction of the airway did not recover a lateral diverticulum, but instead found an extensive, caudal looping of the ventral ascending tract of the nasal passage. We visualized sound wave propagation in this new airway morphology using computational aeroacoustic analysis. Our results revealed that the postorbital portion of the crest was the most acoustically active, with the preorbital region of the crest acting more to direct sound waves out of the nasal passage during phonation. Fluid dynamic analysis found weak airflow in regions of the caudal loop, suggesting a significant amount of soft tissue may have been present in this area. However, aeroacoustic analysis indicated that the multiple curves in this region of the nasal passage may instead have functioned as a parabolic reflector that concentrated and redirected sound waves as they passed through the crest. Our newly interpreted nasal passage shape produced a fundamental frequency of 56 Hz for this unnamed parasaurolophine species, making it also intermediate between *P. walkeri* and *P. cyrtocristatus* in harmonics. This new specimen adds to the diversity in crest morphology as well as acoustics in parasaurolophines.
Grant Information
LMW & RCR: NSF IOB-0517257, IOS-1050154, IOS-1456503

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

ENDOCAST RECONSTRUCTIONS AND COMPARISONS BETWEEN *CRICOSAURUS* SP. AND *STOLOKROSUCHUS LAPPARENTI*
BOURQUE, Robert D., McGill, Montreal, QC, Canada; LARSSON, Hans C., McGill Univ, Montreal, QC, Canada
Crocodylomorpha encompass a wide range of ecological niches that have spanned from the Early Triassic to the modern era. While modern crocodilians share very similar ecological roles to each other, they do not do justice to the long ancestry of the lineage. As the superorder has been so diverse, differences in brain structure between species and lineages is only to be expected. The endocasts of two extinct species within Crocodylomorpha have been reconstructed and examined. The two species that were reconstructed were *Cricosaurus* sp., a member of the marine group Metriorhynchidae, and *Stolokrosuchus lapparenti*, a member of Neosuchia that lived a terrestrial or semi-aquatic life in a fresh-water environment. The endocasts were then compared to each other, followed by comparing each of them with the contemporary *Crocodylus johnstoni* and the extinct *Pholidosaurus meyeri*. The species were chosen as we have excellent reconstructions of the endocasts of modern crocodilians for comparison while the extinct species was chosen due to the similar niche it filled to modern crocodilians, despite having evolved from a separate branch within Neosuchia. In addition to the direct comparison of structures, the two signature species of this poster were plotted along a bivariate graph of brain volume for further extrapolation. Current results show that the endocast of *Cricosauurus* sp. appears to be radically different from the endocasts of other members of Crocodylomorpha, though this may be an artifact of the lower resolution of the CT scans. Due to the poor quality of the scan, in particular the cerebrum, it is difficult to say whether the large differences are due to ecological influences or is a matter of phylogeny. By comparison, the endocast of *Stolokrosuchus lapparenti* has more in common in terms of endocast structure and the contacts between nerves and the endocast with more derived members of Crocodylomorpha. Smaller olfactory bulbs can likely be correlated with its ecology as a probable mud-sifter, relying on the specialized snout tip for detecting prey rather than smell. It is difficult to say what the function of the abnormal pneumatics present within the skull of *Stolokrosuchus lapparenti* was at the given time, though it may simply be a product of being a derived species from basal Neosuchia.
Grant Information
Delise Alison Award: $1,136

Podium Symposium (Friday, October 19, 2018, 8:45 AM)

DEPOSIT YOUR 3D DATA, BUILD A VIRTUAL MUSEUM: MORPHOSOURCE
BOYER, Doug M., Duke University, Durham, NC, United States of America; WINCHESTER, Julie M., Duke University, Durham, NC, United States of America; MUKHERJEE, Sayan, Duke University, Durham, NC, United States of America; MCGEARY, Timothy, Duke University, Durham, NC, United States of America; RYAN, Tim, Pennsylvania State university, State College, PA, United States of America; BLACKBURN, David C., University of Florida, Gainesville, FL, United States of America
MorphoSource is an open use data repository focused on (but not limited to) 3D media representing museum-vouchered specimens. Here we describe the scientific and technological context that led to the creation of MorphoSource. We also review the scope and aims of MorphoSource, its current features, future goals, and best practices for data management.
Improvements in 3D scanning technology over recent decades have led to increased use of 3D digital data in comparative biology, paleontology, archaeology, and the humanities. This transition to a digital approach raises questions about minimum standards and best practices for data access and archiving. Ideally, to validate, communicate, and extend published studies using 3D datasets of natural history and cultural heritage objects, all datasets referenced in such studies should be permanently archived in a way that ensures files will remain discoverable and accessible by stakeholder communities.
MorphoSource is the only online archive designed to accept contributions of 3D data from both independent researchers and museum collections, while also storing data in a way that collections staff can directly manage it and track its reuse. There are no limits on file size, which is important as 3D media can be quite large. Furthermore, it engages with standards-setting organizations like Biodiversity Information Standards (TDWG) and working groups like Community Standards for 3D Data Preservation (CS3DP). MorphoSource directly partners with and has specimen records linked to national and international data aggregating initiatives including iDigBio and the Global Biodiversity Information Facility (GBIF), which ensures synchronization with museum collections and broad discoverability for researchers and public alike.
At time of writing MorphoSource has 6,000 users and 600 independent contributors, but also works directly with collections staff of more than 20 major museums including the American Museum of Natural History, Field Museum, Smithsonian, Florida Museum of Natural History, Harvard Museum of Comparative Zoology, and Yale Peabody Museum. There are currently 44,000 media files on the site representing 12,000 specimens and 4,400 species. These have been downloaded 88,000 times. While MorphoSource's content currently comes primarily from independent researchers, it is coordinating with 16 museum

collections through an NSF-funded project called 'oVert' that will generate and make available whole body scans of at least 20,000 species (85% of vertebrate family diversity) over four years.
Grant Information
NSF BCS 1552848 (to DMB), NSF DBI 1661386 (to DMB, TM, TR, SM, and GF Gunnell), and NSF DBI 1701714 (to DCB, JI Bloch, E Stanley, and DMB)

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

STERNAL ELEMENTS OF THE EARLY DINOSAUR *TAWA HALLAE* FILL A CRITICAL GAP IN THE EVOLUTION OF THE STERNUM IN AVEMETATARSALIA (REPTILIA: ARCHOSAURIA)

BRADLEY, Alexander, Virginia Tech, Christiansburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; BURCH, Sara H., SUNY Geneseo, Geneseo, NY, United States of America; IRMIS, Randall, University of Utah, Salt Lake City, UT, United States of America; SMITH, Nathan, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America

The sternum is a characteristic but poorly understood component of the pectoral girdle in dinosaurs, both living and extinct. In Aves, the sternum consists of a single element that aids in powered flight. However, our understanding of the early evolutionary history of the dinosaurian sternum is complicated by a lack of fossil material and the fact that definitive non-avialan theropod sternal plates have been reported from only as far back as the Middle to Late Jurassic, within Maniraptoriformes. Here we describe the oldest known dinosaur sternal plates from the Late Triassic Hayden Quarry (HQ) (Norian, ~212 Ma) at Ghost Ranch, New Mexico, as well as an isolated specimen from the Sonsela Member (~216 Ma) of the Chinle Formation near Petrified Forest National Park, Arizona. The specimens from the HQ are attributed to the early theropod dinosaur *Tawa hallae* on the basis of their close association with other *T. hallae* remains, including a nearly complete skeleton. The isolated specimen from the Sonsela Member is similar in morphology, but with several subtle differences (such as its proportionally greater width, tapered posterior margin, and the position of comparable ridges on the ventral and dorsal surfaces) that preclude a taxonomic referral at this time. The morphology of all specimens is surprisingly similar to the sterna in avialans in that they bear a sternocoracoidal process, a space along the lateral margin likely homologous to the coracoid facet, costal processes with nutrient foramina in the spaces between them, and a reinforcing ridge possibly homologous to the Pila coracoidea in extant birds. From this new evidence, it is apparent that the distribution of sternal character states across avemetatarsalians shows unexpected variation rather than a stepwise accrual of traits leading to Aves. This was known to be the case for Cretaceous maniraptoriforms but this new sternal material reveals a deeper evolutionary history of the avialan morphology by pushing the appearance of the aforementioned avialan sternal characters back to the Triassic Period. It could either be that these characters existed prior to but were repurposed for the anchoring of powerful flight muscles in avialans or that they evolved in Avialae independently from their early theropod relatives.
Grant Information
This research is funded by the National Science Foundation through the following grants: NSF EAR 1349667, NSF EAR 1349654, NSF EAR 1349554, and NSF EAR 1349650.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

THERE AND BACK AGAIN: BRINGING GLOBAL PALAEONTOLOGY MOOCS BACK INTO THE UNIVERSITY

BRADLEY, Gavin J., University of Alberta, Edmonton, AB, Canada

In 2013 the University of Alberta launched their first Massive Open Online Course (MOOC), Dino 101, as a free educational resource to anybody in the world with internet access. Between this flagship online course and three follow-up palaeontology mini-MOOCs: Theropod Dinosaurs and the Origin of Birds, Ancient Marine Reptiles, and Early Vertebrate Evolution, over 70,000 learners from all over the globe have enrolled to learn more about prehistoric life.

Alongside offering these MOOCs to the global community, the University of Alberta took the opportunity to make them available to its own students as accredited science options. Five for-credit palaeontology courses were created, including four consisting solely of online material, and one blended course (Paleo 201). The continuous educational challenge for the instructors, teaching assistants, and educational developers has been: how to create engaging, university-level courses, from subject matter initially designed for the general public?

In order to create a unique learning experience for the for-credit student, beyond that of the general MOOC learner, the team has had to be innovative in its pedagogy. In Paleo 201, the online videos are married with guest lectures showcasing new research at the university, assessed field trips to important palaeontological sites, and active learning sessions that make use of the university's paleontology facilities, such as the Geoscience Garden and Fossil Preparation Labs.

Even in the fully online for-credit courses, we have pursued high student engagement by creating paper discussion groups, supplementary modules, and audio versions of the course notes, so that they can learn on-the-go. Common questions on the general public forums have also allowed us to identify difficult concepts, such as binomials. Targeting these topics, we have created extra resources such as Quizlet study aids, exclusive 'behind the scenes' instructor videos, and low-stakes assignments in which students may be asked to upload a blog post documenting a new discovery, or summarise a recent paper.

Over 4000 students have taken the palaeontology MOOCs for credit at the university, and since their introduction, the palaeontology honours program has doubled in size. While collection of student feedback on these high-touch, educational resources is ongoing, early comments have been overwhelmingly positive, suggesting that if you are adventurous in your pedagogy, even a hands-on discipline like palaeontology can be successfully taught online at the university level.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

EARS TO THE GROUND: SEISMIC RECEPTION AND THE EVOLUTION OF A NOVEL SENSORY SYSTEM IN NORTH AMERICAN GOPHER TORTOISES

BRAMBLE, Dennis M., University of Utah, Escalante, UT, United States of America; HUTCHISON, John H., University of California Berkeley, Escalante, UT, United States of America

North American gopher tortoises are the only truly fossorial turtles, a behavior that contributes to an exceptional fossil record. Two distinct lineages of gopher tortoise, *Xerobates* and *Gopherus*, have been separate since the late Oligocene (early Arikareean) and include two or more living representatives each. *Gopherus* is more specialized, having unique structural modifications of the cranium, cervical vertebrae, and the neck-shell articulation. These modifications, previously linked to their biomechanical role in burrowing, now seem functionally related to a unique sensory system as well. The most striking feature of *Gopherus* is the possession of two massive saccular otoliths housed within hypertrophied inner ear chambers. The well-defined otoliths of modern *G. polyphemus* appear to be the largest such structures, both relatively and absolutely, of any known tetrapod vertebrate. Details of the otolithic ear of *Gopherus* leave little doubt that they serve as vibration sensors, whose primary role is to detect weak, low-frequency (< 30 Hz) substrate-borne "sounds" propagated as seismic waves. Behavioral observations and biophysical modelling indicate that the tortoises receive substrate signals through the shell, either directly when resting with the plastron on the ground, or indirectly via the forelimbs, shoulder girdle, carapace, and neck when standing. The "seismic ears" of *Gopherus* also imply a capacity for directional discrimination, especially when vibrations are received through the forelimbs. *Xerobates* lacks the specialized inner ear complex and almost certainly lacks the ability to detect substrate vibrations as acutely as does *Gopherus*.

We suggest that the unique otolithic complex of *Gopherus* developed as a mechanism to provide advanced warning against two potentially lethal threats common to the grassland environments in which these tortoises evolved: trampling by herding ungulates and fire. Both hazards are detectable at distance by their associated seismic signals (i.e., foot falls; lightning generated thunderclaps). The Cenozoic fossil record of *Gopherus* suggests that a key factor in the evolution of its specialized seismic detectors was the occupation of geo-seismically "quiet" regions in central and eastern North America while the failure of *Xerobates* to develop a comparable sensory mechanism may be linked to its evolution within the tectonically active western areas of the continent. If so, this would be the first instance of a vertebrate sensory system shaped by continental patterns of geo-seismicity.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

ENGAGING THE SAND AND GRAVEL INDUSTRY TO HELP UNCOVER ALBERTA'S ICE AGE RECORD

BRAMBLE, Katherine K., Royal Alberta Museum, Edmonton, AB, Canada; JASS, Christopher N., Royal Alberta Museum, Edmonton, AB, Canada; BARRON-ORTIZ, Christina I., Royal Alberta Museum, Edmonton, AB, Canada; BENDER, John, Royal Alberta Museum, Edmonton, AB, Canada

In Alberta, sand and gravel deposits are the most productive settings for recovery of Ice Age fossils. Fossils are common but thinly distributed amongst large volumes of gravel. As a result, fossils infrequently appear via normal erosive processes. The vast majority of Ice Age remains from sand and gravel deposits are recovered as the result of aggregate extraction by industry. The Quaternary Palaeontology Program at the Royal Alberta Museum has an active program focused on engaging these industry stakeholders to facilitate the recovery of Ice Age fossils across the province. On-site visits to gravel pits and in-house tours of the palaeontological collections are primary methods of engagement. Three additional strategies are being implemented in an attempt to increase recovery of Ice Age fossils and raise awareness of resources across industry. First, we developed a booklet for distribution to industry stakeholders. The booklet highlights Ice Age mammals commonly recovered as fossils in gravel pits and includes many pictures of typical Ice Age fossils. We view a figure-heavy booklet as essential to communicate that Ice Age fossils are similar in appearance to recent skeletal remains, and sometimes even identical. We also included information on procedures that should be taken when a fossil is found, and discuss the implications of finding fossils for industry (i.e., we address the commonly asked "Will we be shut down?" question). Second, we created "Wild West" style 'Wanted' posters that each focus on one species. Posters include pictures of fossils from individual species, a small amount of information about that taxon, and contact information for the museum. The posters are intended to pique the interest of industry stakeholders and repeatedly raise awareness of fossil resources. Finally, we have developed an app to allow quick and easy reporting of fossils by industry stakeholders. We want to have minimal impact on day-to-day industry operations and the ease of the app allows industry staff to report a fossil and send us an image that includes geographic data in one minute. At a minimum, these strategies should improve recognition and recovery of fossil resources and further enhance a positive and proactive working relationship between the Quaternary Palaeontology program at the Royal Alberta Museum and the operators of gravel pits across Alberta.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ON THE BANKS OF THE WESTERN INTERIOR SEAWAY: POSSIBLE MARINE INFLUENCE AT THE J&M SITE OF THE WILLIAMS FORK FORMATION (UPPER CRETACEOUS, CAMPANIAN) IN COLORADO BASED ON A NEWLY DESCRIBED MICROVERTEBRATE FOSSIL ASSEMBLAGE

BRAND, Nickolas A., Appalachian State University, Gastonia, NC, United States of America; HECKERT, Andrew B., Appalachian State Univ, Boone, NC, United States of America; HUNT-FOSTER, ReBecca K., Bureau of Land Management, Moab, UT, United States of America; FOSTER, John R., Museum of Moab, Moab, UT, United States of America

The Williams Fork Formation (WFF) is an understudied member of the Upper Cretaceous Mesaverde Group in NW Colorado. We collected microvertebrate fossil-bearing matrix from the J&M Site, a known vertebrate fossil-bearing locality near Rangely, CO,that represents river channel deposits in close proximity to the Western Interior Seaway. Although few, if any, definitively marine taxa have been described from the WFF, we report multiple species that may represent marine influence at the J&M site, including the first specimens of multiple selachian taxa within the WFF. Batoid shark fossils are

abundant at the J&M site, including 19 teeth belonging to the guitarfish *Myledaphus bipartitus*. The rays *Cristomylus* sp. and *Pseudomyledaphus* sp. are new records for the Williams Fork Formation, represented by three and 45 teeth respectively. These three taxa comprise the majority (~64%) of our recovered elasmobranch fossils from the J&M site. We also recovered 19 teeth of the hybodont shark *Lonchidion griffisi*, previously known only from putatively estuarine localities in the Mesaverde Formation in Wyoming. Most *Lonchidion griffisi* teeth from the J&M site are fragmentary, but multiple complete and nearly complete crowns display clear, regular serrations along both the occlusal crest and the labial peg, features diagnostic of the species. We also report two more selachian taxa from the J&M site. We attribute 17 squat, inclined, triangular teeth with little to no enamel folding on the labial surface, and no lateral cusplets to the genus *Chiloscyllium*. Two elasmobranch teeth that are squat and triangular with lateral cusplets present and heavy enamel folding on the labial surface are attributed to *Cantioscyllium markaguntensis*. *Lonchidion griffisi*, *Cantioscyllium markaguntensis,* and *Chiloscyllium* sp. are all new records for both the J&M site and the WFF. Isolated osteichthyan teeth belonging to *Paralbula casei* and indeterminate pycnodonts may also represent marine faunal elements present at the J&M site, and are relatively common. Teeth of the amiid *Melvius* sp. are the most abundant identifiable fossil material recovered from the site, and are represented by over 100 specimens. Along with 12 lepisosteid teeth, these fossils provide evidence for a more freshwater fauna at the J&M site. We also repot a broken tooth of an indeterminate lungfish, the first from the J&M site. Between the selachians and the osteichthyans, these faunal groups may represent evidence for a brackish water depositional environment for the J&M site.

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

AN ASSESSMENT OF CONVERGENCE IN ECOLOGY, MORPHOLOGY, AND FUNCTIONAL PERFORMANCE IN OLD AND NEW WORLD VULTURES

BRANIN, Joseph R., University of South Florida, Tampa, FL, United States of America; COBB, Samuel N., University of York, York, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom; BRIGHT, Jen A., University of South Florida, Tampa, FL, United States of America

Vultures are a polyphyletic group of raptorial birds that have convergently evolved a scavenging lifestyle, once in the New World clade (Cathartidae), and twice in the Old World clade (Accipitridae: Aegypiinae and Gypaetiinae). Furthermore, within these groups three specialized feeding guilds have also converged between the two families: large "rippers," who tear open carcasses and consume tough hides; "gulpers," who consume soft viscera; and small "scrappers," who pick at the bones and scraps around a carcass. Despite this, recent morphometric analysis has demonstrated that skull shape variation between the two families of vultures shows a pattern that is closer to parallelism than convergence, and that skull shape is highly allometric. It is therefore possible that the shape differences associated with these guilds are a reflection of size-based niche partitioning, rather than being driven by mechanical selection for different feeding styles, and that performance may be highly constrained by phylogeny. A finite element (FE) study was conducted on the mandibles of representatives of all three guilds in both families, using models constructed from tomographic (CT) scans. All models were loaded with a muscle-driven bite that was scaled to have the same applied load/surface area ratio, in order to facilitate comparison of relative efficiency of performance between birds of different size. Although broad similarities in deformation arise between all vultures, birds in the Cathartidae have mandibles that are more robust and ventrally downturned than their counterparts in the Accipitridae, leading to lower feeding stresses regardless of feeding guild. This demonstrates that phylogeny impacts performance even in the presence of strong morphological and ecological convergence. Interestingly, all extant members of the Cathartidae are vultures, whereas the same is not true of Accipitridae, where vulture ecomorphs have evolved twice from within clades bracketed by eagles (in the case of Aegypiinae) and kites (Gypaetiinae), suggesting that differences between the families may be tied to phylogenetic inertia in the Accipitridae. This means that the attribution of a scavenging lifestyle to extinct birds should, in the absence of other clues such as gut contents, be conducted within a phylogenetic context as much as possible.

Grant Information
BBSRC Grants BB/I011668/1 and BB/I011714/1

Technical Session XIV (Saturday, October 20, 2018, 9:15 AM)

THE HEAD AND SHOULDER OF A STENSIOELLID FISH RESOLVES THE PLACODERM-GRADE AFFINITY OF THIS GROUP

BRAZEAU, Martin D., Imperial College London, Ascot, United Kingdom; CASTIELLO, Marco, Imperial College London, Ascot, United Kingdom; FRIEDMAN, Matt, University of Michigan, Ann Arbor, MI, United States of America

Stensioellida are an enigmatic group of jawed fishes from the Early Devonian Hunsrueck Slate of Germany. This problematic group has been variously interpreted as either placoderms or holocephalan chondrichthyans, and are thus relevant to questions of the earliest appearance of the chondrichthyan crown group. Furthermore, there is an open question as to whether Stensioellida are a natural group or a 'wastebin' for incertae sedis gnathostomes from the Hunsrueck Slate. Importantly, the Hunsrueck Slate provides some of the oldest examples of articulated placoderm fishes. Nevertheless, many of these placoderms—putative or otherwise—have resisted anatomical and phylogenetic understanding as a result of the highly flattened, pyritized, and weakly metamorphosed fossils. Here we present a remarkably preserved braincase and shoulder girdle complex of a stensioellid from the Hunsrueck Slate, which we have investigated using X-ray computed tomography scanning. The details of the braincase show a combination of rhenanid and 'acanthothoracid'-type placoderm characters, including paired occipital glenoids, paravagal cavities, which confirm its placoderm-grade identity. The orbital region is 'petalichthyid'-like, with a broad suborbital floor and well-developed transverse otic processes bounding the orbits laterally. Our 3D data clarify the unusual shoulder girdle morphology of *Stensioella*, including a key apomorphy that unites this taxon with the specimen under study here. The stensioellid shoulder girdle most closely resembles the peculiar morphology of rhenanids. Based on this information, we suggest that stensioellids are proximate relatives of rhenanids. This work helps settle a long- standing debate about the phylogenetically enigmatic stensioellids as placoderms and establishes that the Stensioellida are a valid taxon. The holocephalan affinity of stensioellids can be rejected.

Grant Information
European Research Council under the European Union's Seventh Framework Programme (FP/2007–2013)/ERC Grant Agreement number 311092

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

FRAGMENTARY SPECIMENS PROVIDE EVIDENCE FOR HIDDEN TAXONOMIC DIVERSITY OF ORNITHISCHIAN DINOSAURS WITHIN THE LOWER JURASSIC KAYENTA FORMATION (NORTHEASTERN ARIZONA, U.S.A.)

BREEDEN, Benjamin T., The University of Utah, Salt Lake City, UT, United States of America

The Lower Jurassic Kayenta Formation in northeastern Arizona preserves the earliest unambiguous body fossil record of ornithischian dinosaurs in North America. The most abundant ornithischian within the Kayenta Formation is the thyreophoran *Scutellosaurus lawleri*, and although a greater taxonomic diversity of ornithischian dinosaurs has been alluded to in the literature (including a larger thyreophoran and a heterodontosaurid), *Scutellosaurus lawleri* remains the only species-level ornithischian taxon named from the Kayenta Formation. Several fragmentary pelvic and hindlimb specimens from the Kayenta Formation are here referred to Ornithischia using both an apomorphy-based approach and unique combinations of character states. These specimens are morphologically distinct from *Scutellosaurus*, but only the femora are complete enough to infer a more exclusive taxonomic referral within Ornithischia.

Isolated femora are referred to Ornithischia using two apomorphies: the proximal end of the anterior trochanter is separated from the shaft by a marked cleft, and the absence of a trochanteric shelf. Both apomorphies are convergent with several saurischian taxa, but these specimens are excluded from Saurischia in lacking a deep groove between the lateral distal condyle and the crista tibiofibularis. An apomorphy-based referral of these specimens to a more exclusive clade within Ornithischia is not possible with existing phylogenetic character sets, but the shape of the anterior trochanter hints at a possible neornithischian affinity. In heterodontosaurids and non-eurypodan thyreophorans, the anterior trochanter projects lateral to the greater trochanter and forms an obtuse angle with the long axis of the articular surface of the proximal end of the femur when viewed in proximal view. In contrast, the anterior trochanter of the isolated femora from the Kayenta Formation is inset medially relative to the greater trochanter and forms a right angle with the long axis of the proximal end of the femur, similar to that of the early neornithischian *Lesothosaurus*.

Neornithischian body fossils have been recognized from Lower Jurassic strata only in Gondwana, but it is unclear whether their apparent absence within that same interval in Laurasia is a natural biogeographic phenomenon or simply a result of undersampling. Although tenuous, the possible identification of neornithischian material from the Kayenta Formation is thus significant and encourages further paleontological exploration.

Grant Information
David S. Chapman and Inga M. Chapman Fund; Doris O. and Samuel P. Welles Research Fund

Podium Symposium (Friday, October 19, 2018, 9:45 AM)

WWW.MARKMYBIRD.ORG: CROWD-SOURCINGMACRO-EVOLUTIONARY PATTERNS IN BEAK SHAPE

BRIGHT, Jen A., University of South Florida, Tampa, FL, United States of America; COONEY, Christopher R., University of Sheffield, Sheffield, United Kingdom; CAPP, Elliot J., University of Sheffield, Sheffield, United Kingdom; CHIRA, Angela M., University of Sheffield, Sheffield, United Kingdom; HUGHES, Emma C., University of Sheffield, Sheffield, United Kingdom; MOODY, Christopher J., University of Sheffield, Sheffield, United Kingdom; NOURI, Lara O., University of Sheffield, Sheffield, United Kingdom; VARLEY, Zoë K., University of Sheffield, Sheffield, United Kingdom; THOMAS, Gavin H., University of Sheffield, Sheffield, United Kingdom

The study of macroevolutionary patterns requires a comprehensive sample of the group in question. In some large groups, this may easily run in to hundreds, if not thousands, of species. The acquisition of three-dimensional shape data is notoriously time consuming, and although several advances have been made in the availability of rapid or low-cost scanning methods to capture three-dimensional surface geometries, the rapid placement of landmarks for geometric morphometric analysis has lagged behind. This is because automated methods of landmark placement often fail to correctly place landmarks that are biologically homologous, and because geometric morphometrics is highly sensitive to differences in landmarks that are placed manually, creating error when multiple human landmarkers are recruited. In this latter case, such user errors can be minimized with sufficient replication, but such efforts are beyond the workforce capabilities of most labs. Birds (class Aves) have over 10,000 extant species, and much of their evolutionary success has been attributed to the phenotypic lability of the beak. In order to quantify patterns in beak shape macroevolution across this large clade, we created a crowd-sourcing landmarking website, www.markmybird.org, inviting members of the public to place simple landmarks on surface scans of beaks obtained from museum study skins, with the ultimate goal of landmarking all bird species. Since launching in late 2015, an average of 33 beaks have been landmarked per day, with a relatively low rejection rate of approximately 10% based on automatic detection of poorly placed landmarks, despite the minimal training offered to users. This has resulted in over 31,000 unique landmark configurations submitted to date. To illustrate the scientific utility of this approach, a case study of over 2,000 species (> 97% of genera) reveals several interesting patterns that would not be apparent at a smaller scale. These include variable rates of beak shape evolution across the avian tree associated with changes in the mode of evolution through time, particularly at a time bracketing the Cretaceous-Paleogene boundary, and also a conserved trajectory of beak shape that is common across families, suggestive of an underlying constraint on phenotype. Crowd-sourcing is therefore a viable and attractive

option for groups wishing to obtain large amounts of morphometric data for analysis of extant or fossil specimens while actively engaging the wider public in their research.

Grant Information
European Research Council (grant number 615709, project ‘ToLERates’); Royal Society University Research Fellowship to G.H.T. (UF120016).

Technical Session II (Wednesday, October 17, 2018, 11:30 AM)

THE DYNAMICS OF TOOTH CYCLING IN POLYPHYODONT VERTEBRATES

BRINK, Kirstin, University of British Columbia, Vancouver, BC, Canada; GRIECO, Theresa, University of British Columbia, Vancouver, BC, Canada; RICHMAN, Joy, University of British Columbia, Vancouver, BC, Canada

The ability of animals to continuously replace their teeth, or polyphyodonty, is a character deeply nested within Vertebrata. Polyphyodonty permits the continuance of food processing ability, the building of specialized dentitions (e.g., tooth batteries), tooth shape and size changes through growth, and in turn, changes in dentitions over evolutionary timescales. A thorough understanding of the dynamics of tooth cycling in living polyphyodont animals can elucidate mechanisms for the evolution of new dental structures. Tooth cycling in polyphyodont vertebrates occurs in a regular pattern, passing through alternating tooth positions in waves around the mouth. Although several hypotheses have been proposed for the establishment and maintenance of this phenomenon, it is not yet known if tooth patterning is controlled through global molecular signals in the jaw environment, signaling between adjacent teeth, or local signals within each tooth family. To test this, a historical, unpublished dataset of tooth removal experiments performed in iguanas and tracked for up to 6 months using monthly and bimonthly radiographs was examined. Surgical experiments included functional tooth extraction, tooth bud extraction, and removal of portions of the dental lamina with and without tooth extraction. Some of the tooth bud and dental lamina removal surgeries were recently repeated in leopard geckos, and tooth replacement phenotypes were tracked using wax impressions for up to one year.
Results in both the gecko and iguana show near-complete recovery after six months when developing teeth are removed and the dental lamina is left intact, indicating that developing teeth are not required for subsequent tooth initiation. Damage to the dental lamina creates a strong phenotype in tooth replacement timing and patterning persisting for up to a year, with critical size defects as small as one tooth position. However, tooth replacement continues anterior and posterior to the surgical site, indicating a local rather than global mechanism governing tooth replacement in adult dentitions. These results suggest that tooth replacement is independently controlled within the tooth family and not through global signaling factors traveling along the dental lamina. This has implications for the evolution of dentitions, because discrete regions of the mouth can react differently to selection pressures. This may be a key factor in the evolution of positional shape variation and the generation of novel dentitions in vertebrates.

Grant Information
Michael Smith Foundation for Health Research and Killam Fellowships (KB), NIH F32 Fellowship (TG), NSERC Discovery and RTI grants and NIH R21 grant (JR)

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

THE BLESSING AND CURSE OF MODERN CRYPTIC SPECIES IN CROCODYLIFORM SYSTEMATICS

BROCHU, Christopher A., University of Iowa, Iowa City, IA, United States of America

Crocodylian systematists face several challenges, such as the gharial problem (with related issues surrounding thoracosaur relationships, crocodylian tree rooting, and character independence) and resolution of phylogenetic relationships among the closest relatives of Crocodylia, but the most profound arises from the discovery that, based on molecular and morphological evidence, many living crocodylian species are cryptic species complexes. Regardless of concept adopted, operational species (smallest diagnosable units) approximate actual species diversity. This approximation will always be imperfect. That the number of living crocodylian species may nearly double forces a wholesale reconsideration of ranges of morphological variation, which in turn will require a different approach toward morphological species delineation. Minor but consistent differences between samples that would previously have been regarded as intraspecific variation might instead indicate the presence of multiple species. But it also means we may no longer be able to refer fossil or subfossil specimens to the species level. *Crocodylus ossifragus* from the Pleistocene of Java is usually synonymized with the modern Siamese crocodile (*C. siamensis*) of peninsular Malaysia and Borneo, but although differences between fossil *C. ossifragus* and extant *C. siamensis* are very subtle, they are consistent among multiple specimens. This raises questions about the synonymy of *C. ossifragus* and *C. siamensis*. That mainland and Borneo populations of *C. siamensis* may themselves be distinguishable species is consistent with this argument. We are also trying to determine the time of origin of modern African *Crocodylus*; fossils potentially referable to it in the African Rift Valley are less than 200 ka in age, but the living Nile (*Crocodylus niloticus*) and West African (*C. suchus*) crocodiles—which were only recently split—cannot be readily distinguished on the basis of skeletal material, and although largely allopatric today, genetic evidence from crocodile mummies suggests a more complex biogeographic history into the Holocene. We can thus put modern African *Crocodylus* in the eastern rift in the Late Pleistocene, but we cannot yet calibrate the divergence between the two extant species. Referrals of pre-Quaternary fossils to modern crocodylian species should be viewed carefully, as should assumptions that crocodyliform species had long stratigraphic ranges or that incomplete fossils from widely separated localities are probably conspecific.

Grant Information
NSF DEB 1257786

Technical Session IV (Wednesday, October 17, 2018, 1:45 PM)

THE DEFINITION OF BIOREGIONS IN PALEONTOLOGICAL STUDIES OF DIVERSITY AND BIOGEOGRAPHY AFFECTS INTERPRETATIONS: PALEOZOIC TETRAPODS AS A CASE STUDY

BROCKLEHURST, Neil, Museum für Naturkunde, Faringdon, United Kingdom; FRÖBISCH, Jörg, Museum für Naturkunde, Berlin, Germany

Studies of diversity, whether of species richness within regions (alpha diversity) or faunal turnover between regions (beta diversity), will depend heavily on the “bioregions” into which an assemblage is divided. However, such studies in the paleontological literature have often been extremely arbitrary in their definition of bioregions and have employed a wide variety of spatial scales, from individual localities to formations/basins to entire continents. Such bioregions will not necessarily be separated by biologically meaningful boundaries, and results obtained at different spatial scales will not be directly comparable. In many neontological studies, however, bioregions are defined more rigorously, usually as areas of endemicity. Here a procedure is proposed whereby this principle may be applied to paleontological datasets. In each time bin/assemblage localities are subjected to two hierarchical cluster analyses, the first grouping the localities by geographic distance, the second by taxonomic distance. Clusters shared between the two will represent continuous geographic areas of endemicity and so may be used as bioregions. When calculating alpha or beta diversity through time, the spatial scale at which the bioregions are defined needs to be standardized between each time bin. This is done by grouping clusters of localities below a predefined geographic cluster node height.
This approach is used to assess changes in beta diversity of Paleozoic tetrapods and resolve disagreements regarding changes in faunal provinciality across the Carboniferous/Permian boundary. When the bioregions are defined at a smaller spatial scale, splitting the globe into many small regions, beta diversity decreases substantially during the earliest Permian. However, when the bioregions are defined at larger spatial scales, representing areas roughly the size of continents, beta diversity remains high. This result indicates that local environmental barriers to dispersal were decreasing in importance, rejecting previous suggestions that the rainforest collapse caused an “island biogeography” effect. Instead, dispersal at this time is restricted by continental-scale barriers, with the increased orogenic uplift as a possible control.

Technical Session XIV (Saturday, October 20, 2018, 9:30 AM) Mark Withdrawn

THE FAYETTEVILLE SHALE: A WELL-PRESERVED LATE MISSISSIPPIAN BIOTA AND ITS POTENTIAL IMPACT ON CHONDRICHTHYAN SYSTEMATICS

BRONSON, Allison W., American Museum of Natural History, New York, NY, United States of America

Withdrawn

The Late Mississippian Fayetteville Shale of northwestern Arkansas is a treasure trove that is just now beginning to yield a series of exceptionally preserved chondrichth a though the flora and invertebrate fauna have been described for many years [illegible] han 400 million years, chondrichthyans have diversi d the mor [illegible] ginous skeletons to become the ocean’s op preda [illegible] ematics are still under debate, a stu [illegible] of early [illegible] onception that cartilage ab [illegible] indeed less common [illegible] localities that preserve cartila [illegible] The Fayetteville Shale is a black shale [illegible] geologists. Vertebrates are preserved as concre [illegible] nodules, and traditionally could only be studied by careful [illegible] these nodules in half. Though some traditional nodule splittin [illegible] chondrichthyan teeth and fragments of osteichthyan bone, computed tomogr[illegible]ic (CT) scanning has been highly informative in studying these fishes. CT scans of Fayetteville Shale sharks have revealed the first cranial features of *Carcharopsis wortheni*, a taxon previously only known from jaw fragments and serrated teeth, as well as the internal vascular network of these (and other) teeth. Two specimens, apparently from the same symmoriiform taxon, possess an operculum formed from elongate branchial rays, which is unlike any previously described chondrichthyan and may provide insight into the relationship between symmoriiforms and holocephalans. Symmoriiform remains are common in the Fayetteville Shale, including teeth, crania, and spine-brush complexes, as well as three-dimensionally preserved fins. Beyond conventionally defined chondrichthyans, the Fayetteville Shale also yields acanthodians, large rhizodont sarcopterygians, and palaeoniscoid fishes. To understand the taphonomic processes that produce such well-preserved cartilage, synchrotron imaging, X-ray powder diffraction, and X-ray fluorescence were used to assess nodule zonation. This corroborates earlier student work on the formation’s paleobotanical community and ammonite taphonomy, indicating the Fayetteville Shale was characterized by fluctuating levels of oxygenation and transgressive-regressive cyles, with deltaic freshwater input.

Grant Information
This research was supported by the Richard Gilder Graduate School at the American Museum of Natural History.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

NON-AVIAN THEROPOD DIVERSITY IN CRETACEOUS AUSTRALIA: EVIDENCE FROM THE FOSSIL TOOTH RECORD

BROUGHAM, Tom, University of New England, Armidale, Australia; SALISBURY, Steven W., University of Queensland, Brisbane, Australia; BELL, Phil R., University of New England, Armidale, Australia

Australian Cretaceous non-avian theropods are poorly represented and are known almost exclusively from isolated postcranial elements, with associated remains restricted to only two megaraptorids: *Australovenator wintonensis* from Winton, and an indeterminate taxon from Lightning Ridge. In the absence of an adequate body fossil record, shed teeth constitute the most abundant and informative data on the possible taxonomic diversity, distribution and relative abundance of Australian Cretaceous non-avian theropods. We examined over 130 non-avian theropod teeth from three vertebrate assemblages in Australia: the upper Albian–Turonian Winton Formation of Winton, Queensland; the Cenomanian Griman Creek Formation of Lightning Ridge, NSW, and the upper Aptian–lower Albian Eumeralla Formation of the Otway and Strzelecki groups, Victoria. A subset

of the teeth were also included in a morphometric dataset of theropod teeth and subjected to a linear discriminant analysis (LDA). Two distinct tooth morphotypes were identified. The first morphotype has recurved, labiolingually compressed crowns with a weak figure-8 basal cross-section, and strongly reduced or absent mesial denticles. These features appear in shed crowns associated with megaraptorids *A. wintonensis*, *Megaraptor namunhuaiquii* and *Orkoraptor burkei*; therefore Australian teeth of this morphotype are referred to Tetanurae cf. Megaraptoridae. The second tooth morphotype, restricted to the Eumeralla Formation, comprises crowns that are strongly labiolingually compressed with figure-eight basal and mid-crown cross-sections, no denticles, and no constriction at the cervix. This combination of features is shared with *Buitreraptor gonzalezorum*; teeth of this morphotype are therefore referred to Dromaeosauridae cf. Unelagiinae. The LDA classified all teeth of the second morphotype as unenlagiines, whereas the first morphotype was split between megaraptorids and dromaeosaurids. However, the cf. Megaraptoridae teeth can be distinguished from those of dromaeosaurids by, where present, mesial and distal denticle counts. The tooth record does not support the presence in Australia of a diverse theropod fauna, as purported from parts of the body fossil record. Megaraptorids appear to represent a ubiquitous component of Australia's Aptian–Turonian non-avian dinosaur fauna, whereas teeth assigned to cf. Unenlagiinae support the idea that these theropods were present in the Victorian sample based on an earlier reinterpretation of femora assigned to *Timimus hermani*.

Grant Information
SWS was funded by the ARC Linkage-Project scheme (LP0347332). PRB was funded by the ARC Discovery Early Career Researcher Award (DE170101325).

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

HOMOLOGY OF PARIETOSQUAMOSAL FRILL EPIOSSIFICATIONS IN CERATOPSIDAE (DINOSAURIA: ORNITHISCHIA)

BROWN, Caleb M., Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada

Ceratopsidae is a clade of large, Late Cretaceous, quadrupedal, herbivorous dinosaurs that while diagnosed by a suite of cranial synapomorphies, are most recognizable based on the prominent nasal and postorbital horns and the shield-like frill, formed by elongated squamosals and parietal. The caudal and lateral margins of the parietosquamosal frill are capped by a series of distinct ossifications, historically termed 'epoccipitals', but more recently termed 'epiparietals' and 'episquamosals' based on the underlying bone. These separate ossifications are generally the most useful features for diagnosing and differentiating ceratopsid species, and make up an average of 17% of the characters in recent cladistic analyses. Both Centrosaurinae and Chasmosaurinae bear these epiossifications, with homology between these two clades either implied or stated outright. While both clades generally bear 11–12 epiossifications per side, the differential contribution of the squamosal to the frill margin results in a reciprocal relationship in counts, with Centrosaurinae averaging seven epiparietals and four episquamosals, and Chasmosaurines averaging three epiparietals and seven episquamosals.

Multiple homology schemes have been proposed, largely numbering loci from the medial/caudal to lateral/rostral extreme of each element independently. This scheme, as well as characters coding the size/shape of any epiossification straddling the parietosquamosal suture, have been included in most recent cladistic analyses within Ceratopsidae. Although not problematic when used within either clade, when used across both clades, including outgroups, these loci numbering schemes, and nomenclature, require a highly non-parsimonious evolutionary pathway. Specifically, the loss of four epiparietals and simultaneous gain of four episquamosals in a transition from a centrosaurine-like condition to a chasmosaurine condition.

Here a more parsimonious explanation is suggested, primarily that locus homology is independent of which element (parietal or squamosal) the ossification fuses to, with the distinction between centrosaurine and chasmosaurine conditions being a shift of the parietosquamosal suture while maintaining epiossification count and relative position. To visualize which loci may be homologous between taxa, an approach is taken where the shape and positon of the parietal and squamosals are disregarded, and hypotheses of homology are evaluated based on the shape, size, and sequential order of epiossifications alone.

Grant Information
Funding provided by the Royal Tyrrell Museum Cooperating Society

Preparators' Session (Thursday, October 18, 2018, 3:45 PM)

OPTIMIZING THE SUB-OPTIMAL: USING POINT-AND-SHOOT DIGITAL CAMERAS, GREEN PAPER, AN IMAGE PROCESSING ALGORITHM, AND A KITCHEN TIMER TO BUILD AN INEXPENSIVE SEMI-AUTOMATED 3D SCANNER

BROWNE, Ian D., Oklahoma State University, Center for Health Sciences, Tulsa, OK, United States of America

Many assume an expensive DSLR camera is a prerequisite to achieving high-quality results when using photogrammetry to build 3D digital models. I maintain the axiom that "the best camera is the one you have" applies as much in photogrammetry as in fine-art photography. Here I describe the improvised, semi-automated scanner and associated workflow I use to scan skulls and other objects between 5–30 cm long. At its heart my scanner consists of a backdrop of neon green cardstock, a pair of Nikon Coolpix P90 digital cameras, and what is essentially a mechanical kitchen timer serving as the turntable. Any point-and-shoot (PAS) camera with decent macro capabilities and a built-in intervalometer should be appropriate for this purpose.

When compared to PAS cameras, the main perceived advantages of DSLR cameras are higher megapixel (MP) counts and the ability to tightly control aperture and ISO settings. Many PAS cameras also have high MP ratings and decent ISO control. The main limitation of PAS cameras is the inability to set the aperture to hi f-stop values, which can result in photos with limited depth-of-field and out-of-focus areas. Without masking each photo, photogrammetry software struggles to align poorly-focused images and significant time and system resources are spent searching for structure in out-of-focus regions. I use automated actions in Adobe Photoshop to select and delete the green background and out-of-focus areas in each image and replace them with a uniform green color. While this yields fragmentary images, they are optimized for use in model building in that only high- quality information is retained, significantly improving the signal-to-noise ratio of each image. Since the low information portions of each image have been replaced with a uniform color, it is possible to easily generate masks using the "mask by background" option in Agisoft Photoscan. When compared to using an equal number of unprocessed PAS photos, I have found that point cloud generation time in Photoscan is reduced by approximately 60%, and the time required to manually clean-up the final clouds is reduced to almost nothing. In practice, I use the decreased per image system demands to increase the number of images used in model building. Whereas 200–300 unprocessed images may have represented a strain on my system previously, I now commonly use between 400–700 images in model building, generate point clouds of significantly greater densities with higher-quality points, and often still enjoy significant time savings.

Technical Session VIII (Thursday, October 18, 2018, 3:00 PM)

COMPOSITE STRUCTURE AND HOMOLOGY IN THE THERIAN PRESTERNUM: A HYPOTHESIS

BUCHHOLTZ, Emily, Wellesley College, Wellesley, MA, United States of America; FELDMAN, Asher, Cummings School of Veterinary Medicine, North Grafton, MA, United States of America; YOZGYUR, Zeynep, Wellesley College, Wellesley, MA, United States of America

The therian sternum is the central structure of the ventral axial skeleton, located at the junction of the head, forelimb, and thorax. Uniquely, it integrates structures with origins from the neural crest, somites, and lateral plate mesoderm, and with development in both the primaxial and abaxial domains. The clavicle, first thoracic rib (TR1) and the most anterior of the posterior thoracic ribs (TR2) articulate at characteristic presternal locations via structurally and developmentally distinctive joints. Here we challenge the classic interpretation of the therian presternum as the homolog of the manubrium of multituberculates and monotremes. We propose instead a model of the presternum as a composite of the interclavicle, ancestral manubrium, and anterior sternal bands, with each of these subunits conserving its historic developmental articulations. The highly variable presternal morphology of living taxa is interpreted as the result of the independent evolution of each subunit in response to different functional demands and to the disparate fusion of these modular units in ontogeny and phylogeny. In support of this hypothesis, we present evidence from the fossil record, from fetal and postnatal sternal developmental series, and from the comparative sternal anatomy of phylogenetically and functionally diverse taxa. Presternal subunits discretely associated with the clavicle, TR1, and TR2 were identified in exceptionally preserved fossil xenarthrans. CT scans of fetal Sirenia, Xenarthra, and Cetacea of different body size document the assembly of their presterna from subunits. The presence of multiple, variable ossification centers in CT scans of human presterna supports an interpretation of presternal assembly in humans as well; a large dataset is being evaluated for the presence of dedicated distal articulations. Comparative analysis of adult therians with extreme sternal anatomy indicates the co-occurrence of regional hypertrophy (or loss) of a presternal subunit and the hypertrophy (or loss) of its corresponding articulating structure. No known therian lacks the TR1 / manubrium articulation, which integrates primaxially and abaxially patterned units across the lateral somitic frontier. This model views the presternum as modular and therefore capable of flexible evolutionary responses to diverse selective pressures, and also as constrained by inherited tissue-specific articulations. The model also suggests that element fusion with transformation, and not element loss, is the major theme of therian sternal evolution.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

PREPARATION AND TRANSPORTATION OF A COMPLETE MAMMOTH SKULL FROM CHANNEL ISLANDS NATIONAL PARK, CALIFORNIA, U.S.A.

BUGBEE, Monica M., The Mammoth Site of Hot Springs, SD, Hot Springs, SD, United States of America; WILKINS, William J., The Mammoth Site of Hot Springs, SD, Hot Springs, SD, United States of America

The Larramendy Mammoth skull was recovered from Santa Rosa Island, Channel Islands National Park (CHIS), California in September 2016. The specimen is dated to approximately 13,393 ± 80 cal BP, and is the best preserved mammoth skull recovered from CHIS to date. The skull has both tusks intact and is missing only its right jugal, which was separated along the suture lines. The skull was buried in a thick layer of gravel, and though some minor deformation has occurred, the overall shape of the skull is well-preserved. Sinus cavities in the nasal, frontal, parietal, and occipital regions of the skull, as well as the pulp cavities of the tusks, were never infilled with sediment and remain hollow. The extreme fragility of the occipital and parietal regions necessitated a delicate approach to preparation. To prevent collapse during preparation, exterior bone around the hollow sinuses had to be consolidated prior to cleaning away sediment. Temporary Japanese paper bandages were applied to reinforce cracks around the hollow areas. Consolidated sediment was then removed from adjacent surfaces using acetone and small, soft brushes. Paraloid B-72 in acetone was used for all consolidation of the specimen and adhesion of paper.

Initial preparation was begun by the primary author at the Santa Barbara Museum of Natural History in Santa Barbara, California in 2017. The skull was later moved to The Mammoth Site (MS) in Hot Springs, SD to continue preparation and research. Potential collapse of the hollow areas during transport was a significant concern. To prevent damage in transit, all exposed surfaces of the skull were consolidated, including visible interior surfaces of the sinus cavities, by using long, flexible bottle tips to access difficult to reach areas and undercuts. All exposed exterior surfaces were covered with a layer of Japanese paper applied as thin, overlapping strips. The paper acted as reinforcement for the bone, and to aid in reconstruction should any breaks or collapse of hollow areas occur as a result of unpredictable road conditions. The skull was then rejacketed, and secured inside a plywood crate using wooden braces and expanding foam. The crate was placed on rubber anti-fatigue floor mats in a moving truck and driven nearly 1400 miles to MS. The move was completed successfully with no damage to the specimen sustained during travel.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A PIG-LIKE MAMMAL (ARTIODACTYLA, HELOHYIDAE) FROM THE MIDDLE EOCENE (LATE BRIDGERIAN) WASHAKIE FORMATION OF SOUTHWEST WYOMING

BURGER, Benjamin J., Utah State University, Vernal, UT, United States of America; JOLLEY, Lea Ann, Utah State University, Vernal, UT, United States of America

Pigs originated in the Eocene, during a period of great diversification within the Order Artiodactyla. Molecular studies of modern artiodactyls show evidence for an early divergence of the group from other artiodactyls, including whales, yet modern true pigs (Suborder Suina) have a fossil record that only extends back to the late Eocene in North America and Asia. The Suina Suborder is split into two families, the peccary family Tayassuidae (with a fossil record beginning in the latest Eocene of North America) and the domestic pig family Suidae (with a fossil record beginning in the late Eocene of Asia). A third group of pig-like mammals is also known from the fossil record, the family Entelodontidae or 'hell-pigs,' which came to dominance in the late Eocene and extended into the Miocene. Recent phylogenetic studies have argued that members of the Entelodontidae family may be unrelated to the Suina Suborder; this diverges from the traditional view of a monophyletic grouping that included the three pig-like mammalian families as a monophyletic clade. In addition, there are a handful of pig-like fossil mammals that pre-date the late Eocene and have been reported from the middle Eocene of North America (Uintan and Bridgerian North American Land Mammal Ages). These fragmentary fossils have been loosely grouped within a family called the Helohyidae, and their relationship to Entelodontidae, Tayassuidae, and the Suidae families is not well understood.

We report on a new fossil helohyid from the middle Eocene Washakie Formation Lower Adobe Town Member of Wyoming, which is recognized as latest Bridgerian in age (upper Bridger D/ Twinbuttean Biozone), with an estimated age of 47 Ma. The new fossil consists of a left dentary with P_4–$M_3$and an associated humerus. Body size equations using humeral measurements indicate a body-size between 232 to 706 kg, with a dental body-size estimation of 586 kg, indicating a body-size much larger than modern wild pigs living today. The new fossil features bunodont, bulbous teeth and lacks distinct paraconid cusps on the lower molars. The fossil is larger than *Helohyus*, including the largest species *Helohyus lentus*, but about half the size of *Achaenodon* from the Uinta Formation of Utah. The fossil compares to *Parahyus vagus*, but differs in lacking distinct paraconids on the molars, a more reduced P_4, and a narrow rather than wide hypoconulid heel on the M_3. The new fossil is important because it establishes an early presence of large pig-like mammals in North America during the middle Eocene.

Grant Information
Fossils collected under Bureau of Land Management Permit PA13-WY-205.

Technical Session XVI (Saturday, October 20, 2018, 9:00 AM)

A NEW JUVENILE *TYRANNOSAURUS REX* FROM THE HELL CREEK FORMATION OF EASTERN MONTANA PROVIDES INSIGHTS INTO CRANIAL AND DENTAL ONTOGENY

BURNHAM, David A., University of Kansas, Lawrence, KS, United States of America; ATKINS-WELTMAN, Kyle L., Lawrence, KS, United States of America; JEVNIKAR, Evan M., Biodiversity Institute, Lawrence, KS, United States of America

While *Tyrannosaurus rex* is perhaps the icon of large, non-avian theropods, very little is known about their early life history. Those few specimens that are known suggest that the morphology, and thus ecological niche, of *T. rex* changed quite dramatically with age. Here, we report on a new specimen of a young individual of *T. rex* collected in Garfield County, Montana. The new *T. rex* now resides in the collections at the University of Kansas as KUVP 156375.

The cranial material comprises both maxillae with much of the dentition intact, a partial premaxilla, jugal, postorbital, vomer, and an ectopterygoid. Postcranial elements include a cervical and a dorsal vertebra, ribs, chevrons, metatarsals I, IV, and V, two complete pedal phalanges and the distal condyle of a third, pedal I ungula, and tips of two other unguals. Skeletal measurements and surface bone texture indicate KUVP 156375 is a juvenile and it is nearly the same size as another juvenile tyrannosaur, BMRP 2002.4.1. A striking feature of the new specimen is the maxilla which only contains 12 alveoli. This count is congruent with known adult *Tyrannosaurus rex,* such as FMNH PR 2081, but contrasts the higher tooth count of 15-16 maxillary teeth described in BMRP 2002.4.1. Moreover, the first maxillary tooth of KUVP 156375 is morphologically distinct from that of BMRP 2002.4.1. To better visualize the tooth morphology of these juvenile *T. rex*, measurements and denticle densities were plotted using Principal Components Analysis (PCA) statistical software. Preliminary results demonstrate teeth of young *T. rex* plot outside of the adult morphology but share minute details such as denticle shape. We suggest this pattern is due to their smaller size and during ontogeny expect they would become stouter and larger while the denticle density decreases.

Technical Session XVIII (Saturday, October 20, 2018, 2:15 PM)

IDENTIFYING DEVELOPMENTAL CONSTRAINTS TO UNDERSTAND CONVERGENCE IN RODENT DENTITION

BURROUGHS, Robert W., University of Chicago, Chicago, IL, United States of America

Evolutionary patterns are often revealed in the fossil record, including repeated convergences to various morphologies. The mechanistic underpinnings of these patterns remain unknown. This is especially common in the dentition of rodents. To understand the processes by which evolution (and convergence) occur, I developed an integrative study system focused on the evolutionary history of Rodentia. I discovered that rodent dentition is fundamentally limited by the number of cusps that can form embryologically. Lower first molars (m1) appear to have limits of nine cusps, and total tooth rows appear to have a limit of 28 cusps. I combined empirical data from the fossil and extant records with in silico developmental modeling of rodent molars, to identify these constraints. I identified multiple developmental pathways that produce the same structural limitations. These constraints are confirmed by empirical investigation of extant and fossil rodent molars. Because multiple developmental pathways converge to a single pattern, and this pattern is found across the evolutionary history of Rodentia (supported by empirical data), we can now recognize that rodent dentition is fundamentally limited by cusp number. Thus, the role of development on the contingency of convergence has become much clearer. The structural limitations discovered here explain why convergence occurs within rodent dentition. They also allow a clear demarcation to tooth morphologies as defined by development, allowing a separation of developmental factors from ecological factors that are influencing rodent tooth evolution. In doing so, this study demonstrates how bridging the gaps between process and pattern can be successfully done.

Technical Session XIII (Friday, October 19, 2018, 2:00 PM)

A NEW SPECIES OF *MYSTRIOSUCHUS* FROM THE LATE TRIASSIC OF AUSTRIA PROVIDES EVIDENCE FOR MARINE ADAPTIONS IN PHYTOSAURS

BUTLER, Richard J., University of Birmingham, Birmingham, United Kingdom; JONES, Andrew, University of Birmingham, Birmingham, United Kingdom; BUFFETAUT, Eric, Paris Sciences et Lettres Research University, PARIS, France; MANDL, Gerhard, Geological Survey of Austria, Vienna, Austria; SCHEYER, Torsten, University of Zurich, Zurich, Switzerland; SCHULTZ, Ortwin, Natural History Museum of Vienna, Vienna, Austria

Phytosaurs are a major group of early archosaurian reptiles that attained an almost global distribution during the Late Triassic, and which were remarkably morphologically convergent with modern crocodilians. Phytosaur fossils are commonly recovered from fluviolacustrine depositional environments, and are reconstructed as key carnivorous and semi-aquatic components of Triassic terrestrial ecosystems. However, a small number of phytosaur specimens have been recovered from marine deposits, potentially suggesting that some members of the clade were adapted for ocean-going life. We describe a new species of the phytosaur genus *Mystriosuchus* from the middle Norian Dachstein Limestone of Austria, from a marine lagoonal depositional environment. The best-known previous occurrences of *Mystriosuchus* are *M. planirostris* and *M. westphali* from the terrestrial Löwenstein Formation of Germany, while two specimens from the marine Norian of Italy have been assigned to *M. planirostris*. The new Austrian material comprises well-preserved remains of at least three individuals of similar size (c. 4 metres in length) found in association but disarticulated, and includes one complete and two partial skulls, as well as postcrania. The specimens apparently represent a single taxon, which is distinguished by numerous anatomical features from the two previously named *Mystriosuchus* species. The phylogenetic position of the new Austrian taxon was tested using a new, comprehensive morphological dataset (comprising 43 taxonomic units and 94 characters), which incorporates for the first time nearly all valid phytosaur species, and which utilises both continuous and geometric morphometric data. Maximum parsimony analysis of this dataset recovered strong statistical support for the position of the new Austrian taxon within *Mystriosuchus*, as the sister taxon to a clade comprising *M. planirostris* and *M. westphali*. Histological analysis suggests that the Austrian phytosaur specimens represent individuals that were at least eight years old at time of death, but which had not yet reached skeletal maturity. Taphonomic and paleoenvironmental data indicate that these phytosaurs were living within the marine lagoon in which they were preserved, providing the strongest evidence to date of marine adaptations in phytosaurs. Morphological convergences between the Austrian *Mystriosuchus* and geologically later marine crocodylomorphs (e.g., teleosaurids) provide further evidence for the repeated evolution of similar body plans in secondarily marine tetrapods.

Technical Session XV (Saturday, October 20, 2018, 12:00 PM)

PUT A BEAK ON IT: DATA-DRIVEN RECONSTRUCTION OF KERATINOUS SOFT TISSUE IN THEROPOD DINOSAURS

BUTTON, Khai, North Carolina Museum of Natural Sciences & NC State University, Raleigh, NC, United States of America; ZANNO, Lindsay E., North Carolina Museum of Natural Sciences & NC State University, Raleigh, NC, United States of America

A keratinized rhamphotheca is hypothesized as having independently arisen a minimum of fifteen times within Archosauria, alluding to the ubiquitous adaptive significance of this composite bony and soft tissue structure. In Theropoda, the rhamphotheca has been linked to dietary transitions and diversification in clades most closely related to birds. Thus, to understand the success and paleoecology of theropod dinosaurs, the beak is a vital, yet relatively understudied structure of interest. Unfortunately, despite the diagenetic resistance of keratin, the rhamphotheca rarely survives fossilization. Even in cases of exceptional preservation, precious few fossils bearing a beak impression, let alone fossil beak material, have been found. With a dearth of examples of rhamphotheca morphology in the fossil record, how best to reconstruct this soft tissue remains an open question. Previous work has hypothesized that the presence of neurovascular foramina on the rostrum are correlates of a keratinous rhamphotheca in edentulous and/or partially edentulous taxa. However, these same structures have alternatively been cited as evidence for other forms of peri- or extra-oral soft tissues such as flat scales and crocodilian-like integumentary sensory organs. Clearly, the mere presence of foramina is not enough to guarantee that a keratinous rhamphotheca was present, nor enable us to make specific claims about the extent or shape of the cornified sheath.

No work has yet attempted to utilize quantitative comparisons with living birds, the only clade of extant dinosaurs, to develop testable hypotheses about the specific dimensions and properties of the beak in extinct taxa. We investigated the correlation between rhamphotheca and premaxilla morphology in avian and non-avian dinosaurs to reconstruct the presence and shape of the beak in extinct taxa. We find that the presence, extent, and curvature of the rhamphotheca are significantly predicted by the anatomy and surface morphology of the premaxilla in extant birds, and extend these relationships to infer the morphology of extinct theropods. In particular, relative porosity of the premaxilla can be used to predict the extent of the soft tissue-only component of the maxillary rostrum in theropods. When phylogeny is accounted for, quantification of the shape and surface texture of the rostrum allows us to generate data-driven hypotheses of soft tissue ecomorphology in edentulous and partially edentulous extinct taxa.

Grant Information
Georgia Ornithological Society|Bill Terrell Graduate Research Grant, 2016

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

ASSESSING PATTERNS OF ECOLOGICAL ASSOCIATION AND HABITAT PREFERENCE IN NORTH AMERICAN DINOSAURS

BYKOWSKI, Richard J., Georgia Southern University, Statesboro, GA, United States of America

Dinosaur-bearing formations of North America preserve a record of environmental change and biotic turnover during the Mesozoic. For example, across the Jurassic/Cretaceous boundary, we observe the transition from the dry, savannah-like paleoenvironment of the Late Jurassic Morrison Formation to the wetter, more coastal environments of the Campanian Dinosaur Park and Maastrichtian Hell Creek Formations. Within these ecosystems, we see the decline of sauropod/allosauroid-dominated ecosystems and the rise of ornithischian/tyrannosaurid-dominated ecosystems. Knowing how dinosaur clades responded to changing environmental conditions is crucial for our understanding as to why these biotic transitions occurred. To assess this, I tested for environmental associations among North American dinosaur clades using a comprehensive database of genus-level fossil occurrences from the Paleobiology Database and primary literature. Using a rank-index for three environmental variables (temperature: 1–6, precipitation: 1–6, and paleoenvironment: 1–5) from published interpretations of dinosaur-bearing formations, I scored each taxon's occurrence in a given formation and used an abundance-average for each genus to test for potential habitat preferences and partitioning among conspecific taxa. Among herbivorous clades, only sauropods showed a consistent preference ($p<0.05$) for hotter, drier, more inland habitats compared to other herbivorous groups. Preferences for these types of habitats might have contributed to sauropods' absence from the fossil record of North America from the Cenomanian until the latest Cretaceous. Among other conspecific herbivores, only ceratopsids differed, with chasmosaurines preferring wetter habitats than centrosaurines ($p=0.005$). Carnivores showed no significant differences ($p>0.05$) for any variable indicating no environmental preference and suggesting any habitat partitioning was due to other factors, such as prey preference. Yet, although this study did not detect conclusive habitat preferences among North American dinosaurs, individual faunal assemblages from successive time bins appear to respond to the Jurassic-Cretaceous environmental transition illustrating significant differences within all three variables (PERMANOVA: $F=42.2$, $p=0.001$). These results suggest a more global, comprehensive database of dinosaur occurrences and environmental metrics may be needed to determine for certain whether any of these patterns are valid or a mere taphonomic artifact.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

FOSSIL EGGSHELLS AND TWO PERINATAL DINOSAURS FROM THE EL GALLO FORMATION (LATE CRETACEOUS), EL ROSARIO, BAJA CALIFORNIA, MEXICO

CABRERA HERNÁNDEZ, Jonathan S., Centro Universitario de Ciencias Biológicas y Agropecuarias, UDG, Zapopan, Jalisco, Mexico; HERNÁNDEZ RIVERA, René, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico; MONTELLANO, Marisol, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico

In the area of El Rosario, Baja California, outcrops of the Campanian-aged El Gallo Formation comprise a non-marine sedimentary sequence. A diverse terrestrial vertebrate assemblage has been recovered from these beds. Recently, remains of two perinatal dinosaurs and several eggshell fragments were collected from three microsites. The eggshells were identified by thin sections studied under a polarized light microscope and by scanning electron microscopy. Three oofamilies have been recognized: Spheroolithidae, Prismatoolithidae, and Gekkolithidae. The oogenus *Spheroolithus* was identified from its prolatosferulitic morphotype: a prolatocanaliculate pore system with smooth external surface, and some fragments showing a sagenotuberculate or ramotuberculate ornamentation. The oogenus *Guegoolithus*is is recognized because the acicular radial ultrastructure at the base of the shell units is separated from the overlying region of the radial-tabular structure by an irregular boundary, with a prominent sagenotuberculate ornamentation that comprises one-third of the eggshells´ thickness. The eggshells assigned to *Prismatoolithus* (Prismatoolithidae) show a smooth outer surface, with an angustiprismatic morphotype: shell units composed of two structural layers of calcite, with a gradual transition between mammillary and prismatic layers and a mammillary/prismatic layer thickness ratio 1:2.11–2.16. The Gekkolithidae eggshells consist of columnar shell units with irregular boundaries between them, and an ornamentation of domed tubercles and conical nodes in which the pore opening occurs within the center of the domed tubercles. One of the perinatal specimens, associated with eggshell fragments, consists of disarticulated postcranial bones, including several vertebrae, a nearly complete right humerus, a mid-shaft fragment ofa humerus, a proximal fragment of femur, and metacarpal II of an embryonic-nestling stage of a hadrosaurine hadrosaur. The associated eggshells are recrystallized, making it difficult to determine to which ootaxa they belong. The other perinatal specimen includes semi-articulated cranial elements of a late-nestling kritosaurine hadrosaur. Owing to the dorsolateral expansion of the medial margin of the lateral process of the premaxilla and a great ventral expansion of the ventrocaudal flange of the jugal, this specimen is referred to *Gryposaurus*. These dinosaurs are the first hadrosaurines recovered from the El Gallo Formation, and are the first perinatal dinosaurs reported from Mexico.

Grant Information

We thank the support of DGAPA, through the projects PAPIIT IN 100913 and IN103616.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

BIOGEOGRAPHY OF LATE CRETACEOUS NORTH AMERICAN DINOSAURS: AN APPLICATION OF CLADISTIC BIOGEOGRAPHY TO EXTINCT BIOTAS

CAHAL, Joshua C., Katy, TX, United States of America

The Mesozoic had a rich diversity of animals that included some of the largest megafauna in Earth's history. Virtually all megafauna and much of the diversity of smaller terrestrial vertebrates from this era come from a single clade, the Dinosauria. The Mesozoic dinosaurs are one of the most heavily studied extinct organisms and persisted through a geologically dynamic part of Earth's history (the breakup of Pangaea, development of the Western Interior Seaway, etc.). These three factors (rich diversity, substantial amount of research, geologically dynamic history) make dinosaurs a model organism for biogeographical studies of fossil organisms. Most studies have relied on direct interpretation of fossil distribution to test biogeographic hypotheses and very few have employed cladistic biogeography as a method to test and develop biogeographic hypotheses. The studies that use cladistic biogeography tend to focus on large spatial and temporal scales (i.e., continents and epochs). Presented here is the first study to use cladistic biogeography to study dinosaur distributions on the smallest possible temporal and spatial scales, focusing primarily on North American biotas of the Late Cretaceous where multiple areas of endemism can be found.

For North America, the latter part of the Late Cretaceous can be broken up into three faunal stages (the Judithian, the Edmontonian, and the Lancian), cumulatively lasting about 18 Ma and coinciding with an onerous time in North America, where the Western Interior Seaway both transgressed and regressed. The last faunal stage, the Lancian, has been of particular interest due to its marked difference from the prior two stages. Here Brooks Parsimony Analysis was used to interpret the biogeographic history North American areas of endemism from the three faunal stages of the Late Cretaceous. Results yielded a well resolved general area cladogram that was used not only to test hypotheses about the spatial distribution of these animals but the temporal distributions as well. Findings are consistent with the hypothesis that dinosaurs from the Lancian arose from the expansion of upland refugia.

Technical Session XVIII (Saturday, October 20, 2018, 3:15 PM)

THE PHYLOGENETIC RELATIONSHIPS OF ENTOPTYCHINE GOPHERS AND THE RISE OF BIOLOGICAL DIVERSITY IN BURROWING RODENTS

CALEDE, Jonathan J., The Ohio State University, Marion, OH, United States of America

Burrowing is a very successful ecology present in numerous taxa across the vertebrate tree. Some clades have evolved adaptations for digging repeatedly. Rodents are one of those groups; fossoriality has evolved at least nine times within Rodentia. Several families of rodents have succeeded one another in the dominant role within the burrowing herbivore niche since the start of the Arikareean North American Land Mammal Age, 30 million years ago (Ma). Palaeocastorine beavers occupied this role 30 to 26 Ma; gophers (family Geomyidae) occupied it 26 to 23 Ma, and do again since 4.5 Ma. Together, these taxa provide an opportunity to explore the tempo and mode of the evolution ofdiversity.

Such investigation requires the development of a time-calibrated phylogeny for the subfamily Entoptychinae. I present such a framework including all known species of entoptychine gophers as well as several unpublished new taxa. My analysis of more than 30 species using discrete and quantitative characters as well as unpublished radiometric dates and occurrence data reveals a protracted dominance of gophers over the burrowing herbivore niche that was driven by multiple pulses of diversification.

Gophers underwent rapid rises in species diversity around 29 Ma, 26 Ma, 23.5 Ma, and again 20 Ma. The first of these waves of diversification corresponds to speciation within the genera *Pleurolicus* and *Entoptychus*; the second to diversification within *Entoptychus*; the third to speciation within *Gregorymys*, and the last to the appearance of the genus *Ziamys* and a second spur of diversification within *Pleurolicus*.

This new phylogenetic tree for Entoptychinae enables comparisons with a published phylogeny of palaeocastorines. The assessment of phylogenetic lineage diversity between the two clades shows differences in the patterns of radiation. Specifically, the diversification of geomyids persists across the tree throughout the evolutionary history of the clade whereas the diversification events within Palaeocastorinae are concentrated in isolated sections of the group's tree. These differing modes of evolution suggest different pathways to high species richness and ecological success.

Grant Information

This research is supported by The Ohio State University College of Arts and Sciences and a Paleontological Society Norman Newell Early CareerGrant.

Technical Session II (Wednesday, October 17, 2018, 9:15 AM)

BONE HISTOLOGY OF AN ELASMOSAURID (SAUROPTERYGIA, PLESIOSAURIA) FROM THE UPPER CRETACEOUS (CAMPANIAN) DINOSAUR PARK FORMATION OF SOUTHERN ALBERTA

CAMPBELL, James A., University of Calgary, Calgary, AB, Canada; MITCHELL, Mark T., Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; WERNING, Sarah, Des Moines University, Des Moines, IA, United States of America; ANDERSON, Jason S., University of Calgary, Calgary, AB, Canada

Plesiosaurs are secondarily-aquatic Mesozoic reptiles known predominantly from marine deposits. They have also been documented from non-marine units such as the fluvial and estuarine sediments of the Upper Cretaceous (Campanian) Dinosaur Park Fm (DPF) of southern Alberta. Deposited along the western margin of the Western Interior Seaway, these sediments have yielded a stratigraphically extensive collection of elasmosaurid fossils. This assemblage is unusual in that all members are small-bodied relative to marine taxa, but it is not known whether they represent juveniles or small-bodied adults. Despite 120 years of collecting, body length estimates for DPF elasmosaurids have been hindered by poor preservation, and age assessments have been restricted to relative methods (e.g., degree of neurocentral fusion).

TMP 2009.037.0068 is a partial skeleton from the Lethbridge Coal Zone and represents the most complete DPF elasmosaurid. Although the neck (long in elasmosaurids) is not preserved, we estimate a total length of 4–5 m for this individual based on its trunk length of 1.3 m. Its skeletal elements are comparable in size to other DPF specimens, but are only half the length of contemporaneous marine taxa. To estimate age, we histologically sampled a humerus and rib.

The humerus is largely characterized by radially-vascularized, fibrolamellar bone, suggesting rapid growth early in life. At least four closely-spaced lines of arrested growth (LAGs) are visible in the outermost cortex on the dorsal margin. There is a marked decrease in the spacing between these LAGs, possibly representing an external fundamental system, but at least indicating that this individual was approaching asymptotic size. The rib is extensively remodelled internally, but has slowly-deposited lamellar-zonal bone in the

outer cortex, with possibly nine LAGs on the anteroventral margin. The difference in LAG count in the rib vs. the humerus likely reflects inter-elemental differences in growth rate. We interpret TMP 2009.037.0068 as an adult of a small-bodied taxon. Despite having grown for at least four years (probably more), this individual was not osteologically mature at the time of death; neurocentral sutures are closed in only 1/3 of the preserved vertebrae. The diminutive size of elasmosaurids in the DPF may represent an adaptation to the physically-constraining fluvial and estuarine environments recorded in this unit, a possible example of niche-partitioning within a predominantly marine group of extinct tetrapods.
Grant Information
NSERC Discovery Grant 307756-2011 (J.S.A.)
NSERC PGS-D (J.A.C.)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A JUVENILE CORYTHOSAUR (LAMBEOSAURINAE) FROM THE WAPITI FORMATION OF WESTERN ALBERTA, CANADA

CAMPIONE, Nicolás, University of New England, Armidale, Australia; BELL, Phil R., University of New England, Armidale, Australia; SISSONS, Robin, Edmonton, AB, Canada; FANTI, Federico, Alma Mater Studiorum - Università di Bologna, Bologna, Italy; SULLIVAN, Corwin, University of Alberta, Edmonton, AB, Canada; VAVREK, Matthew J., Royal Ontario Museum, Toronto, ON, Canada

The Wapiti Formation (WF) spans some 12 million years (~79–67 Ma), equivalent to the famed dinosaur-bearing beds of the Belly River and Edmonton groups in southern Alberta. Unlike these units, the WF preserves a continuous terrestrial record filling major gaps left by marine transgressions (e.g., Bearpaw Formation). The WF, therefore, provides important insights into macroevolutionary dynamics during the Late Cretaceous and, given the inferred high paleolatitudes for this region, faunal interchange with its southern counterparts. Despite these obvious incentives, collecting and prospecting in the WF are hampered by the restriction of surface outcrops to river valleys and it is only recently that we are beginning to uncover the faunal diversity of these deposits.

Here we present the first lambeosaurine from the WF, found in the Bearpaw-equivalent Unit 3. Discovered in 2017 along the northern bank of the Wapiti River, the skeleton preserves a number of features that permit taxonomic evaluation, despite its juvenile state. The cranial anatomy, specifically the crest, reveals a bifurcated nasal, typical of both *Corythosaurus* and *Hypacrosaurus* but not *Lambeosaurus*. Diagnostic characters of the former genera are difficult to assess in juveniles, but the anteriorly straight to convex lacrimal and the <140° crest angle are more typical of *Corythosaurus*. Assessment of growth in the crest angle among contemporaneous lambeosaurines (N=52) places the WF specimen outside the range of variation of *Hypacrosaurus* and within the trajectories of *Corythosaurus* and *Lambeosaurus*. A broader multivariate analysis based on a principal component analysis of 12 cranial measurements reveals that crest angle is a major driver of size-independent variation among these taxa and similarly places the WF specimen among *Corythosaurus* variants.

Corythosaurus is well-known from the lower, sandy strata of the Dinosaur Park Formation (DPF). Its discovery in Bearpaw-equivalent deposits extends its temporal range to ~74–73.4 Ma and suggests that taxa along the *Corythosaurus* lineage may have dispersed north, likely tracking environmental changes resulting from the major transgression of the Western Interior Seaway that covered southeastern Alberta during this time. Rates of lambeosaurine evolution, inferred from the DPF, and certain crest characters suggest it is unlikely that the WF *Corythosaurus* pertains to one of the known species. However, owing in large part to its juvenile state, the specific affinities of the WF *Corythosaurus* remain uncertain at this time.

Grant Information
Research supported by grants from the Dinosaur Research Institute, logistical aid from the Grande Prairie Regional College, and an endowment from the County of Grande Prairie.

Technical Session VII (Thursday, October 18, 2018, 2:45 PM)

NEW DATA ON THE SKELETAL DISTRIBUTION OF MEDULLARY BONE IN NEORNITHES: PALEOBIOLOGICAL IMPLICATIONS

CANOVILLE, Aurore, North Carolina State University & North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; SCHWEITZER, Mary H., North Carolina State University & North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; ZANNO, Lindsay E., North Carolina Museum of Natural Sciences & North Carolina State University, Raleigh, NC, United States of America

Medullary bone (MB) is an estrogen-dependent, sex-specific tissue produced by female birds during the laying cycle, inferred to be present in some extinct archosaurs. Preliminary studies documenting the skeletal distribution of MB in living birds suggest that the tissue can be deposited within the cavities of most skeletal elements, including skull bones. However, these studies are restricted to commercial layers or hormonally-treated male pigeons, which are poor analogues for wild birds. By contrast, studies in wild bird species, based upon limited sampling of skeletal elements, have noted the presence of MB almost exclusively within limb bones. This has spurred the common misconception that MB is mostly formed in long limb bones, such that its presence in some extinct archosaurs has been debated based on "unusual" anatomical locations of MB-like tissues. Previous works also reported that the amount of MB deposited in the limbs follows a decreasing proximo-distal gradient from stylopod to autopod, hypothesized to result from decreasing blood supply (and thus estrogen) throughout the limb. Finally, some studies hypothesized that MB should be scarce or absent in pneumatized elements and that its skeletal distribution might differ between wild and captive birds.

To document the skeletal distribution of MB across the avian phylogeny, reassess previous hypotheses pertaining to its distribution patterns, and develop a set of criteria from which to evaluate purported MB tissue in fossil archosaurs, we subjected the (sub-) complete skeletons of 40 female birds (38 species) that died at different stages of the egg-laying cycle to examination using micro-computed tomography. Our sample is representative of the taxonomic, ecological, and body-size diversity of extant Neornithes.

We show that the skeletal distribution of MB varies interspecifically, but does not differ between captive and wild-caught individuals. Furthermore, we find MB in virtually all skeletal elements, including cranial elements, and note that it is uniformly present in the proximal part of the tibiotarsus of all studied specimens. Although rare in autopodial elements, MB can be found in great quantity in the tarsometatarsus and carpometacarpus. Finally, we often observed MB in pneumatized skeletal elements, contrasting with prior suggestions that skeletal pneumaticity acts as a constraint against the deposition of MB. Thus, we find anatomical location of purported MB in extinct archosaurs to be an invalid criticism against the potential reproductive nature of these tissues.

Grant Information
This research project was funded by NSF award #1552328

Technical Session IX (Friday, October 19, 2018, 8:30 AM)

TAXONOMIC AND ECOMORPHOLOGICAL DIVERSIFICATION IN HORSES

CANTALAPIEDRA, Juan L., Universidad de Alcalá, Alcalá de Henares, Spain; PRADO, Jose Luis, Universidad Nacional del Centro de la Provincia de Buenos Aires (UNICEN), Olavarría, Argentina; SANISIDRO, Oscar, University of Kansas, Lawrence, KS, United States of America; ALBERDI, María Teresa, Museo de Ciencias Naturales, Madrid, Spain

The fossil record of horses is rich and well-known. It also spans the last 60 million years, covering a period of marked ecological shifts in terrestrial ecosystems. Thus, horses are a perfect study group to assess the connections between changes in abiotic settings, phenotypic adaptations, and diversity. We ask whether diversification in horses is related to shifts in phenotypic functional traits. We surveyed the NOW and the Paleobiology databases, using the literature to solve synonyms and maximize occurrence data. Finally, we gathered 3148 occurrences of 233 horse species, for which we also compiled information of body size, hypsodonty, number of functional toes, and seven traits that reflect molar function: presence of acute lophs, occlusal morphology, presence of coronal cementum, overall tooth shape, number of lingual cusps, number of longitudinal lophs, and number of transversal lophs. Using *PyRate* to analyze our fossil occurrences, we estimated speciation and extinction through time while controlling for sampling heterogeneity. We found that horse diversification was constant through time, with extinction surpassing speciation just in the last 2 million years. When the Neogene radiation of equine horses was analyzed separately, we did find evidence for an early speciation pulse of the group beyond sampling effects. We constructed several time-calibrated trees for the 233 horse species using an informal super tree approach. We placed a total of 213 species in a functional space using a Principal Component Analysis (PCA) based on their functional traits and used phylogeny-based techniques to model the first two components of the PCA (85% of the variance). We found large macroevolutionary shifts in optimal molar functionality (PC1) between 25 and 20 Ma, whereas evidence for shifts in optimal body size and functional toes (PC2) was weak. In fact, PC2 evolved faster and under more relaxed selective pressures and constraints than molars. When analyzed separately, equine horses show an early Miocene speciation burst that postdates by 5 million years the shifts in selection pressures. This suggest that, whereas shifting selection pressures shaped horse ecomorphology, diversity trends respond to other modulating factors.

Grant Information
JLC was funded by the German Research Foundation (DFG, AOBJ: 637491) and Talent Attraction Program of the Madrid Government (2017-P1/AMB-5298).

Technical Session XIV (Saturday, October 20, 2018, 12:00 PM)

SABER-TOOTHED GIANT ANCHOVIES (TELEOSTEI, ENGRAULOIDEA) FROM THE EARLY–MIDDLE EOCENE OF BELGIUM AND PAKISTAN

CAPOBIANCO, Alessio, University of Michigan, Ann Arbor, MI, United States of America; FRIEDMAN, Matt, University of Michigan, Ann Arbor, MI, United States of America; BECKETT, Hermione, University of Oxford, Oxford, United Kingdom; GINGERICH, Philip D., University of Michigan, Ann Arbor, MI, United States of America; CARNEVALE, Giorgio, Università degli Studi di Torino, Torino, Italy

Clupeiforms (herrings, anchovies, and relatives) are widely distributed and both ecologically and economically significant. Despite their prominence in modern ecosystems and a wealth of paleontological material, the fossil record of Cenozoic clupeiforms has received comparatively little attention.

We undertook a revision of the fossil species *Clupeopsis straeleni* from the marine Ieper Formation of Belgium (middle-late Ypresian, 54–50 Ma). Known from a single specimen originally described as a toothless clupeid, *Clupeopsis* is unusual among Cenozoic clupeiform specimens in being preserved in three dimensions. External examination of the fossil corroborates a clupeiform interpretation, but the geometry of the jaws seems inconsistent with clupeid affinity. MicroCT reveals distinctive—and unanticipated—dentition in *Clupeopsis*, comprising well-developed caniniform teeth on the lower jaw and a single, giant vomerine fang on the palate. The maxilla is completely devoid of teeth. Strikingly, the suspensorium of *Clupeopsis* bears some features that are uniquely found in engraulids (anchovies), such as a posteriorly reclined hyomandibula with an elongated ventral limb that reaches the quadrate. Fangs in *Clupeopsis* are developed to a greater degree than in any living anchovy with caniniform dentition and are comparable to those found in chirocentrids (wolf herrings).

We have also discovered a *Clupeopsis*-like specimen from the Domanda Formation of Pakistan (middle–late Lutetian, 46–40 Ma). Similarly, it displays caniniform lower teeth and a single upper fang, but with even more extreme proportions than the Belgian specimen. The Domanda Formation fossil shows that large-toothed, macrophagous clupeiforms were present both in the Indo-Pacific and in the Northeastern Atlantic during the early–middle Eocene, reinforcing the strong biotic affinities between these two marine regions in the Paleogene.

The combination of engraulid-like suspensorium and chirocentrid-like fanged jaws in these early Eocene clupeiforms raises questions about the evolution of both these traits—as well as macrophagy—within Clupeiformes. Although some have hypothesized a relationship between chirocentrids and engraulids, molecular evidence does not clearly support this link. A better understanding of relationships among modern clupeiforms in general, and clupeoids in particular, will help clarify these patterns of ecological evolution.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE UTILITY OF PHYSICAL TAPHONOMIC CHARACTERISTICS TO RESOLVE TIME IN REWORKED MICROVERTEBRATE ASSEMBLAGES

CAPTEIN, Jacob J., University of New Mexico, Albuquerque, NM, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America

Establishing the age relationships of microvertebrate fossils from reworked, concentrated assemblages has been a long-standing paleontological problem. In rare cases a reworked assemblage may contain specimens spanning a major faunal shift, providing the a priori ability to differentiate older from younger specimens in the assemblage. Using sediment from the Bug Creek locality in McCone County, Montana that includes reworked fossils from directly before and after the K-Pg extinction, we aim to determine whether there are quantifiable taphonomic differences between the older and younger fossils in the assemblage. To do this we examine a variety of physical characteristics, including: size; shape; color; weathering; and abrasion of specimens from Cretaceous-specific and Paleogene-specific species. Should one or more of those physical properties demonstrate discrete patterns of change across the boundary then a model could be constructed to assign any given fossil in the assemblage to either period, and hence recover previously unavailable temporal relationships.

All vertebrate specimens were collected from over 100 kilograms of screenwashed sediments from Bug Creek. Fossils were separated into Cretaceous, Paleogene, or boundary-crossing taxa. No significant differences between the taphonomic patterns of the Cretaceous and Paleocene fossils have been uncovered. This suggests that despite the major, ecology-shifting extinction event, the taphonomic processes in the region remained mostly similar over the interval captured by the Bug Creek deposits. Furthermore it suggests that physical taphonomic characteristics of reworked, concentrated microvertebrates are likely a poor estimator of residence in the taphonomically active zone.

Podium Symposium (Friday, October 19, 2018, 11:45 AM)

***ARCHAEOPTERYX HOLOGRAPHICA*: BRINGING THE URVOGEL BACK TO LIFE WITH SCIENTIFIC ANIMATION AND VR/AR**

CARNEY, Ryan, University of South Florida, Tampa, FL, United States of America; KAPLAN, Howard, University of South Florida, Tampa, FL, United States of America; KIRK, Alex, University of South Florida, Tampa, FL, United States of America; BAINES, Alec, University of South Florida, Tampa, FL, United States of America; MASON, Spenser, University of South Florida, Tampa, FL, United States of America

Recent technological advances are providing new possibilities for imaging, animating, and visualizing morphology in 3D, including virtual reality and augmented reality (VR/AR). Here, a photorealistic 3D *Archaeopteryx* skeleton was reconstructed using multiplanar X-ray microtomosynthesis and macrophotogrammetry of the Thermopolis specimen (WDC-CSG-100). 32-bit .tif stacks (26 total) from the former were segmented using Avizo Fire software (FEI), and digital photographs (~21K total) from the latter were processed using RealityCapture photogrammetry software (Capturing Reality).

To animate the skeleton, articular joint surfaces were analyzed and rigged with 3D coordinate systems using Geomagic (3D Systems) and Maya (Autodesk), respectively. Next, *in vivo* locomotion datasets from extant archosaurs that phylogenetically bracket *Archaeopteryx*—alligator (*Alligator mississippiensis*) and chukar (*Alectoris chukar*)—were analyzed using marker-based X-ray Reconstruction of Moving Morphology. The resulting kinematic data was used to directly drive select joints in the *Archaeopteryx* model using scientific motion transfer, and to indirectly inform animation of otherjoints.

To create low-polygon anatomical assets usable in VR/AR, the high-resolution *Archaeopteryx* bone models were decimated and retopologized using ZBrush (Pixologic). The photogrammetry data was used to create texture maps and/or sprite sheets (.tif, .png), and subsequent normal maps were created using CrazyBump, xNormal, and the NVIDIA normal map filter in Adobe Photoshop. The Unity (Unity Technologies) game engine was used to develop custom VR/AR apps, which were deployed to various platforms such as smartphones and HoloLens (Microsoft).

The immersive and dynamic nature of VR/AR enables novel insights and methods for communicating complex 3D data and concepts, such as flight stroke kinematics and morphological evolution. These technologies also provide exciting new opportunities to inspire and engage students and the public. For example, augmented paleontology apps can anchor 3D digital models onto 2D analog target images, to retrofit existing textbook illustrations or museum displays. Bringing dinosaurs "back to life" with immersive digital content, such as interactive holograms, provides the "gateway science" of paleontology with new avenues to foster interest in STEM fields and inspire the next generation of scientists.

Grant Information

This work was supported by software donations from Capturing Reality and FEI to Ryan Carney.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A NEW PLIOPLATECARPINE MOSASAUR FROM THE BEARPAW FORMATION, MONTANA, U.S.A.: TAXONOMIC AND PALEOBIOLOGIC IMPLICATIONS

CARR, Richard, Earth Sciences Department and Museum of the Rockies, Montana State University, Bozeman, MT, United States of America; SCANNELLA, John, Museum of the Rockies; Montana State University, Bozeman, MT, United States of America

Plioplatecarpine mosasaurs were a widely distributed group of marine reptiles whose remains have been recovered throughout North America and parts of Europe. Despite this broad geographic range, only one specimen has previously been reported from Montana: the holotype of *Plioplatecarpus peckensis*. MOR 1093 is a previously undescribed mosasaur from the Upper Cretaceous Bearpaw Formation of eastern Montana. This specimen preserves a majority of the skull, part of the cervical and dorsal vertebral series, many ribs, and a shoulder girdle. Of particular note is the preservation of the calcified tympanic membrane, an extracolumella, and the endosseous labyrinth. The morphology of the endosseous labyrinth is comparable to specimens of *Plioplatecarpus*. This genus is characterized, in part, by the position of the parietal foramen and the morphology of the cephalic condyle of the quadrates, which match the condition noted in MOR 1093.

Phylogenetic analysis recovered MOR 1093 as a member of the genus *Plioplatecarpus* in a sister group relationship to the unresolved clade consisting of the geologically youngest *Plioplatecarpus* species (including *P. peckensis*). Preliminary results of this study indicate that MOR 1093 may represent either ontogenetic variation within a previously described species of *Plioplatecarpus*, or a new taxon morphologically intermediate between *P. nichollsae* and *P. primaevus*. This specimen provides further insight into the phylogeny, paleobiogeography, and paleoecology of *Plioplatecarpus* in the Bearpaw Formation.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

SIGNIFICANT GEOGRAPHIC RANGE EXTENSION FOR THE SYMPATRIC TYRANNOSAURIDS *ALBERTOSAURUS LIBRATUS* AND *DASPLETOSAURUS TOROSUS* FROM THE JUDITH RIVER FORMATION (LATE CAMPANIAN) OF NORTHERN MONTANA

CARR, Thomas D., Carthage College, Kenosha, WI, United States of America

Evidence for the southward geographic range extension of the late Campanian tyrannosaurids *Albertosaurus libratus* and *Daspletosaurus torosus* was found in the collections of the Museum of the Rockies (MOR, Bozeman). The fossils were collected from the Judith River Formation (JRF) of Montana, which include an isolated postorbital (MOR 1196) and a maxilla (MOR 395). The fossils are a long overdue opportunity to compare, at the species level, the JRF tyrannosaurids with those from the Belly River Group (BRG) of Alberta. These diagnostic bones are a major improvement over published tyrannosaurid fossils from the JRF, based on specimens (e.g., a partial dentary, isolated postcranial bones, and teeth) that are inadequate for species-level assessment.

The postorbital was collected in Hill County; it can be referred to *A. libratus* based on (1) a small cornual process that (2) consists of a dorsal ridge and a ventral boss that (3) is positioned close to the orbital margin and (4) does not extend toward the laterotemporal fenestra, and (5) a stout and tapering squamosal process. The bone is 156.2 mm tall, which is shorter than the 188.4 mm tall bone of the type specimen, CMN 2120. The bulbous cornual process and overall size shows the specimen corresponds to the adult growth stage. The maxilla was collected from Blaine County, on BLM land, and is referable to *D. torosus* based on (1) a large maxillary fenestra that is (2) longer than tall, and (3) a coarse subcutaneous surface rostral to the external antorbital fenestra. The bone is 484.2 mm long, which is smaller than the 612.0+ mm long bone of the type specimen, CMN 8506. Its small size and a high count of 16 dental alveoli shows it is from a subadult. The long and low maxillary fenestra distinguishes it from the stratigraphically younger *D. horneri*.

The identifications of these fossils implies that they correlate to the Dinosaur Park Formation (DPF) of Alberta, from which *A. libratus* and *D. torosus* are known. However, the JRF correlates with the entire BRG. Other dinosaurs collected from Hill County, such as the hadrosaurid *Probrachylophosaurus burgei*, correspond to radiometric dates that range from 79.8 to 79.5 Ma, which correlates to the upper Foremost and lower Oldman formations of Alberta, which are older than the DPF. The chronological ages of the tyrannosaurid fossils await clarification before placing them in a precise chronostratigraphic position. Based on the pattern seen in Alberta, it is reasonable to predict that *A. libratus* and *D. torosus* were sympatric apex predators at the southern end of their known range.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

TESTING GEOGRAPHIC RANGE SHIFT AS AN EXPLANATION FOR HYPERTHERMAL MAMMAL BODY SIZE CHANGES

CARROLL, Abigail R., Amherst College, Amherst, MA, United States of America; ROWE, Rebecca J., University of New Hampshire, Durham, NH, United States of America; CLYDE, William C., University of New Hampshire, Durham, NH, United States of America

Previous work has suggested that decreases in mammal body size may be a common response to ancient rapid global warming events (i.e., 'hyperthermals'). For instance, during the Paleocene–Eocene Thermal Maximum (PETM; ~56 Ma), fossil evidence from the strata of Wyoming's Bighorn Basin suggests that early equids decreased in body size by 30% in response to ~5–8 degrees Celsius of warming. During a subsequent hyperthermal event known as ETM2 (~54 Ma), the same lineage of equids decreased in size by ~14% in response to ~3 degrees Celsius of warming. Body size interpretations were based on tooth size measurements, as tooth size can be used as a proxy for body size in adult mammals. Here, we test whether the presence of 'dwarfed' equids in the Bighorn Basin during the PETM and ETM2 hyperthermals may have been the result of a geographic range shift of smaller-bodied individuals from lower latitudes, rather than an in situ change in body size (e.g., anagenesis or phenotypic plasticity). To test whether range shift is a viable explanation, we identify a modern analog to early equids that exhibits Bergmann's rule, a positive relationship between latitude and body size. The biological similarities between modern African duikers (*Philantomba monticola* and *Philantomba maxwellii*) and Eocene equids make them a fitting taxon to test whether the body size changes observed during the early Paleogene hyperthermals could be due to a climate-driven range shift. A bivariate linear regression analysis of duiker tooth size on latitude yielded a statistically significant positive correlation ($r^2 = 0.1811$, slope = 0.024, n = 172, $p < 0.0001$), suggesting duikers follow Bergmann's rule. If the latitude-tooth size relationship of early equids was similar to that of duikers, then the difference between their pre- and mid-PETM tooth size values suggests a total geographic range spanning ~10 degrees latitude. Similarly, the ETM2 tooth size values suggest a geographic range of ~4 degrees latitude. Therefore, if early equids from the most southern extents of their geographic range shifted into the most northern extents of their geographic range during either of the early Eocene hyperthermals, the entirety of the tooth size decrease observed in the stratigraphic records surrounding the PETM and ETM2 hyperthermals can be explained.

Technical Session XVIII (Saturday, October 20, 2018, 3:45 PM)

OLDEST SKELETON OF A FOSSIL FLYING SQUIRREL (SCIURINAE, PTEROMYINI) ALLOWS FOR A RECALIBRATION OF THE TIME OF ORIGIN AND DIVERSIFICATION OF THE GROUP

CASANOVAS-VILAR, Isaac C., Institut Catala de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Bellaterra, Spain; GARCIA-PORTA, Joan, Centre de Recerca Ecològica i Aplicacions Forestals (CREAF), Universitat Autònoma de Barcelona (UAB), Bellaterra, Spain; FORTUNY, Josep, Institut Catala de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Bellaterra, Spain; SANISIDRO, Óscar, 4Biodiversity Institute, University of Kansas, Lawrence, KS, United States of America; PRIETO, Jérôme, Ludwig-Maximilians-Universität München, Munich, Germany; QUEREJETA, Marina, Centre de Recerca Ecològica i Aplicacions Forestals (CREAF), Universitat Autònoma de Barcelona (UAB), Bellaterra, Spain; LLÁCER, Sergio, Institut Catala de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Bellaterra, Spain; ROBLES, Josep M., Institut Catala de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Bellaterra, Spain; BERNARDINI, Federico, Centro Fermi, Museo Storico della Fisica e Centro di Studi e Ricerche 'Enrico Fermi', Rome, Italy; ALBA, David M., Institut Catala de Paleontologia Miquel Crusafont, Universitat Autònoma de Barcelona, Bellaterra, Spain

Flying squirrels (Sciurinae, Pteromyini) have been classically regarded as a distinct subfamily among the Sciuridae, and even sometimes considered a separate family derived from a different group than the remaining sciurids. The fact that presumed fossil flying squirrels are at least as old as (or even older than) tree squirrels may support the latter hypothesis. Flying squirrels are currently recognized as a monophyletic clade, as supported by a set of synapomorphies in the wrist related to their particular gliding position, which differs from that of all other gliding mammals. Molecular phylogenies further indicate that flying squirrels are nested within tree squirrels (subfamily Sciurinae) and likely diverged as recently as the latest Oligocene–early Miocene (23 ± 2.1 Ma). Notwithstanding, the pteromyin fossil record, almost exclusively consisting of isolated cheek teeth, suggests a much older split dating back to the late Eocene of North America (36.6–35.8 Ma). This discrepancy of nearly 15 million years may result from the identification of fossil flying squirrels exclusively on the basis of dental features that are also present in other sciurids. As for today, postcranial remains of extinct flying squirrels, which show diagnostic characters of the pteromyins, have not been described.

We report the oldest known partial skeleton of a fossil flying squirrel from the Miocene of Catalonia (Spain), which is attributed to *Miopetaurista neogrivensis* and dates back to 11.6 Ma. The wrist bones unambiguously show that it displayed the gliding adaptations of extant pteromyins and indicate that it belongs to the large-sized flying squirrel clade. This new fossil evidence allows for a recalibration of the divergence date between tree and flying squirrels using two independent phylogenetic approaches that combine morphological and paleontological data: total evidence and node dating analysis. Both methods provide older estimates for this event (most probably around 31–25 Ma), which are still consistent with previous molecular studies and further indicate that fossils older than 31 Ma are unlikely to belong to the flying squirrel clade. In addition, total evidence analysis recognizes *Miopetaurista* as the sister taxon of the extant *Petaurista*, their striking morphological similarities further showing that giant flying squirrels have undergone little evolutionary change for almost 12 million years.

Grant Information

CGL2016-76431-P, CGL2017-82654-P (AEI/FEDER, EU), RYC-2013-12470 to I.C.-V., FJCI-2014-20380 to J.G.-P. (MINECO/FEDER, EU), Generalitat de Catalunya (CERCA Programme)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

CHANGES IN ROSTRAL LENGTH UNDERLIES SPECIES DIVERSIFICATION IN LATEST OLIGOCENE EKTOPODONTID MARSUPIALS FROM SOUTH AUSTRALIA

CASE, Judd A., Eastern Washington University, Cheney, WA, United States of America

Most mammalian paleospecies are differentiated based on minor differences in their respective dentitions. For the Australian marsupial family Ektopodontidae, this is a more difficult task due to the complex nature of the upper molars, where the anterior and posterior lophs are composed of a series of cusps with ridges and struts descending the anterior and posterior faces of the lophs. While the molar morphologies between latest Oligocene genera, *Chunia* and *Ektopodon*, are easy to distinguish, species determinations are more difficult as the pattern of ridges and crests appear to be individual variation.

As more specimens have been collected, more maxillary fragments with molars and/or alveoli and a portion of the rostrum preserved are available. With a suite of maxillae now known, new ektopodontid features have revealed themselves, including the shortening of the rostrum compared to other families of contemporary possums. The facial angulation represented by the flexure of the rostrum at the boundary between P3 and M1 so that P3 and the rostrum are angled differently than the molar row. Ektopodontids have a significantly greater angulation (65°) and shorter faces, compared to that seen in contemporary miralinid, phalangerid, and pseudocheirid possums (35°).

For the genus *Chunia*, two new species from the lower Etadunna Formation, South Australia, can be distinguished from the type species, *Chunia illuminata*, of the Ditjimanka local fauna (Faunal Zone B) also from the lower Etadunna Formation. While the molar dentitions are very similar, the degree of facial angulation is quite different. The *Chunia* sp. nov. Minkina from the lowest faunal zone (A) and the Minkina Local Fauna has a facial angulation of 52°, *C. illuminata* from the next higher faunal zone (B, Ditjimanka Local Fauna) has a greater facial angulation at 63°, while a second new species, also from Faunal Zone B, *Chunia* sp. nov. Dijimanka has a facial angulation of 73°. This value of facial angulation in the second Ditjimanka species of *Chunia* is comparable to the genus *Ektopodon* (71°). Thus, the degree of facial shortening is a valid discriminator between species of ektopodontid marsupials.

Technical Session IV (Wednesday, October 17, 2018, 3:30 PM)

COMPLETENESS OF THE BAT FOSSIL RECORD

CASHMORE, Daniel D., University of Birmingham, Birmingham, United Kingdom; BROWN, Emily, University of Birmingham, Birmingham, United Kingdom; SIMMONS, Nancy, American Museum of Natural History, New York, NY, United States of America; BUTLER, Richard J., University of Birmingham, Birmingham, United Kingdom Changes in fossil specimen completeness through time and space can bias our understanding of macroevolutionary processes. It is important to assess these changes in order to identify the various natural and human biases that can make direct interpretations of the fossil record problematic. The quality of the tetrapod fossil record has previously been quantified as the proportion of a complete skeleton that a specimen preserves (skeletal completeness metric, SCM) and the proportion of phylogenetic characters that can be scored for an individual species (character completeness metric, CCM). Here, we use these metrics to analyse the fossil record of bats (Chiroptera), which evolved in the aftermath of the Cretaceous–Palaeogene mass extinction, but are only found approximately 14 million years later and are generally thought to have a poor fossil record.

Specimen-level completeness scores were collected from the literature for 386 valid fossil bat species from the Eocene to Pleistocene. Skeletal proportions used to calculate SCM were determined from (1) bone surface areas from 2D scientifically-informed skeletal reconstructions and (2) bone volumes of a CT-scanned 3D skeleton. Character proportions used to calculate CCM were determined from an osteological character list designed to include fossil bats. SCM and CCM scores were statistically compared to each other, to species richness through geological time, between different depositional environments and geographical localities, against other tetrapod groups, and in relation to historical year of discovery.

All metrics record the same temporal patterns: peaks in completeness in the Ypresian and Lutetian reflect the presence of Lagerstätten, and subsequent stages have very low completeness except an Aquitanian high and a Pleistocene peak in SCM. There is no correlation between taxic diversity and completeness as the bat fossil record predominately consists of diagnostic but isolated teeth. Consequently, CCM values are significantly higher than SCM metrics, but bats have significantly lower completeness than any previously assessed tetrapod group for both metrics. There is no statistical difference between completeness of bats from northern and southern hemispheres and between taxa derived from cave and non-cave deposits. However, SCM is highest in North America while CCM is highest in Europe, and Asia has the lowest relative completeness for both metrics. There is also a weak positive correlation between year of publication and completeness, with completeness improving for recently described taxa.

Grant Information

European Research Council Starting Grant (grant agreement 637483)

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A NEW EDAPHOSAUR FROM THE EARLY PERMIAN OF NEW MEXICO WITH NOVEL SPECIALIZATIONS FOR HERBIVORY

CELESKEY, Matthew D., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America; LUCAS, Spencer G., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America; RINEHART, Larry F., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America

Fossils of edaphosaurid eupelycosaurs document one of the earliest transitions from faunivory to high-fiber herbivory in amniotes. Teeth of the oldest known edaphosaurid, the Late Pennsylvanian *Ianthasaurus hardestorum*, suggest an insectivorous or omnivorous diet. By the early Permian, multiple species of *Edaphosaurus* display dental, cranial, and postcranial specializations for obligate herbivory. Outside of these taxa, however, the low taxonomic diversity and limited fossil material of other edaphosaurids shed little light on this dietary shift.

We describe a new edaphosaurid known from an articulated skull, lower jaw, and partial postcranium found in the early Permian Bursum Formation of southern New Mexico, U.S.A. Several of its cranial proportions are intermediate between those of *Ianthasaurus* and *Edaphosaurus*, but it possesses an uniquely specialized dentition consisting of large, chisel-like incisors separated by a long diastema from a short row of small, peg-like marginal teeth. The palate is obscured, although part of a grinding dental pavement is visible on the inner surface of the lower jaw. The cervical and dorsal vertebrae have elongate neural spines with distinctive small, thorn-like lateral tubercles randomly distributed along their length. Phylogenetic analysis recovers this specimen as the sister taxon to a clade consisting of *Lupeosaurus* and *Edaphosaurus*, with *Glaucosaurus* and *Ianthasaurus* being successively more distantly related within the Edaphosauridae. This new form is the oldest known herbivorous tetrapod with a dental diastema, indicating a significantly different mode of ingestion and intraoral transport of vegetable matter from that of *Edaphosaurus* and other Paleozoic herbivores. This surprisingly early specialization of the dental apparatus parallels adaptations seen in later cynodont and mammalian herbivores and shows that the development of edaphosaurid herbivory was more complex than previously realized.

Technical Session XV (Saturday, October 20, 2018, 11:00 AM)

MODELING VISUAL ABILITIES IN EXTINCT SPECIES USING VIRTUAL OPHTHALMOSCOPY, WITH A CASE STUDY IN PREDICTING EYE SIZE, OPTICAL PARAMETERS, AND VISUAL FIELDS IN TERROR BIRDS (AVES: PHORUSRHACIDAE).

CERIO, Donald G., Ohio University, Athens, OH, United States of America; DEGRANGE, Federico J., CONICET-Universidad Nacional de Córdoba, Córdoba, Argentina; TAMBUSSI, Claudia P., Museo de La Plata, La Plata, Argentina; RIDGELY, Ryan C., Ohio University, Athens, OH, United States of America; WITMER, Lawrence M., Ohio Univ, Athens, OH, United States of America

All animals face competing visual perceptual challenges including food-acquisition and vigilance against predation. There has been much recent work to shed light on the visual abilities of extant species and to correlate bony dimensions of the orbit with the soft tissues of the visual system. However, few studies have made quantitative predictions of visual abilities in extinct animals, and most of these have focused on diel activity patterns (e.g., diurnal vs. nocturnal). Behavioral studies have commonly employed ophthalmoscopy and geometrical optics to measure visual fields of living animals. A new method for modeling visual fields, called Virtual Ophthalmoscopy (VO), was devised to allow the study of attributes of the visual system in fossil birds and other dinosaurs. Eyeballs for 10 extant bird species were virtually modeled using optical schematics from the literature, and their optical properties and visual fields were generated in raytracing and animation software. The resulting in silico models of visual fields were validated by comparison to in vivo and ex vivo measurements taken from the literature and the modeled values fell within the ranges of literature values. An intriguing case-study for reconstructing the visual abilities of an extinct species is *Llallawavis scagliai*, an exceptionally well-preserved phorusrhacid that preserves scleral rings and exemplifies the uniquely narrow bill morphology typical of phorusrhacids. Here, we present estimates of eye size and shape for *L. scagliai*, and we make quantitative predictions of the optical properties and performance of its visual system. A broad taxonomic survey of cadaveric birds was undertaken to identify bony correlates for the orientation of the eyeball within the orbit. Measurements of eyeball, scleral ring, and skull dimensions were also taken for 113 extant bird species and on *L. scagliai*. Phylogenetically-informed regression equations for eyeball and lens dimensions for *L. scagliai* were calculated, and an eyeball was virtually modeled and optically tested using VO. When its eyes were converged, *L. scagliai* would have had a binocular field of view between 18° and 38° wide. In addition, the tip of the bird's bill would have fallen squarely within this binocular field, consistent with an animal that was using its beak to acquire food, a key perceptual challenge for birds. Moving forward, the success of VO presents an opportunity to expand our ability to reconstruct the visual apparatus and make inferences about the visual ecology of extinct organisms in deep time.

Grant Information
DGC: Jurassic Foundation, OU Student Enhancement Award. LMW: NSF IOB-0517257, IOS-1050154, IOS-1456503; OU Heritage College of Osteopathic Medicine.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

TAPHONOMY OF TRIASSIC TEMNOSPONDYLS OF INDIA

CHAKRAVORTI, SANJUKTA, Indian Statistical Institute, KOLKATA, India; SENGUPTA, Dhurjati P., Indian Statistical Institute, Calcutta, India; ROY, Pummy, Geological Survey of India, Kolkata, India

Early, Middle, and Late Triassic temnospondyls are known from the Panchet, Yerrapalli, Denwa, Maleri, and Tiki Formations of India. The above formations are separated in time and space but similar taphofacies are noted within them. The occurrences of Triassic temnospondyls from India conforms to those taphonomic groups. Firstly, disarticulated small fragments of bones of several temnospondyl taxa are noted from the Olenekian Panchet Formation. The Formation has alternating sand and mud of fluvial origin. The sandstones are multi-storied and trough-crossbedded with occasional concentrations of clay clasts whose average long axis is around 2 cm. Bone fragments of *Goniogyptus*, *Indobrachyops*, *Manubrantlia*, *Capulomala*, and possible benthosuchids and lydekkerinids are present. These fragments are channel lag deposits of a few centimeters in size. Post glenoid area, mandibular rami, and skull fragments are most common. The Yerrapalli and middle part of the Denwa has skull and mandible dominated assemblages of capitosaurids. The Denwa is very rich in monospecific remains of *Cherninia dewai*, which are often found lying parallel to the beds of mud-dominated inclined heterolithics. These heterolithics are lateral accretions of point bars in mixed to suspended load-bearing sinuous channels. Muddy point bars were generally developed in the meandering channels of a low gradient floodplain. Isolated skulls and mandibles could easily be trapped in the muddy point bars while moving with the water. The Upper Denwa of probable Ladinian age has calcirudites and red mudstones with subordinate sansdstones. A polyspecific assemblage of mainly a new species of *Cherninia* and *Paracyclotosaurs crookshanki* are present there in a rich pocket having fish remains. At least eight mostly complete capitosaurid skulls were recovered from this area. This are thought to be accumulated in flood-basin ponds where temnospondyls were bogged down due to drying of water. The caliche-derived calcirudites and fish scales that appear first time in this part of the Denwa suggest occasional aridity. The Carnian metoposaurids from the Maleri and Tiki as well as the Norian chigutisaurids from Upper Maleri show similar isolated hydraulic accumulations. In the Lower Maleri, a small pocket is found with nearly 100 bones of metoposaurids. No complete skeleton has been noted from any of these formations. Hence, hydraulic accumulation in fluvial floodplains, ponds, and channels are the main reasons for temnospondyl occurrences in the Triassic continental deposits of India.

Grant Information
We acknowledge Indian Statistical Institute for funding and infrastructural facilities

Technical Session I (Wednesday, October 17, 2018, 9:00 AM)

LOCOMOTORY SHIFTS IN DINOSAURS DURING ONTOGENY

CHAPELLE, Kimberley E., Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa; CHOINIERE, Jonah N., Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg, South Africa; BENSON, Roger B., University of Oxford, Oxford, United Kingdom; OTERO, Alejandro, Museo de La Plata, La Plata, Argentina

Massospondylus carinatus is an iconic South African basal sauropodomorph dinosaur known from an array of well-preserved specimens representing a nearly complete ontogenetic series from embryos to adults. It has previously been hypothesized that *M. carinatus* experienced a change in gait during ontogeny: hatchlings were obligate quadrupeds, whereas adults were facultative bipeds. This hypothesis is surprising–within Dinosauria there are several instances of lineages evolving quadrupedality from bipedality, but no counter examples. The ontogenetic postural shift from quadrupedality to bipedality has been found in several other dinosaur taxa, and has even been suggested to represent the ancestral condition for the entire group. However both non-destructive and quantitative methods for testing this have been lacking. Our research group recently described a reliable, quantitative method for determining tetrapod posture based on the relative robustness of the forelimb compared to the hindlimb. Here, we modify this method for use on ontogenetic datasets, including both growth series and histological data, and apply it to a wide range of tetrapods, including mammals, crocodylomorphs, and dinosaurs. We find that the method provides an excellent proxy for postural changes during development. The growth trajectories of animals that are obligate quadrupeds from birth (such as bovids) can readily be discerned from those that are obligate bipeds since birth and from animals that change posture during ontogeny (such as humans). Our results clearly show that *M. carinatus* was a biped from hatching, and possessed bipedal skeletal proportions even in ovo. Other dinosaurs, like *Mussaurus*, have limb proportions consistent with a shift in posture from quadrupedal to bipedal during their developmental sequence. Phylogenetic hypotheses imply different interpretations of this finding because *Mussaurus* may represent either (1) a recent evolutionary origin of bipedalism from quadrupedal sauropodiform ancestors, or (2) a close bipedal relative to the ancestor of quadrupedal sauropodiforms. If the latter is found to be correct, then our data suggest that bipedal to quadrupedal postural shifts in dinosaurs may have been presaged by adoption of novel stances at earlier ontogenetic stages.

Grant Information
DST-NRF Centre of Excellence in Palaeosciences (CoE-Pal) and Palaeontological Scientific Trust to KC; NRF CPRR to JNC #98906; ANPCyT PICT 2015-0504 to AO.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

BIRD TO THE BONE: TRABECULAR MORPHOLOGY IN THE AVIAN SHOULDER

CHASE, Hila Tzipora T., University of Montana, Missoula, MT, United States of America; O'BRIEN, Erynn, University of Montana, Missoula, MT, United States of America; TOBALSKE, Bret, University of Montana, Missoula, MT, United States of America

To understand the evolution of flight in the avian lineage, it is necessary to resolve the functional morphology of the flight stroke. Recent success in this approach focuses on the cross-sectional geometry of cortical bone at the midshaft. Trabecular bone, the spongy matrix which fills cortical bone at the ends of long-bones, has been shown to structurally adapt to an organism's function, and thus can provide subtle and specific mechanical signals within a joint that correlate with behavior. While this has led to major discoveries in mammalian biomechanics and fossil interpretation, trabecular morphology in relation to avian flight has yet to be explored. To begin to assess structure-function relationships in the avian shoulder, we used existing kinematic and mechanical data from various species to model the loading regime for different flight modes (i.e., flapping, soaring). We then collected microCT scans of the proximal humerus across a broad, comparative set of avian museum specimens and an ontogenetic series of chukars. Preliminary analysis suggests that trabecular structure is indeed related to flight mode, in combination with body size and phylogeny. Mean trabecular thickness (Tb.Th) in the humeral head appears to be higher in species that flap than in species that soar, while the degree of anisotropy (DA) is higher in soarers than flappers- both results congruent with differences in joint loading during these flight modes. Additionally, we found that Tb.Th scales with negative allometry, proportional to the 0.185 power of mass, which is lower than has been reported in the femur of birds and closer to the scaling exponent found in mammals. In the ontogenetic series, it appears that an increase in Tb.Th and decrease in DA is concurrent with the onset of lift production in chukars using wing-assisted incline running and flight. Elucidating the relationship between trabecular structure and flight mechanics in the avian shoulder provides both significant insight into extant avian flight and a fundamental resource for fossil interpretation in the avian lineage. Future work will attempt to use the functional signals found here in extant birds to interpret forelimb mechanics in fossil aves and paraves.

Grant Information
NSF GRFP M66252

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

LIZARDS FROM EL GALLO FORMATION (CAMPANIAN), BAJA CALIFORNIA, MÉXICO

CHAVARRIA-ARELLANO, Maria L., UNAM, Mexico City, Mexico; GARCÍA-ALCANTARA, Dalia, Mexico City, Mexico; ROMO DE VIVAR-MARTÍNEZ, Paulo, Universidade Federal so Rio Grande do Soul, Porto Alegre, Brazil; MONTELLANO, Marisol, UNAM, Mexico City, Mexico

In the area of El Rosario, Baja California, outcrops of the Campanian El Gallo Formation comprise a non-marine sedimentary sequence that contains and important vertebrate local fauna. Lepidosaurs are relative rare in these deposits, with a lower diversity compares to their number in other North American Late Cretaceous local faunas. A collaborative research project initiated in 2004 has yielded a microvertebrates assemblage that includes lepidosaur teeth and incomplete jaws. Fossils of only one taxon, *Dicothodon bajaensis*, a borioteiioidean, has been extensively described. In addition, we can now recognize four families occurring in the formation: Xenosauridae, Varanidae, Anguidae, and Polyglyphanodontidae. One isolated tooth, probably from a posterior position, has been tentatively referred to Xenosauridae: it is a dagger-like appearance, slightly recurved, lacks striations, but is not serrated along its cutting edges. Two somewhat more trenchant isolated teeth, tentatively referred to the varanoid *Palaeosaniwa canadiensis,* display the characteristic infolded bases, lateral compression, strong curvature, and anterior and posterior serrations of this species. Anguidae are represented by a posterior fragment of dentary bearing five teeth, these most resemble those *Odaxosaurus piger,* having a shoulder-like expansion and are heavy striated medial and laterally.

These families are also known from other southern Late Cretaceous occurrences, in the Aguja and Cerro del Pueblo formations, in Texas and Coahuila, respectively; however their presence in the El Gallo Formation extends their distribution to the rim of the Pacific Basin. The only other squamates not yet recovered from the El Gallo Formation are Serpentes, which may simply be an artifact of collecting.

Some additional isolated teeth and fragmentary jaws from the El Gallo Formation suggest the presence of Xantusiidae and Scincidae in these beds. The identification of these fossils is tentative, but shows that lizard diversity in the formation is greater than previously considered. Relationship of some taxa from the El Gallo Formation with Asian species,

such *Dicothodon bajaensis* with *Adamisaurus magnidentatus* from Mongolia, would be strengthened with the identification of the scincid.
Grant Information
PAPIIT: IN104506-2, IN 111209, IN 100913, IN 103616

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

GEOMETRIC MORPHOMETRIC ANALYSIS OF THE MANUS AMONG MESOZOIC MAMMALS AND ITS IMPLICATION FOR THEIR FEEDING ECOLOGY

CHEN, Meng, Nanjing University, Nanjing, China; MENG, Jin, American Museum of Natural History, New York, NY, United States of America; WANG, Yuanqing, Institute of Vertebrate Paleontology and Paleoanthropology, CAS, Beijing, China; MAO, Fangyuan, Institute of Vertebrate Paleontology and Paleoanthropology, CAS, Beijing, China

Over the last two-decades discoveries of Mesozoic mammal fossils around the world have reshaped the fundamental understanding of the evolutionary history of those now-extinct species. Recent studies on well-preserved skeletal remains, using both qualitative and quantitative approaches, have suggested that extinct mammals had a great ecological diversity in Mesozoic terrestrial ecosystems. Their locomotor diversity could be compared to that of extant small-bodied species. The diverse manual morphologies played an important role in assisting Mesozoic species to adopt diverse locomotor modes and to occupy different ecological niches. However, the manus also plays an important role in feeding ecology among extant mammals, which was largely ignored in previous studies on Mesozoic mammals. To investigate the function role of the manus in feeding ecology among Mesozoic mammals, we conducted a geometric morphometric analysis of the manus of 58 extant small-bodied mammals of 12 orders, including Afrosoricida, Carnivora, Didelphimorphia, Dasyuromorphia, Diprotodontia, Erinaceomorpha, Monotremata, Peramelemorphia, Primates, Rodentia, Scandentia, and Soricomorpha. We categorized their dietary preference into carnivore, frugivore, omnivore, granivore, herbivore, and insectivore. We digitized 71 landmarks of the manus to outline its general shape in dorsal view and performed Generalized Procrustes Analysis (GPA) and Principal Component Analysis (PCA) on the dataset. Our preliminary results indicate that extant frugivore and herbivore (root-tuber feeding) species have distinct manual morphologies from the rest of the others, whereas extant carnivore, omnivore, and insectivore species show indistinct morphologies. Most of our inferred dietary preferences of Mesozoic mammals were consistent with the inferences of previous studies. However, the eutriconodontan species exhibit some morphological features in the manus that are similar to some extant herbivore species.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

SHINING A LIGHT ON NIGHTBIRD RELATIONSHIPS: A TOTAL-EVIDENCE PHYLOGENY OF STRISORES

CHEN, Albert, University of Bath, Bath, United Kingdom; FIELD, Daniel, University of Bath, Bath, United Kingdom

Strisores is a clade of mostly insectivorous crown-group birds that includes highly specialized fliers such as the Apodiformes (swifts and hummingbirds), as well as the nocturnal Caprimulgidae (nightjars), Steatornithidae (oilbird), Nyctibiidae (potoos), Podargidae (frogmouths), and Aegothelidae (owlet-nightjars). Recent molecular and morphological phylogenetic analyses have uniformly recovered the nocturnal strisorians as a paraphyletic grade with respect to Apodiformes. However, despite the use of large- scale molecular datasets, the precise phylogenetic relationships between the nocturnal strisorians have been resolved inconsistently by different studies and remain controversial. Given the lack of consensus between results based on molecular data, we examined the possibility that incorporating morphological data from fossils might improve resolution of this phylogenetic problem. Putative stem-members of nearly all major strisorian lineages have been described from Eocene fossil deposits, potentially providing critical information on ancestral character states within Strisores. We adopted a total-evidence approach combining both molecular and morphological data, which has hitherto only been applied to strisorian phylogeny to a limited extent. Our phylogenetic dataset includes 117 morphological characters scored for 24 strisorian taxa (of which 14 were fossil taxa) as well as DNA sequences from the extant taxa. This dataset was analyzed using Bayesian phylogenetic methods in MrBayes, resulting in a novel phylogenetic topology of Strisores that is nonetheless largely congruent with the findings of a comprehensive recent molecular phylogenetic analysis of modern birds.

In future work, we aim to further clarify the early evolution of Strisores by performing a tip-dating analysis on our dataset to generate a time-calibrated phylogeny of these specialized birds.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

HIND LIMB MORPHOLOGY OF PALEOGENE MICROMOMYID PLESIADAPIFORMS (EUARCHONTA, PRIMATES)

CHESTER, Stephen G., Brooklyn College, City University of New York, Brooklyn, NY, United States of America; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; BOYER, Doug M., Duke University, Durham, NC, United States of America; SARGIS, Eric J., New Haven, CT, United States of America

Micromomyid plesiadapiforms are small euarchontan mammals known from the late Paleocene and early Eocene of western North America. Recent phylogenetic analyses support micromomyids as the most basal stem primates known from partial skeletons. We analyzed the hind limb of all of these skeletons (*Tinimomys graybulliensis*, n = 3; *Dryomomys szalayi*, n = 1). Micromomyids had a mobile hip joint with a craniocaudally elongated acetabulum and spherical femoral head that is slightly higher than the greater trochanter. The acetabulum is cranially buttressed with an expanded articular surface for incurring loads when using orthograde postures on vertical supports. Micromomyids lacked the hind limb features of specialized leapers and runners for powerful extension of the knee, and instead have a small anterior inferior iliac spine, dorsoventrally shallow distal femur, and short patellar groove indicating a habitually flexed knee. These hind limb features are similar to those of other plesiadapiforms, butsmicromomyids differ in having a relatively longer crus. Their fibula is unique among plesiadapiforms in having a dorsoventrally expanded proximal end for the origin of flexor fibularis and peroneus longus. This corresponds with the large, wide groove on the astragalus for the tendon of flexor fibularis, which aids in pedal plantarflexion, digital flexion, and pedal grasping. The entocuneiform-1st metatarsal joint suggests a divergent hallux capable of non-opposable pedal grasping, and the long volar processes on the distal phalanges suggest long apical pads for grasping. Overall, the hind limbs of *T. graybulliensis* and *D. szalayi* are similar and support the hypot hesis that they were non-leaping arborealists capable of pedal grasping like that of the extant treeshrew *Ptilocercus lowii*. Though these species are relatively derived and recent within Micromomyidae, their shared features likely characterize the clade at least back to the divergence of *Tinimomys* and *Dryomomys* in the late Tiffanian North American Land Mammal Age (NALMA). Furthermore, micromomyid astragali and calcanei are uniquely similar to those attributed to *Purgatorius*, the oldest and most basal known plesiadapiform from the Puercan NALMA, which suggests that certain micromomyid hind limb features also characterize the ancestral primate. As early Paleocene plesiadapiform postcrania remain elusive, the fairly basal position and well-preserved skeletons of micromomyids make them critically important for understanding early locomotor and postcranial evolution in primates.

Grant Information
National Science Foundation SBE-1028505 (EJS, SGBC), NSF BCS-0129601 (JIB), Leakey Foundation Research Grant (SGBC), and PSC CUNY Award (SGBC)

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A REMARKABLE ASSEMBLAGE OF ENANTIORNITHINE BIRDS FROM THE LATE CRETACEOUS OF SOUTHEASTERN BRAZIL

CHIAPPE, Luis M., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; NAVA, William, Museu de Paleontologia de Marilia, Marilia, Brazil; MARTINELLI, Agustin G., Museo Argentino Ciencias Naturales, Capital Federal, Argentina; TUCKER, Ryan, Stellenbosch University, Stellenbosch, South Africa; ALVARENGA, Herculano, Museu Historia Natural Taubate, Taubate, Brazil

Despite abundant discoveries of Mesozoic birds in recent decades, knowledge of their evolution during the last 20 million years of the Cretaceous remains scant. However, this time interval is essential to better understand the rise of modern birds and the pattern of avifaunal turnover during the Cretaceous-Paleogene transition. We report on a remarkably rich site (William's Quarry; discovered in 2004 by WN) contained in the Upper Cretaceous Adamantina Formation (Bauru Group) of southeastern Brazil (Presidente Prudente, western São Paulo State). Excavations at this site have produced hundreds of isolated and partially articulated remains of small to medium-sized enantiornithine birds concentrated in a very small area (approximately 6 m^2) of red-pink fluvial sandstones and claystones. Representing at least three taxa, the remains include numerous postcranial elements as well as many skull portions (isolated rostra, mandibles, and crania) preserved in three dimensions. As the most abundant avian Mesozoic locality in the Americas and the richest site of Late Cretaceous age in the world, this site provides key information for contrasting hypotheses of avian diversification during the K-Pg transition and the earliest divergences of modern birds. Along with other Late Cretaceous localities from Gondwana, the information revealed at this site indicates a clear abundance of enantiornithine bird species during the ~80–70 mya interval. Such a record is difficult to reconcile with hypotheses arguing that modern (neornithine) birds originated in the southern hemisphere during the Late Cretaceous.

Technical Session IV (Wednesday, October 17, 2018, 2:45 PM)

ECOLOGICAL NICHE MODELLING SUPPORTS SUSTAINED DINOSAUR DIVERSITY TRENDS PRIOR TO THE CRETACEOUS/PALEOGENE MASS EXTINCTION

CHIARENZA, Alfio A., Imperial College London, Lodon, United Kingdom; MANNION, Philip, Imperial College London, London, England; FARNSWORTH, Alexander, University of Bristol, Bristol, United Kingdom; LUNT, Dan, University of Bristol, Bristol, United Kingdom; KELLAND, Sarah-Jane, Getech, Leeds, United Kingdom; ALLISON, Peter, Imperial College London, London, United Kingdom

Dinosaur diversity in the lead-up to the Cretaceous/Paleogene mass extinction (66 million years ago) remains a topic of heated debate. Whereas some authors argue that dinosaurs were already in long-term decline, others contend that they were thriving until their sudden demise. The latest Cretaceous (Campanian–Maastrichtian) of North America provides the best paleontological record to address this debate, but even here diversity reconstructions are biased by uneven sampling. Subsampling and other methods are heavily constrained by their inability to deal with the absence of data, especially when the spatial distribution of the fossil record is strongly heterogeneous. Ecological niche modelling, using species occurrences and climatic data to reconstruct habitat distribution, offers a possible solution for interpolating biogeographic patterns despite fragmentary information, enabling the integration of models of distributional patterns from unsampled areas. We combined fossil occurrence data with HadCM3L paleoclimatic simulations to define latest Cretaceous North American dinosaur habitat availability. A time series analysis of species distribution models was developed from the early Campanian to the late Maastrichtian. The ecological niches modeled on available outcrop area through time show a decline in habitability for major non-avian dinosaur clades, an outcome mirroring results based on previous analyses of diversity and morphological disparity. However, when a continental projection is considered, the pattern shifts dramatically, showing an overall increase in niche suitability from the Campanian to the Maastrichtian instead, although niche evolution between stages was minimal. Combining digital elevation models of the latest Cretaceous of North America with results from our climate model, we created virtual taphofacies (using physical parameters such as sediment flux and surface runoff), identifying areas suitable for potential dinosaur fossil preservation. The combination of these approaches demonstrates how dinosaur habitat increased spatially as a result of the Sevier-Laramide orogeny and the forced regression of the Western Interior Seaway in the Maastrichtian. However, these same agents limited areas of high taphonomic suitability in the final stage of the Cretaceous. These results hint at a hidden diversity of dinosaurs in the Maastrichtian

that is obscured by a reduction in the spatial sampling window, highlighting the impact of spatial bias in interpreting macroecological dynamics.

Romer Prize Session (Thursday, October 18, 2018, 9:00 AM)

TESTING OSTEOHISTOLOGY-BASED BODY MASS GROWTH CURVE RECONSTRUCTION IN EXTANT AND EXTINCT TETRAPODS

CHIBA, Kentaro, University of Toronto, Toronto, ON, Canada

Body mass growth curves have been reconstructed in numerous extinct animals, particularly non-avian dinosaur species, based on growth marks preserved in the osteohistological cross sections of limb bones. Utilizing the parameters obtained from the growth curves, recent studies have quantitatively estimated the physiology and life history of extinct animals. Growth curve reconstructions based on growth marks need two sets of estimated parameters: body mass estimation with consideration of ontogeny, and the number of missing growth marks (age) of the samples. Several estimation methods for age and mass have been proposed and used in previous studies, but the methods have never been applied to extant tetrapods. Thus, the accuracy of the reconstructed growth curves still has considerable uncertainties. This study evaluated the available age and mass estimation methods and the overall performance of osteohistology-based growth curve reconstructions in fossil taxa using extant tetrapod datasets for the first time.

Firstly, the dataset of eight extant tetrapod taxa including Reptilia, Aves, and Mammalia demonstrates that mass can be reliably estimated based on growth marks using Developmental Mass Extrapolation (DME) when adult body mass is scaled down by limb circumferences. Secondly, combinations of DME with section-stacking (the most commonly used estimation method) and growth-model-fitting age estimations were applied to a dataset of *Alligator mississippiensis* growth marks, and the reconstructed curves were compared to observational growth curves of the population. The comparison revealed that DME combined with model-fitting can reliably approximate the observational curves, but not the section-stacking method. Finally, the two combinations were applied to mass death bonebed samples of the non-avian dinosaur *Centrosaurus apertus*. The results show that the parameters such as maximum growth rate and inflection point can be vastly different based on the reconstruction method used, and underscores the poor performance of the section-stacking age estimation method.

This study strongly recommends the use of DME combined with model-fitting age estimation in future studies and suggests many of the previous studies using section-stacking are likely not accurate and need further consideration. Using these best practices, accurate body mass growth curve reconstruction in fossil taxa is a powerful tool that enables quantitative physiological and ecological variables to be estimated and incorporated into macroevolutionary studies.

Grant Information

I would like to thank the Dinosaur Research Institute, Natural Sciences and Engineering Research Council of Canada, Royal Ontario Museum, University of Toronto.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

ELECTRON BACKSCATTEER DIFRACTION (EBSD) IS A NEW POWERFUL TECHNIQUE FOR FOSSIL EGGSHELL RESEARCH: A NOVEL METHOD PROVIDES CRSTALLOGRAPHIC INFORMATION ON CONTACT INCUBATION AND A WAY TO IDENTIY THE TRUE PORE CANAL AND EXTEERNAL LAYER

CHOI, Seung, Seoul, Korea, Republic of (South); LEE, Yuong-NamSeoul National University, Seoul, Korea, Republic of (South)

Electron backscatter diffraction (EBSD) is a powerful electron microscopy technique to investigate crystallographic information directly from carbonate biominerals. Compared with invertebrate paleontology, its application in vertebrate paleontology is still not popular. However, 'paleo-oology' is a perfect research field in which EBSD can be widely used. We compared extinct non-avian maniraptoran dinosaur and avian eggshells with extant bird eggshells to find out important crystallographic features using EBSD analysis. They are eggshells of *Elongatoolithus* sp., *Macroelongatoolithus xixiaensis*, *Prismatoolithus levis*, *Gobioolithus minor*, ostrich, rhea, domestic duck, domestic chicken, Japanese tit, and Korean magpie. The results were presented by the inverse pole figure map, Euler map, grain boundary map, and misorientation histogram. All maps showed that some ambiguous morphological features such as wedge-like or acicular structure of a mammillary layer can be judged more objectively in eggshells. The results also implied that presence of an external layer in maniraptoran eggshells is not always associated with avian eggshells. The misorientation angle distribution of the maniraptoran eggshells can be clearly divided into two groups that may be related to reproductive behavior of Maniraptora. The oviraptorosaur and paleognath eggshells showed low-angle dominant misorientation distribution, whereas troodontid and enantiornithine eggshells showed high-angle ones like neognath eggshells. Therefore, we could infer that oviraptorosaurs did not contact incubate their eggs, whereas the troodontid and enantiornithes adopted contact incubation. Finally, EBSD analysis can be used for identification of true pore canals. Simple cracks in the eggshell radial section are easily distinguished from the pore canals by an Euler map. It can prevent the misidentification of pore-like structures in fossil eggshells. We expect that new EBSD data on diverse maniraptoran eggshells will enhance our knowledge of maniraptoran brooding behavior in future.

Grant Information:

This research was supported by National Research Foundation of Korea (grant number: 2016R1AA2B2015012) to Yuong-Nam Lee.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

COMPARISON OF CREODONT AND CARNIVORAN DENTAL MORPHOLOGY FROM THE CALF CREEK LOCAL FAUNA (LATE EOCENE) OF SASKATCHEWAN

CHRISTISON, Brigid E., Carleton University, Ottawa, ON, Canada; GAIDIES, Fred, Carleton University, Ottawa, ON, Canada; PINEDA-MUNOZ, Silvia, Smithsonian, Washington, DC, United States of America; EVANS, Alistair R., Monash Univ, Monash University, Australia; FRASER, Danielle, Canadian Museum of Nature, Ottawa, ON, Canada

Carnivora (including bears, cats, and dogs) is a monophyletic order of placental mammals possessing two pairs of carnassial teeth. Carnassials function as self-sharpening blades that enable slicing during mastication. Creodonta is an extinct, possibly polyphyletic order of carnivorous mammals, which emerged around the same time as Carnivora, but went extinct globally during the Miocene. Unlike carnivorans, creodonts often possessed more than two pairs of carnassials, which have likely convergently evolved. Competition with carnivorans has been proposed as a driver for creodont extinction, potentially exacerbated by late Paleogene and Neogene climate change. Using tooth shape metrics (Orientation Patch Count and Dirichlet Normal Energy) and estimates of body mass (log10 transformed), we tested for similarities in morphospace occupation amongst coeval creodonts and carnivorans. We explicitly compared Carnivora and Creodonta only from a single faunal assemblage (the late Eocene Calf Creek locality, Saskatchewan). Using Principal Component Analysis, we found apparent niche partitioning amongst carnivorans that are primarily associated with differences in tooth shape. The two creodonts, *Hyaenodon horridus* and *Hemipsalodon grandis* share characteristics of their tooth shape with their carnivoran counterparts but diverge greatly in body mass. Based on the modern correlation of prey size with carnivoran body size, we suggest that, at the Calf Creek, competition among carnivorans and creodonts was unlikely. Construction of niche overlap for creodonts and carnivorans at a larger number of localities will allow us to definitively test the competition hypothesis.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

MODULARITY OF THE COMMON DOLPHIN SKULL (*DELPHINUS DELPHIS*)

CHURCHILL, Morgan, University of Wisconsin Oshkosh, Oshkosh, WI, United States of America; GEISLER, Jonathan, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; BEATTY, Brian L., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; GOSWAMI, Anjali, University College London, London, United Kingdom

The skull of toothed whales (Odontoceti) is radically modified from those of their terrestrial ancestors. These modifications include near dental homodonty and retrograde telescoping of facial bones, coupled with extreme bilateral cranial asymmetry and polydonty in many species. To examine how these changes may have influenced modularity, the covariation of traits, in the dolphin skull, we digitized 27 common dolphin (*Delphinus delphis*) skulls using a Creaform Handyscan 700 3D laser scanner. We then placed 67 landmarks over each skull. After Procrustes superimposition of landmarks was performed, we carried out cluster analysis of the covariance matrix produced to explore novel modules in the landmark data. The novel module hypothesis recovered was then compared with several previously proposed hypotheses of modular organization of the mammalian cranium using a maximum likelihood approach in the R package EMMLi. These hypotheses differ in the total number of modules for the skull (2 to 8) and the allocation of landmarks. Furthermore, we used different model parameters for each hypothesis, varying correlation coefficients within and between modules, resulting in a total of 31 models being tested. Tests of modularity consistently found our novel hypothesis to perform best, suggesting that the modularity of dolphin skulls is significantly different from that of terrestrial mammals. The five modules recovered for the dolphin skull include modules related to the face, zygomatic, nasal, pterygoid, and vault. Of these modules, the nasal and vault modules are similar in composition of landmarks to those of existing module hypotheses formulated for terrestrial mammals. The face and pterygoid modules are associated with the development of structures related to echolocation, the former including landmarks associated with attachment sites for muscles used in sound production, the latter associated with the distinctive pterygoid sinuses, which are used in sound reflection and acoustic isolation of the ear. The zygomatic module includes features largely related to bite force and feeding. This study reveals the mosaic of adaptive responses to an aquatic lifestyle found in the development and modularity of the dolphin skull. Further studies will explore variation in modularity across other whale groups, extant and extinct, and examine how cranial modularity has changed over the course of whale evolution.

Grant Information

NSF-DEB 1349697

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

SMALL TETRAPOD AND FISH TRACE FOSSILS FROM THE MIDDLE PERMIAN OF THE SOUTH AFRICAN KAROO

CISNEROS, Juan C., Universidade Federal do Piaui, Teresina, PI, Brazil; DAY, Michael O., The Natural History Museum, London, United Kingdom; RUBIDGE, Bruce S., University of the Witwatersrand, Johannesburg, South Africa

A trackway referable to a small tetrapod and imprints produced by minute fishes are recognized in the *Tapinocephalus* Assemblage Zone of the Karoo Basin. The ichnofossils are located on the surface of a slab that was found ex situ on the floor of a quarry in 2012, in the upper Moordenaars Member of the Abrahamskraal Formation, at Sutherland, Northern Cape. The slab has several trace fossils, all preserved as concave epirelief. Invertebrate ichnofossils are also present, which include *Tonganoxichnus*-like impressions and sinuous, bilobate traces. Two partial counter-slabs preserve some of the tetrapod imprints as convex epirelief. The tetrapod manus is tetradactyl and the pes is pentadactyl. Both manus and pes digits have rounded anterior edges, indicating the absence of claws. A continuous, nearly straight tail-trace is present, indicating that the tail was not employed for body propulsion at the time and thus that the tetrapod walked outside the water-level. The manus configuration and claw-less footprints support temnospondyl affinities for the trackmaker. The most peculiar feature of the tetrapod is a pes that only produces impressions from digits III–V, whereas digits I and II are recognized only from drag marks.

This condition has not been reported before and can therefore be recognized as a new tetrapod ichnotaxon. These footprints occur in association with smaller imprints referred to *Broomichnium,* an ichnogenus previously known in South Africa from the lower Permian Ecca Group but also found in Pleistocene deposits in North America and Europe. *Broomichnium* is currently regarded as a trace fossil produced by demersal fishes as they lay on the substrate. The *Broomichnium* imprints were presumably produced during a higher water-level stage, before the trackway made by the amphibian. Neither the footprints nor the fish traces can be attributed to any vertebrate taxon currently known from osteological remains in the lower Beaufort, and so evince a higher vertebrate diversity in the Karoo middle Permian.

Grant Information
Conselho Nacional de Desenvolvimento Científico e Tecnológico; National Research Foundation African Origins Platform; Palaeontological Scientific Trust

Technical Session XIV (Saturday, October 20, 2018, 11:30 AM)

FISHES FROM THE TRANS-SAHARAN SEAWAY OF MALI, AFRICA

CLAESON, Kerin M., Philadelphia College of Osteopathic Medicine, Philadelphia, PA, United States of America; ROBERTS, Eric, James Cook University, Queensland, Australia; HILL, Robert V., Hofstra University, Hempstead, NY, United States of America; TAPANILA, Leif, Idaho State University, Pocatello, ID, United States of America; MCCARTNEY, Jacob, Department of Biology, State University of New York College at Geneseo, Geneseo, NY, United States of America; BOUARÉ, Mohamed, École Nationale des Ingénieurs, Republic of Mali, Bamako, Mali; O'LEARY, Maureen, Stony Brook University, Stony Brook, NY, United States of America

In dramatic contrast to the present Saharan desert environment of western Africa, an ancient shallow sea, the Trans-Saharan Seaway (TSS), periodically bisected the region from the Late Cretaceous to the early Eocene. As the result of over ~50 million years transgression and regression, extensive near shore marine sedimentary structures and fossiliferous deposits document a dynamic tropical paleoecosystem. These deposits are important in recording the changes across the Cretaceous–Paleogene (KPg) extinction and the Paleocene-Eocene (PE) Thermal Maximum, because rock records for both are rare worldwide, especially in Africa. Here, our collaborative team presents on the fossil fishes recovered during fieldwork in Mali, described in the context of a synthesis of two decades work on alpha taxonomy, stratigraphy, and phylogenetics. We reconstruct the Malian fish fauna as greatly diverse. Higher clade levels of marine fishes we note are known from throughout the TSS and the freshwater taxa are generally well distributed across the African continent. There was a substantial local freshwater influence on the embayment at Mali based on the high volume of catfish and lepidosirenid lungfishes. A brackish environment is also consistent with a nearby freshwater influence, supported by the potentially anadromous giant actinopterygian, †*Maliamia*. The remaining fish fauna reconstructed as shallow marine to pelagic marine includes batoids and sharks, pycnodonts, and an osteoglossid. Large body size appears to have been particularly pronounced within the Eocene fish fauna from Mali, indicating that within the Eocene a major proliferation of large predators may extend not only to pelagic waters, but also to epeiric seas. Sharks in Mali decrease in diversity at the KPg while batoids cross the KPg with reasonably high success. No pycnodonts are reported from the Cretaceous of Mali and three species are present in the Paleogene. Freshwater fish turnover is notable across the PE. The last appearance of the Lepidosirenid lungfish †*Lavocatodus* occurs in the middle Eocene Tamaguélelt Formation. Claroteid catfishes make their first appearance in the Malian lower Eocene.

Grant Information
This work was made possible by funding from the National Science Foundation, the National Geographic Foundation, the L.S.B. Leakey Foundation, and author institutions.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

PALEONTOLOGICAL SURVEY OF THE MOKA MOUNTAIN RANGE, MAURITIUS

CLAESSENS, Leon, College of the Holy Cross, Worcester, MA, United States of America; HUME, Julian P., Natural History Museum, London, United Kingdom; JANOO, Anwar, University of Mauritius, Reduit, Mauritius; WIERSMA, Jelle P., James Cook University, Townsville, Australia; RUPEAR, Vikash, Natural History Museum of Mauritius, Port Louis, Mauritius; MUNGUR-MEDHI, Jayshree, National Heritage Fund, Ministry of Arts and Culture Mauritius, Port Louis, Mauritius; RIJSDIJK, Kenneth F., University of Amsterdam, Amsterdam, Netherlands

Despite high levels of faunal resilience following mid-Holocene megadroughts, multiple Mauritian vertebrate species went extinct in less than one or two centuries following human colonization of the island. A number of contemporary written records of extinct endemic Mauritian fauna exist and these are typically brief, sometimes of questionable veracity, and usually of limited scientific value. Much of our knowledge of extinct Mauritian vertebrates is based on remains collected from a fossil-rich marsh deposit, the Mare aux Songes, located at low elevation near the coast of southeastern Mauritius. Only a few (sub)fossil remains were collected elsewhere on the island, but detailed locality and other contextual information for these finds is usually not available. Here we report the results of an exploratory expedition in the Moka Mountain Range in northwestern Mauritius, in the region where the only known complete skeleton of a dodo was discovered more than a century ago. Our expedition discovered rare remains of the extinct dodo (*Raphus cucullatus*), Mauritian owl (*Mascarenotus sauzieri*), blue pigeon (*Alectroenas nitidissimis*), and giant skink (*Leiolopisma mauritiana*), together with giant tortoise (*Cylindraspis* sp.) and Round Island skink (*Leiolopisma telfairii*) remains. In addition, we recovered numerous skeletal remains of introduced species including tenrec (*Tenrec ecaudatus*), black rat (*Rattus rattus*), Asian musk shrew (*Suncus murinus*), Rusadeer (*Cervus timorensis*), black-naped hare (*Lepus nigricollus*), and frog (Anura indet.). Subfossil remains were found in microsites on densely vegetated steep boulder slopes at or near ground surface level. Sites often yielded multitaxic assemblages with a combination of extinct and extant vertebrate remains in close proximity. Within the Moka Range, dodo, owl, giant skink, and giant tortoise remains were discovered at elevations approximately 300 meters above sea level. Preliminary Accelerated Mass Spectrometry ^{14}C dating shows that the native fauna date to the last millennia, and that endemic birds and reptiles ranged from the lowland forests to the steep mountain slopes of the island. Our expedition represents the first comprehensive survey of terrestrial fossil localities on Mauritius and highlights the preservation potential of fossil remains at high altitudes on this tropical island. Continued exploration for fossils is likely to shed further light on the taphonomic, biogeographic, and population dynamics of the endemic vertebrate fauna of Mauritius.

Grant Information
This expedition was funded by the National Geographic Society (CRE 9899-16).

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

EARLIEST PUERCAN 1 (PU1) FAUNAS FROM MONTANA WITH HIGH-RESOLUTION INSIGHTS ON MAMMALIAN FAUNAL RECOVERY AFTER THE K–PG MASS EXTINCTION EVENT

CLAYTOR, Jordan, University of Washington, Seattle, WA, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America; CLEMENS, William A., University of California Berkeley, Berkeley, CA, United States of America

The Cretaceous–Paleogene (K–Pg) mass extinction was a pivotal event in mammalian evolution. All three North American clades (multituberculates, metatherians, and eutherians) survived the event, but eutherians became the numerically and taxonomically dominant clade within one million years (Ma). The Hell Creek area of eastern Montana is an excellent study system to resolve local fine-scale patterns of the K–Pg recovery and eutherian radiation. It has a sequence of fossil localities in the Hell Creek and Tullock formations within a high-resolution temporal framework spanning the last ~2 million years of the Cretaceous and the first ~1.2 million years of the Paleogene. Here, we track changes in taxonomic composition and diversity within earliest Paleogene mammalian faunas from the Hauso Flats and Hell Hollow areas of Garfield County, MT. We recovered mostly isolated mammal teeth via surface collection and underwater screenwashing of the Herpijunk, Morales 1, and Carrie Padgett localities. The first two localities are from a channel complex that cuts through the K–Pg boundary clay layer, and the third is from a channel complex that in places cuts through the Hell Hollow channel and the K–Pg boundary clay layer. The localities are bracketed in time by the IrZ-Coal and HFZ-Coal, and fall within the first ~80 thousand years of the Paleogene. Stratigraphic mapping implies Herpijunk and Morales 1 are older than the Carrie Padgett localities. In a sample from Herpijunk and Morales 1, the multituberculates *Mesodma* spp. and *Cimexomys minor* have the highest relative abundances. Other typical Pu1 species present include the metatherian *Thylacodon montanensis*, cimolestids *Procerberus formicarum* and *Cimolestes simpsoni* and the archaic ungulates *Baioconodon nordicum* and *Mimatuta* sp. In comparison, a sample from the Carrie Padgett localities has similar relative abundances of *Mesodma* spp. and *Cimexomys minor*, but higher relative abundances of the metatherian *Thylacodon montanensis* and the archaic ungulate *Oxyprimus erikseni.* Other eutherians present in the sample include *Procerberus formicarum* and *Protungulatum donnae*. Our results support a mammalian recovery model in which older Pu1 localities with high relative abundances of disaster taxa (*Mesodma* spp.) and low richness and relative abundances of archaic ungulates transition to younger Pu1 localities with higher richness and relative abundances of therians. High temporal resolution analysis of post-K–Pg mammalian faunas will continue to shed light on this faunal recovery and radiation and, more broadly, models of ecosystem recovery.

Podium Symposium (Wednesday, October 17, 2018, 9:30 AM)

THE EFFECT OF SAMPLING BIASES ON LONG-TERM RICHNESS TRENDS OF NON-MARINE LEPIDOSAURS AND TURTLES FROM THE TRIASSIC–PALEOGENE

CLEARY, Terri J., Natural History Museum, London, United Kingdom; BENSON, Roger B., University of Oxford, Oxford, United Kingdom; EVANS, Susan E., University College London, London, United Kingdom; HOLROYD, Patricia A., University of California Berkeley, Berkeley, CA, United States of America; BARRETT, Paul M., The Natural History Museum, London, United Kingdom

Quantifying fossil record quality is fundamental to elucidating patterns of taxon richness through time. Many studies have applied a variety of techniques in order to alleviate issues with uneven sampling that may obscure genuine richness patterns. Here, we investigated the genus richness of non-marine lepidosaurs (lizards, snakes, amphisbaenians, and tuatara) and turtles (Testudinata, including terrapins and tortoises) from the Triassic– Paleogene (252–23 myr) using Shareholder Quorum Subsampling (SQS). Data for both clades were downloaded from the Paleobiology Database. We used generalized least- squares regressions (GLS) to test for correlations between various combinations of variables (e.g., proxies for sampling, palaeotemperature, and non-marine area) against richness through time. In addition, we explored trends in latitudinal richness levels through time.

The lepidosaur record is more poorly sampled than the turtle record, but for both clades the Southern Hemisphere is severely undersampled compared to the Northern Hemisphere. This bias affects 'global' richness curves, which reflect the combined, but uneven, contributions of a few well-sampled continents rather than genuine global trends; continental-level scale curves were produced instead to reduce this issue.

During the Late Cretaceous both groups appear to diversify. Of particular interest is a contrast in clade response to the K-Pg boundary, where North American turtles increase in richness while lepidosaurs decrease. Additionally, there are similar sequential peaks and troughs in richness during the Paleogene for both clades, which raises questions about whether they shared a response to environmental stimuli or if there are taphonomic and/or geographic biases at work. Both clades decrease in richness at the Eocene-Oligocene boundary, at the time of the Grande Coupure turnover event. GLS analyses reveal that the number of available collections has a strong relationship with observed richness, though in turtles there are likely other influencing factors that are difficult to measure in the fossil record such as rainfall and water body availability.

Grant Information
This work was funded by NERC grant NE/L002485/1 and by an ERC Starting Grant (grant agreement 637483).

Technical Session XV (Saturday, October 20, 2018, 9:30 AM)

THERE AND BACK AGAIN: POLLEN AND SEDIMENTARY ORGANIC MATTER RECORDS ASSOCIATED WITH PLEISTOCENE MEGAFAUNA RECOVERED FROM NATURAL TRAP CAVE, WY

CLEMENTZ, Mark T., University of Wyoming, Laramie, WY, United States of America; MINCKLEY, Thomas, University of Wyoming, Laramie, WY, United States of America; MEACHEN, Julie, Des Moines University, Durham, NC, United States of America

In western North America, caves and rock shelters can serve as excellent repositories of environmental information for the late Quaternary. Natural Trap Cave, which is situated on the eastern margin of the Bighorn Basin of northern Wyoming, is one of the best repositories of late Pleistocene faunal remains in the world, having 'collected' a representative fauna of the area for over 110,000 years. Interpretations of environmental variability in the late Pleistocene at this site have primarily been based on the environmental preferences of faunal assemblages found in the cave. Here, we have complemented and expanded prior methods of quantifying late Pleistocene environments in the Rocky Mountain region by examining sediments recovered during renewed fieldwork at Natural Trap Cave.

Using pollen, elemental, and carbon isotopic analyses of organic matter recovered from cave sediments, we are reconstructing the environmental conditions that supported late Quaternary faunal biodiversity in the Bighorn Basin from the last interglacial period (110 ka) to the terminus of the last Ice Age (13 ka). An ~5-meter thick section within the primary excavation pit of the cave was sampled at 1-cm intervals for loss-on-ignition, elemental, and isotopic analyses. Within this pool of samples, ~60 1-cc samples, evenly spaced through the section, were selected for pollen analysis.

We found organic content was low (2–4 wt%), but of sufficient quality to support isotopic and pollen analyses. Shifts from grassland to steppe conditions in the pollen record correspond directly with ~1–2‰ increase in isotopic values at the beginning of the last glacial cycle shift. Pollen data are relatively invariant through most of the last glacial period, despite a distinctive drop in isotopic values at ~2-m depth (-25.3 ± 0.3‰). The last glacial maximum is characterized by an increase in grasses and conifers, along with a small drop in $\delta^{13}C$ values (-25.0 ± 0.2‰). The Holocene is characterized by relatively high conifer pollen and a significant negative spike in $\delta^{13}C$ values (-26.9 ± 0.9‰), after which values remained low (-25.5 ± 0.3‰) relative to the baseline values for the last glacial cycle (-24.8 ± 0.4‰). This record from the Bighorn Basin reveals the unique aspects of environmental change in the lower elevation basins of the intermountain West. In particular, the present and penultimate interglacials are not parallel in floristic composition; the glacial period was relatively stable floristically, but isotopically variable; and the last glacial maximum was dominated by grasslands.

Grant Information
This project was supported by funds from the Roy J. Shlemon Center for Quaternary Studies at the University of Wyoming.

Podium Symposium (Wednesday, October 17, 2018, 8:15 AM)

STANDARDISING FOR SPATIAL SAMPLING BIAS DEMONSTRATES CONSTRAINED DIVERSIFICATION OF PHANEROZOIC TERRESTRIAL TETRAPODS

CLOSE, Roger A., University of Birmingham, Birmingham, United Kingdom; BENSON, Roger B., University of Oxford, Oxford, United Kingdom; BUTLER, Richard J., University of Birmingham, Birmingham, United Kingdom

Species richness scales ubiquitously with sampled area, so variation in the geographic extent of fossil localities can profoundly distort fossil diversity curves. However, conventional approaches for estimating palaeodiversity do not correct for spatial biases. Most methods assume that the 'scope' (e.g., geographic spread) of the underlying taxon pool remains constant. In fact, however, this varies substantially between time intervals, and spatial biases explain ~80% of the variation in diversity estimates for non-flying, non-marine tetrapods (= "terrestrial tetrapods"), even when using sampling-standardisation methods such as shareholder quorum subsampling to control for other forms of bias. We have corrected for this by standardising the paleogeographic spread of fossil localities prior to subsampling. This approach substantially alters interpretations of terrestrial tetrapod diversity patterns during the Mesozoic–early Paleogene, contradicting popular models of "unbounded" tetrapod diversification based on face-value (= "raw") taxon counts. Here, we modify and extend this approach to the entire Phanerozoic record of terrestrial tetrapods, using a data set of unprecedented size (~40,000 occurrences from ~10,500 collections) from the Paleobiology Database. Patterns of spatially-standardised diversity are robust across a range of geographic scales, and suggest that diversity increased by a factor of ~1.5 from the Paleozoic into the Mesozoic. Consistent with previous work, spatially-standardised terrestrial tetrapod diversity exhibits stasis during the Mesozoic, with no statistically significant increase, but rises 2–3-fold across the Cretaceous/Paleogene boundary, driven by the radiation of Cenozoic mammals. However, there is no evidence for further systematic increases in tetrapod diversity during the Cenozoic. In fact, median spatially-standardised diversity may have even declined from the late Paleogene to the present, perhaps in response to the cooling of global climate. These results strongly contradict face-value 'global' diversity curves that have been used to suggest exponential increases over the last ~100 million years. Instead, they suggest that long-term terrestrial tetrapod diversification was largely constrained, with long periods of stasis punctuated by large, stepwise increases.

Grant Information
European Union's Horizon 2020 research and innovation programme 2014–2018 under grant agreement 637483 (ERC Starting Grant TERRA to R.J.B.)

Technical Session XIV (Saturday, October 20, 2018, 9:30 AM)

THE UNEXPECTED FACE OF *HELODUS SIMPLEX*

COATES, Michael, University of Chicago, Chicago, IL, United States of America; SANG, Stephanie, University of Chicago, Chicago, IL, United States of America; TROLL, Ray, Ketchikan, AK, United States of America; FRIEDMAN, Matt, University of Michigan, Ann Arbor, MI, United States of America; JOHANSON, Zerina, Natural History Museum, London, United Kingdom; TIETJEN, Kristen, University of Chicago, Chicago, IL, United States of America

Helodus simplex is the textbook transitional form linking specialized chimaeroids to their conventionally shark-shaped chondrichthyan relatives and ancestors. Helodontid teeth, well represented in Museum collections, range from the Upper Devonian to the lower Permian, but *H. simplex* is the only species with associated fossil skeletal remains. These remains include large dibasal paired fins, a dorsal fin with synarcual plate, and a low, broad, holocephalan skull with a short rostrum and a wide ethmoid trough: a feature that has generated debate about its relationship to the distinctive ethmoid canal of modern chimaeroids. Lastly, the characteristic teeth are aligned in well-separated files, occasionally fused to form a seeming proto-toothplate. Here, we leave the body untouched, but provide a more detailed, CT-generated, reconstruction of the *Helodus* chondrocranium and dentition. Classic specimens from the Middle Pennsylvanian of England show the skull shape to be radically different. The rostrum extends anteriorly to an acute apex, with substantial, double walls flanking the ethmoid trough, each enclosing an ethmoid canal. The trough is clearly extracranial. For the first time, compact statoliths have been found in the otic capsules, as in modern chimaeroids. Individual *Helodus* teeth are larger relative to jaw size than previously estimated, and successive members of lingual-to-labial files are alternately positioned so that adjacent files interdigitate into a continuous, prominent dental battery. The total dentition is also revealed as decidedly heterodont. Small petalodont-like teeth contribute to a mandibular parasymphysial platform, and another tooth form, *Diclitodus*, forms a complete spiral file locked into the anterior extremity of rostrum. Ontogenetically oldest members of this file are recessed within the midline socket of an elongate rostral plate roofing the entire ethmoid trough. This curious arrangement raises questions about their dental affinity, and whether *Diclitodus* 'teeth' might, rather, be part of an extended frontal clasper, foreshadowing that of the Mesozoic chimaeroid *Metopacanthus*. In summary, these new data present a less transitional and altogether more derived early chimaeroid, perhaps closer to the crown clade than its cochliodont contemporaries, adding new diversity to the spectacular radiation of late Paleozoic chondrichthyans.

Grant Information
NSF DEB-1541491: Fishlife

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

GEOLOGICALLY OLDEST PEDIOMYOIDEA (MAMMALIA, MARSUPIALIFORMES) FROM THE LATE CRETACEOUS OF NORTH AMERICA AND REVIEW OF AQUILADELPHIDAE

COHEN, Joshua E., Loyola Marymount University, Los Angeles, CA, United States of America; DAVIS, Brian M., University of Louisville, Louisville, KY, United States of America; CIFELLI, Richard, University of Oklahoma, Norman, OK, United States of America

Cretaceous terrestrial faunas of Turonian age are poorly understood due to limited sampling from only a few units worldwide. The Smoky Hollow Member of the Straight Cliffs Formation of southern Utah has yielded a rich assemblage of terrestrial vertebrates and here we recognize the geologically oldest definitive members of Pediomyoidea. Pediomyoidea consist of two major groups, the Aquiladelphidae and the Pediomyidae, both of which are present in the Smoky Hollow Fauna. Two new taxa are recognized as members within Aquiladelphidae based upon shared characteristics with the family, including a subdivided B cusp, rounded and inflated main cusps, and an anteroposteriorly expanded protocone. A fragmentary specimen possibly belonging to the genus *Leptalestes* is recognized, with a strong reduction in the anterior stylar shelf and the loss of stylar cusp B. The occurrence of these two distinctive groups in the Turonian prompted a re-evaluation of possible antecedents from earlier in the Cretaceous, and a review of specimens referred to Aquiladelphidae. A possible antecedent is the Cenomanian *Dakotadens*, which shares a number of characters with the family. Of specimens referred to Aquiladelphidae, we recognize ?*Aquiladelphis laurae* as a valid member of the family and genus, but the "Edmontonian" Williams Fork specimen is sufficiently different from *Aquiladelphis* to be placed outside of the family. The Williams Fork specimen most likely belongs within the pediomyoid family Glasbiidae and represents a new species within *Glasbius*. Additionally, a new species of *Aquiladelphis* from the mid-Campanian Judith River Formation of Montana is recognized.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

CHEMICALLY CHARACTERIZING ORGANIC PRESERVATION IN TERRESTRIAL VERTEBRATES FROM THE LATE TRIASSIC HAYDEN QUARRY (~212 MA) AT GHOST RANCH, NEW MEXICO

COLLEARY, Caitlin, Virginia Tech, Blacksburg, VA, United States of America; O'REILLY, Shane, University of Dublin, Dublin, Ireland; PENKMAN, Kirsty, York University, York, United Kingdom; DICKINSON, Marc, York University, York, United Kingdom; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America

To understand the potential for organic molecules to preserve in terrestrial vertebrates on very long timescales (e.g., hundreds of millions of years), multiple factors need to be considered: (1) Can biomolecules preserve in bone and other types of organic fossils (e.g., teeth, coprolites)? (2) Does burial environment influence preservation? (3) Is it possible to separate organic contaminants from original biomolecules? Here, we address these three questions by combining a series of analytical techniques including high-resolution mass spectrometry to examine three different fossil types from a single depositional environment. An early dinosaur femur, a phytosaur tooth, and a coprolite from the Late Triassic Hayden Quarry (~212 Ma) were analyzed and compared to detect biomolecules and organic contaminants while controlling for burial environment, by selecting samples from a single fluvial deposit. Time-of-flight secondary ion mass spectrometry (TOF-SIMS) was used to detect amino acids in the three fossil types and compare the amino acids found to matrix control samples. Amino acids were found in the fossil bone, teeth, and coprolites that are unique when compared to the matrix, however, these amino acids could not be used to distinguish between the different types of fossils. Lipid analyses revealed a limited range of fatty acids and no sterols and the high concentration of lipids in the matrix all indicate that the lipids are not original to the fossil bone from this locality. Additionally,

amino acid racemization (AAR) shows high levels of serine (Ser) in the fossil bones, suggesting that the amino acids are not original. Despite the presence of amino acids that are unique to the fossils when compared to the matrix, this combination of analyses suggests that the biomolecules in these three fossil types are not original. Therefore, ages older than the Late Triassic may be an upper bound for expectations of original organic preservation in terrestrial vertebrate fossils in fluvial environments.
Grant Information
NSF EAR 1337291

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE OLDEST LAMBEOSAURINE DINOSAURS OF EUROPE

CONTI, Simone, University of Bristol, Bristol, United Kingdom; PRIETO-MARQUEZ, Albert, Catalan Institute of Paleontology, Sabadell, Spain; G. SELLÉS, Albert, Catalan Institute of Paleontology, Sabadell, Spain; VILA, Bernat, Catalan Institute of Paleontology, Sabadell, Spain; GALOBART, Angel, Catalan Institute of Paleontology, Sabadell, Spain; BENTON, Michael J., University of Bristol, Bristol, United Kingdom The hollow-crested lambeosaurine hadrosaurids represent one of the latest and rapidest radiations of ornithischian dinosaurs, attaining a nearly global distribution during the Late Cretaceous. We present the earliest occurrence of lambeosaurines in Europe, with an updated age of early Maastrichtian. The remains documenting this occurrence have been collected from strata of the La Posa Formation cropping out at the Els Nerets locality (Tremp Group, eastern Tremp Syncline, northeastern Spain). The material consists of several vertebrae, a humerus, two ischia, two femora, and other fragmentary elements representing two individuals, one of which reached adulthood. This lambeosaurine shares characters with *Tsintaosaurus spinorhinus*, from the Campanian of China, while displaying notable differences from *Pararhabdodon isonensis* from the uppermost Maastrichtian Talarn Formation of northeastern Spain. The relatively small body size of this animal, compared to that of other lambeosaurines such as *T. spinorhinus*, suggests the possibility of insularity affecting the life history of the Iberian form. The phylogenetic position of the lambeosaurine from Els Nerets was inferred using Maximum Parsimony and Bayesian analyses, confirming that it is as a member of Tsintaosaurini.
This study reinforces the Eurasian distribution of basal lineages of lambeosaurine hadrosaurids, indicating a greater diversity in the tsintaosaurin tribe than previously realized. Further, the new fossils add to the complexity of the faunal turnover that occurred in the Ibero-Armorican Island at the Campanian-Maastrichtian boundary. The event was triggered by multiple Asian migratory waves, leading to a Campanian fauna dominated by rhabdodontid ornithopods, nodosaurid ankylosaurs, and titanosaur sauropods, being subsequently replaced primarily by lambeosaurines during Maastrichtian times.
Grant Information
Supported by the University of Bristol; Ramón y Cajal Program (RyC-2015-17388) and CGL2016-73230-P grant (Government of Spain); CERCA Program (Government of Catalonia).

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

CLEAR FORK DIVERSITY CYCLE: RICH LARGE PREDATOR-MEGAHERBIVORE FAUNA IN MID-EARLY PERMIAN

COOK, Leigh A., Whiteside Museum of Natural History, Seymour, TX, United States of America; FLIS, Christopher J., Whiteside Museum of Natural History, Seymour, TX, United States of America; FLIS, James E., Whiteside Museum of Natural History, Seymour, TX, United States of America; BELL, Troy, Whiteside Museum of Natural History, Seymour, TX, United States of America; BAKKER, Robert T., Houston Museum of Natural Science, Houston, TX, United States of America; TEMPLE, David P., Houston Museum of Natural Science, Houston, TX, United States of America
Over 11 years, the Houston Museum of Natural Science and the Whiteside Museum of Natural History have censused vertebrates in the section from the bottom of the Clear Fork Group through Olson's Event in the middle Clear Fork. In the basal Clear Fork, the bone-bearing mudstones change dramatically from dark, clay-rich ponds, to red silty ponds with extensive caliche zones. The basal Clear Fork shows the earliest record of the last and largest diadectids and edaphosaurids, the only two large herbivore families in the fauna (body mass 50 kg plus). The Lower Clear Fork contains the highest diversity of large land predators for the entire early Permian. The long-necked, slender-jawed dimetrodonts, *D. loomisi*, appear in basal Clear Fork and achieve a body length as high as that of short-necked, deep jawed species. Contrary to recent suggestions, *D. loomisi* is not a juvenile of the much more massive *D. giganhomogenes*. All through its ontogeny, *D. loomisi* retains a very high post-canine number, laterally flattened canines and small premaxillary fangs. Strongly procumbent anterior lower teeth distinguish a new long-necked, shallow jawed species from *D. loomisi*. This new species approaches *Secodontosaurus,* present through the Lower Clear Fork. The short-necked *D. grandis* is distinguished from its close kin *D. giganhomogenes* by reduced post canine count, plus dorsal fin spines with a thick, quadrate cross-section. Both short-necked dimetrodonts share dorsal fins with posterior spines that are strongly recumbent, producing a fin area that is expanded posteriorly. Curiously, the last species of edaphosaurids also developed posteriorly expanded fins; perhaps the herbivores mimicked the dimetrodonts. Long-necked and short necked dimetrodonts diverge so strongly that generic separation is recommended.
This diverse megafauna collapses at Olson's Event, middle Clear Fork (Olson's "Vale Formation"). Edaphosaurids and diadectids, plus secodontosaurs and most other dimetrodonts disappear. In the later Clear Fork, mid sized caseids and captorhinids evolve larger body size to fill the large land herbivore role. Olson's Event appears to be the earliest mass extinction of large land tetrapods in classic Cuvieran pattern.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A LATE PLEISTOCENE TO HOLOCENE FAUNAL COMMUNITY IN PEDERNALES PROVINCE, DOMINICAN REPUBLIC

COOKE, Siobhan B., Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; MYCHAJLIW, Alexis, Stanford Univ, Los Angeles, CA, United States of America; ALMONTE, Juan, Museo Nacional de Historia Natural Prof. Eugenio de Jesus Marcano, Santo Domingo, Dominican Republic; FELIZ, Gerson, Grupo Jaragua, Santo Domingo, Dominican Republic; MCAFEE, Robert K., GA Campus - Philadelphia College of Osteopathic Medicine, Suwanee, GA, United States of America; TURVEY, Samuel, Zoological Society of London, London, United Kingdom; LOVETT, Sarah, Zoological Society of London, London, United Kingdom
Hispaniola is a geologically and biogeographically complex island once composed of two paleoislands divided by the Enriquillo Graben. Previous research on endemic Hispaniolan mammals has shown population structuring in accordance with this geographic barrier, but little paleontological research has been done at the boundary of the paleoislands. We report on a mammalian faunal community recovered from cave sites in Parque Jaragua, Pedernales Province, Dominican Republic. This region lies on the eastern edge of the southern paleoisland and has a unique faunal composition in comparison with other regions of the island (e.g., Plain de Formon, Haiti; Altagracia Province, Dominican Republic).
Using MNI/NISP, we examined community change through time at Cueva del Mono, the most extensively excavated of our sites. Two test pits yielded different age-depth models suggesting varying taphonomic and depositional conditions throughout the cave. While the fauna is late Pleistocene/Holocene more than 40 bones failed to yield collagen sufficient for direct radiocarbon dating, suggesting a high thermal age and potential recurrent water movement in the cave. Radiocarbon dating of land snail shells and charcoal indicate that the material was deposited between 33,000 cal yr BP and 850 cal yr BP.
The fauna recovered comprises at least 15 mammalian species, including a previously undescribed rodent. The rodent community was comparable in diversity, though not in species present, with faunal communities recovered from the Plain de Formon, Haiti. In particular, extinct large-bodied (*Plagiodontia velozi*, *Hyperplagiodontia araeum*) and small-bodied (*P. spelaeum*) plagiodontine taxa as well as extant *P. aedium*are are represented in the fauna. Multiple species of *Isolobodon* have been recovered including a species dentally similar to *I. portoricensis* but 30% smaller, which has not been found elsewhere. *Brotomys voratus* is also present. The sloths *Acratonus ye*, *Neocnus comes*, and *N. toupiti* are present and indicate a range extension for *Neocnus* into the eastern portion of the southern paleoisland. The eulipotyphlan insectivore *Nesophontes*is is well-represented in the fauna; three species have been recovered: *N. hypomicrus*, *N. paramicrus*, and *N. zamicrus*. Though extant, *Solenodon paradoxus*is is present only in low numbers. Finally, one primate specimen, a femur, has been recovered extending the range of the Hispaniolan monkeys. Invasive species (e.g., *Rattus*, *Bos*) are found at the top of the sequence indicating that deposition is on going.
Grant Information
Professional Development Grant, American Association of Physical Anthropologists to SBC; DDIG NSF #1600728 and Stanford Center for Latin American Studies to AMM

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

ECOLOGICAL INFLUENCES ON CRANIAL MORPHOLOGY IN ODONTOCETE WHALES

COOMBS, Ellen J., University College London, London, United Kingdom; CHURCHILL, Morgan, University of Wisconsin Oshkosh, Oshkosh, WI, United States of America; PARK, Travis, Natural History Museum, London, London, England; GEISLER, Jonathan, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; BEATTY, Brian L., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; GOSWAMI, Anjali, University College London, London, United Kingdom
Odontoceti (toothed whales) make up one of two cetacean suborders and represent more than 70 of approximately 90 extant cetacean species. Odontocetes are morphologically and ecologically diverse. The earliest odontocetes are from the Oligocene and demonstrate that odontocetes rapidly evolved refined, high-frequency echolocation and retrograde cranial telescoping. However, little is known about morphological evolution of the crania with regards to potential ecological influences in these early odontocetes. Here we quantify skull shape in living and fossil odontocetes and investigate whether it can provide information on the ecology of early members of this clade.
To do this, we used geometric morphometrics and quantified potential ecological influences on shape, including diet and habitat. With a dataset of 30 extant and extinct crania, we collected shape data using 47 3-D discrete and curve landmarks, and investigated potential ecological influences on shape with non-parametric MANOVAs.
We found that most cranial variation (PC1 = 40%) occurs in the length of the rostrum, with dolichocephalic (e.g., *Pontoporia blainvillei*) and brachycephalic (e.g., *Kogia sima*) crania representing the extremes. High variation (PC2 = 24%) also occurs in the positioning of the nares, positioned anteriorly in Oligocene cetaceans and shifting posteriorly in Miocene and modern species. We found that the Oligocene odontocetes (e.g., *Cotylocara macei*) are positioned apart from the Miocene and extant odontocetes in cranial morphospace.
Secondly, we found that centroid size does not significantly correlate with variation in skull shape across extant odontocetes ($p = 0.186$). Further, we found that diet and habitat both significantly correlate with skull shape in extant species ($p = 0.02$, $r^2 = 0.22$ and $p = 0.01$, $r^2 = 0.48$, respectively). As information on extinct cetacean ecology is not often available, we examined the distribution of extinct specimens in odontocete crania to hypothesise potential ecological influences.
We found Miocene species (e.g., *Eurhinodelphinidae*; *Schizodelphis*) occupy a similar morphospace to extant species that occupy nearshore, oceanic environments, suggesting that these Miocene species may have occupied a similar habitat. The Oligocene odontocetes in this sample cluster together in a distinct area of morphospace from extant and Miocene species, indicating that cranial shape across Oligocene species may have been driven by other factors or that the relationship between cranial shape and ecology differed in these early forms.
Grant Information
Natural Environment Research Council Doctoral Training Partnership (London NERC DTP), training grant code NE/L002485/1

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

AN EXCEPTIONALLY PRESERVED JUVENILE SPECIMEN OF THE MULTITUBERCULATE *TOMBAATAR SABULI* PROVIDES NEW DATA ON MULTITUBERCULATE DENTAL DEVELOPMENT

CORFE, Ian J., University of Helsinki, Helsinki, Finland; FOSTOWICZ-FRELIK, Lucja, Institue of Paleobiology, Polish Academy of Sciences, Warsaw, Poland; COX, Philip, University of York, York, United Kingdom; COBB, Sam, University of York, York, United Kingdom; JANISZEWSKA, Katarzyna, Institue of Paleobiology, Polish Academy of Sciences, Warsaw, Poland

The djadochtatheroidian multituberculate *Tombaatar sabuli* was described from a single partial skull, lacking the lower jaws and dentition, from the Late Cretaceous Ukhaa Tolgod locality, Mongolia. Here we describe a new juvenile specimen of *T. sabuli* from Ukhaa Tolgod, represented by an exceptionally preserved skull and left dentary. We used conventional and synchrotron x-ray computed tomography to image the internal structure and determine the nature and timing of the tooth replacement in this specimen and species. The dentary and lower dentition of *Tombaatar* are described for the first time, and the skull, substantially more complete than the holotype, brings to light features previously unknown for this genus. In addition, the skull has all deciduous and permanent upper incisors in situ concurrently—the deciduous dI2 and permanent/replacement I2, dI3 and I3, but no dI1 or I1 as these are absent in derived multituberculates. This reveals the relative positioning of all the replacement and permanent incisors in the multituberculate skull for the first time. The replacement mode of dI2 by I2 is unusual, with resorption occurring from the posterior side of the dI2 instead of the base or root as for most other replacement teeth, especially incisors, in mammals. Timing of the dI3/I3 replacement is shown to be considerably earlier than in previously hypothesized replacement schemes for Late Cretaceous Mongolian multituberculates. The overall mode of tooth replacement in *Tombaatar* is sequential, and the direction anteroposterior.

Other features of the dental eruption and replacement sequence allow the specimen to be placed within the relatively early second ontogenetic stage of multituberculate growth, as the most complete example known. This completeness helps clarify aspects of the order and timing of dental development of ontogenetically young multituberculates, and increases the size of the clade of multituberculates with the sequential, anteroposterior tooth replacement type. However, despite considerable evidence from multiple specimens and species across the entire clade, the ancestral state of tooth replacement in multituberculates remains unclear. Unique features in this individual of *Tombaatar* reinforce the degree of variation in dental development within the clade Djadochtatherioidea, within Late Cretaceous Mongolian multituberculates, and within Multituberculata as a whole.

Grant Information

Project supported by the Ella and Georg Ehrnrooth Foundation, the Otto A. Malm Foundation, NanoFun POIG.02.02.00-00-025/09, and the European Synchrotron Radiation Facility.

Technical Session XVII (Saturday, October 20, 2018, 3:45 PM)

A SYSTEMATIC REVIEW OF THE GIANT ALLIGATOROID *DEINOSUCHUS* FROM THE CAMPANIAN OF NORTH AMERICA AND ITS IMPLICATIONS FOR THE RELATIONSHIPS AT THE ROOT OF CROCODYLIA

COSSETTE, Adam, University of Iowa, Iowa City, IA, United States of America

Deinosuchus is a lineage of giant (≥10 m) Campanian age crocodylians from North America. These were the largest semiaquatic predators in their environments and are known to have fed on dinosaurs. Three species have been named—*D. hatcheri* and *D. riograndensis* from the Western Interior, and *D. rugosus* from the Atlantic Coastal Plain— and recent consensus has been that all three represent a single wide-ranging species. This study explores the hypothesis that the three named species of *Deinosuchus* represent a single species and includes newly-collected material from the Big Bend region of Texas as well as increased sampling of the lineage from throughout North America. Species of *Deinosuchus* can be consistently differentiated on the basis of cranial and osteodermal features and represent different species.

Species of *Deinosuchus* preserve a number of derived features in a basal lineage; as such, phylogenetic relationships have proven enigmatic. Previously published analyses have recovered species of *Deinosuchus* in a poorly resolved position at the base of Alligatoroidea. Here we provide new characters, a reevaluation the three named species of *Deinosuchus*, and place eastern North American *D. rugosus* in a published phylogeny for the first time.

New material from Texas includes nearly complete skulls and associated postcrania. Well-preserved specimens from the Atlantic Coastal Plain allow a detailed description of the character-rich braincase. For the first time, the cranial morphology of a very bizarre crocodylian can be reconstructed. Moreover, because of its putative phylogenetic position near the root of Alligatoroidea, this new material will play a central role in ongoing efforts to estimate the basal relationships among major crocodylian clades and closely related outgroups.

A better understanding of the lineage suggests that *D. rugosus* and *D. hatcheri* are based on types that cannot be diagnosed at the level of species. Since the generic name holder, *D. hatcheri*, is based upon an undiagnostic type, the generic name is rendered a *nomen dubium*. Additionally, the original generic assignment of *D. riograndensis* cannot be used—*Phobosuchus* is named for a polyphyletic assemblage of South American crocodylians. The name *Deinosuchus* is historically important to professional systematists and the public alike but it is taxonomically most stable to restrict the name *Deinosuchus* to *D. hatcheri* and to establish a new genus based on the most complete specimen of *D. riograndensis*, a species with several individuals known from its type locality.

Grant Information

This research was supported by the University of Iowa Graduate Student Senate and the University of Iowa Graduate College

Technical Session XVI (Saturday, October 20, 2018, 8:30 AM)

CRANIAL KINESIS IN *TYRANNOSAURUS REX*: INTERPRETING THE BIOMECHANICAL ENVIRONMENT OF SKULLS

COST, Ian N., University of Missouri, Columbia, MO, United States of America

Assessing mechanisms of cranial kinesis in tetrapods remains extremely difficult because the biomechanical loading environment of the skull is not fully understood. *Tyrannosaurus rex*, the hardest biting animal to have ever lived, is often hypothesized as having had cranial kinesis; however, many of the hardest biting tetrapods, such as crocodilians, are akinetic. Solving the biomechanical paradox of hard biting versus cranial mobility requires anatomical understanding and novel research approaches. The kinetically permissive palate articulates with the rest of the craniofacial skull via the otic, palatobasal, and jaw joints, all of which are essential for cranial kinesis. This study investigates the kinetic competency of *T. rex* using a series of postures in the gape cycle framed by a functional and phylogenetic bracket of extant taxa possessing different modes of kinesis: grey parrot (*Psittacus erithacus*; fore-aft prokinesis) and tokay gecko (*Gekko gecko*; mediolateral pleurokinesis). Static finite element models of *Psittacus*, *Gekko*, and *Tyrannosaurus* were constructed using bone and joint tissue data as well as eleven pairs of PCSA-informed cranial muscles. These models simulated joint excursions, musculoskeletal forces, and feeding behaviors in anatomically accurate kinetic postures. Kinetic competency was then modeled in akinetic, prokinetic, and pleurokinetic postures of *T. rex*. The models of *T. rex* were evaluated using stress and strain data from the bony elements of finite element models. I found that the akinetic model was subjected to the lowest overall stresses and strains. I also found that stresses associated with the pleurokinetic posture were prohibitively excessive and the skull was ill-equipped to facilitate mediolateral excursions of the palate. Even though prokinetic stresses were lower than pleurokinetic stresses, portions of the medial pterygoid and the rostral palatine were disproportionately stressed in the prokinetic model. The robusticity of the craniofacial skeleton and the results of analyses of the postural models provide sufficient evidence to interpret the skull of *Tyrannosaurus rex* as akinetic. Approaches similar to the integrative and comparative biomechanical posture modeling method used in this study will lead to more insight into the origin of avian cranial kinesis and the evolution and distribution of kinesis in the tetrapod lineage.

Grant Information

National Science Foundation (NSF IOS-1457319), University of Missouri Research Board, University of Missouri Research Council

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

A COMPARISON OF DENTAL MOLDING AND CASTING COMPOUNDS USED FOR MICROWEAR STUDIES

CREIGHTON, Jamey H., University of Calgary, Calgary, AB, Canada; ROBSON, Selina V., University of Calgary, Calgary, AB, Canada; THEODOR, Jessica M., University of Calgary, Calgary, AB, Canada

Dental microwear analysis has been used throughout the years to reconstruct the diets of extant and extinct animals. To study microwear, negative impressions of teeth are made with a molding compound. These negative molds are then filled with a casting compound, often an epoxy resin, to produce transparent casts. Various techniques are used to examine these casts for microwear. Here, we have investigated whether two molding compounds used for microwear analysis—the Regular Body President microSystem polyvinylsiloxane and the Sinclair Dental VPS Impression Material—are significantly different in their ability to capture microwear. A comparison of these compounds has never been done, despite both being commonly used in microwear studies. The microwear of extant ungulate species with known diets was examined with HDRI low magnification microscopy. Our sample included moose (*Alces alces)*, elk (*Cervus canadensis*), bighorn sheep (*Ovis canadensis*), bison (*Bison bison*), and horses (*Equus ferus*). Preliminary results comparing total microwear counts and pit-to-scratch ratios suggest that the Sinclair and President molding compounds do not capture significantly different microwear signals. However, we have found that the compounds differ in their ease of use. The President molding compound has a shorter setting time than the Sinclair compound (2 minutes and 3.5 minutes respectively), and President has a higher viscosity. Because of these properties, President does not flow as well around the tooth cusps. More product is then wasted from having to redo molds and from the compound setting while still inside the applicator wand. We have also noticed that President does not interact well with the epoxy casting compound we use (EpoTek). When poured into President molds, the epoxy retains many more small bubbles than it does with the Sinclair molds, which leads to more discarded casts and wasted epoxy. We are now working to increase our sample size, and to expand our analysis to include a comparison of two casting compounds: EpoKwick and EpoTek. These results will help determine whether there are any significant differences between commonly used molding and casting compounds, which will help inform researchers as to which compounds are best for microwear studies.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

GLOBAL COOLING AND THE EVOLUTION OF GIGANTIC FLIGHTLESS BIRDS

CROUCH, Nicholas, The University of Texas at Austin, Austin, TX, United States of America; CLARKE, Julia A., The University of Texas at Austin, Austin, TX, United States of America

Palaeognathae is a species-poor extant clade of birds with body sizes ranging over several orders of magnitude, including the largest-known terrestrial avian species. However, establishing when this variation arose remains unclear. Earlier hypotheses emphasize that flight loss and increasing body size began early in the evolutionary history of palaeognaths, prior to the divergence of the major extant lineages; however, more recent phylogenetic studies suggest the ancestral species was probably smaller and volant, with increases in body sizes occurring more recently, within many extant lineages. Estimating the masses of extinct taxa can provide direct insight into the history of the group and shed light on the timing of these increases in body size. Here, we use linear regression equations to estimate the masses of extinct taxa from both the crown and stem of Palaeognathae and, in combination with specimen ages, evaluate temporal trends in body size. We also allocate more fragmentary specimens to discrete body mass categories to accommodate species for which precise body mass estimation is not possible. We then model sampling intensity

through time to attempt to estimate uncertainty in the first appearances of paleognath taxa. Our results recover major increases in body size in the Neogene, incongruent with Mesozoic or Paleogene origins. Specifically, we estimate that in the mid-Miocene, a time of pronounced global cooling, maximum palaeognath body size increased from approximately that of a rhea (20 kg) or smaller to ostrich size (100 kg). Island-dwelling and continental clades show broad temporal congruence in the timing of their estimated gain of large body sizes, meaning geographical restriction on islands does not alone explain the observed trend. We suggest large and giant Palaeognathae body sizes may be more closely linked to abiotic factors such as global cooling, a factor that has received extensive attention as a driver of mammalian body size extremes but has been relatively little discussed with respect to birds.

Grant Information
NSF EAR 1355292 Collaborative Research: Phylogenomics of palaeognathous birds and understanding the evolution of flightlessness

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A REVIEW OF FOSSILS OF MIDDLE PLEISTOCENE *EQUUS* FROM RALPH B. CLARK REGIONAL PARK, ORANGE COUNTY, CALIFORNIA, US

CROWE, Makena, Ralph B. Clark Paleontology Museum, Buena Park, CA, United States of America; BABILONIA, Lisa C., Ralph B. Clark Paleontology Museum, Buena Park, CA, United States of America; SCOTT, Eric, Cogstone Resource Management, Inc., Riverside, CA, United States of America

Sediments of the early to middle Pleistocene (Irvingtonian North American Land Mammal Age) La Habra Formation at Ralph B. Clark Regional Park, Orange County, California (formerly the Emery Borrow Pit) have yielded a rich Pleistocene vertebrate assemblage. Over 35 species of mammals, 19 species of birds, and 16 species of amphibians and reptiles have been identified from this site, although the majority of this material remains to be fully described. Horses (genus *Equus*) have been previously reported from the site, referred by some authors to the diminutive Pleistocene horse species *Equus tau* and by other researchers to the much larger species *E. occidentalis*, although neither assignment has been supported with published morphological descriptions. To assess whether the equid fossils from Clark Park might be reliably assigned to any known Pleistocene species, we reviewed specimens from two recent excavations in the park that yielded fossil horse remains.

Fieldwork in 1997 resulted in the recovery of a partial right maxilla with P3–M3 of an older adult horse; advanced wear on the teeth precluded any reliable specific assignment for this specimen. Subsequent field efforts in 2008–09 yielded several associated teeth and postcranial remains of a separate, ontogenetically younger male horse. The size of the postcranial remains demonstrate that this individual represents a large species of horse; assignment to the small horse species *Equus tau* is therefore not warranted. (We note in this context that the species *E. tau* is technically invalid on taxonomic grounds, and so assignment to this species could not be supported irrespective of body size.)

Two large horse species have been well documented from middle to late Pleistocene sediments in southern California: *Equus scotti*, abundant in Irvingtonian assemblages but absent in Rancholabrean faunas, and *E. occidentalis*, which is only known from the Rancholabrean NALMA. Because fossils from the La Habra Formation have recently been interpreted to be exclusively Irvingtonian, we suggest that large horse fossils from Clark Regional Park more likely belong to *E. scotti* than to *E. occidentalis*. The observed dental morphology is not inconsistent with this interpretation, but unfortunately the recovered remains are not sufficiently complete or diagnostic to warrant more confident assignment. It is hoped that future work at Clark Park will continue to reveal significant remains of extinct Pleistocene megafauna, including horses, and that these discoveries will help resolve this question more fully.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW ADAPID MATERIAL FROM WYOMING'S GREAT DIVIDE BASIN: DIVERSITY AND BIOGEOGRAPHY IN THE EARLY WASATCHIAN OF THE AMERICAN WEST

CROWELL, Jordan, University of North Carolina, Greensboro, NC, United States of America; ANEMONE, Robert L., University of North Carolina, Greensboro, NC, United States of America

The Great Divide Basin (GDB) is an internal drainage basin in SW Wyoming that forms the eastern-most sub-part of the Greater Green River Basin. The GDB possesses extensive fossil-bearing sediments of Paleogene age that have been the subject of vertebrate paleontological and geological investigation by our team over the past twenty years. Situated between Wyoming's Bighorn Basin (500 km to the north) and the San Juan Basin of New Mexico (800 km to the south), the GDB can play an important role in understanding latitudinal constraints on the evolution and biochronology of vertebrate faunas across the Paleocene–Eocene boundary. Previous work has suggested that the evolution of notharctines during the Eocene reflects gradual, anagenetic change in molar size and morphology among several lineages, and a variety of differing phylogenetic hypotheses have been proposed. Here we explore the diversity and morphology of the notharctine (Primates, Adapidae) fauna from a series of early Wasatchian localities in the GDB, and compare it with the extensive collections of these primates from other intermontane basins in the American West. Using biostratigraphy as a tool for interbasinal correlation, we describe metric and non-metric morphological differences between chronological species of *Cantius* and *Copelemur* in high (i.e., Bighorn) and low latitude (i.e., San Juan) settings, comparing each with the mid-latitude notharctines from the GDB. While there is little doubt of the significance of climate change during the early Eocene for mammalian evolution, especially during several hyperthermal periods of extremely rapid and intense warming, latitudinal differences between mammalian faunas in the American West have been understudied. Our analysis of the notharctine samples from five Wasatchian localities from the GDB, including Smiley Draw (N = 163), Red Desert (N = 29), Tipton Buttes (N = 46), Scorpio (N = 42), and Lightning Park (N = 16), reveals a rich assemblage of notharctines that includes several species of both *Cantius* and of *Copelemur*. Metric and morphological comparisons with samples from the Bighorn and San Juan Basins show the same temporal trends in changing molar size and occlusal morphology that have been described by previous authors, as well as some specimens with clear transitional morphology between named species. Overall, the GDB notharctines more closely resemble Bighorn Basin taxa, but other aspects of the GDB faunal assemblage (i.e., high frequency of the archaic ungulate *Meniscotherium*) more closely resemble San Juan Basin faunas.

Grant Information
National Science Foundation BCS-1227329. Fieldwork was conducted in accordance with U.S. Bureau of Land Management paleontological survey permit 287-WA-PA95.

Technical Session I (Wednesday, October 17, 2018, 9:15 AM)

RECONSTRUCTING THE ONTOGENY OF THE SAUROPODOMORPH *MUSSAURUS* AND IMPLICATIONS FOR LOCOMOTION

CUFF, Andrew, Royal Veterinary College, Hatfield, United Kingdom; OTERO, Alejandro, Museo de La Plata, La Plata, Argentina; SUMNER-ROONEY, Lauren, Oxford University Museum of Natural History, Oxford, United Kingdom; POL, Diego, Museo Paleontológico Egidio Feruglio, Trelew, Argentina; HUTCHINSON, John R., Royal Veterinary College, Hatfield, United Kingdom

Mussaurus patagonicus is a sauropodomorph from the Early Jurassic of Argentina, originally described from hatchling remains. Further discoveries of juvenile and mature specimens provide a sufficiently complete series to reconstruct general patterns of ontogeny. Here, one each of a hatchling, juvenile (~1 year old), and adult (8+ years old) individual was studied. Digital models of the bones were created for each specimen, from segmented μ-CT scans for the smaller bones and photogrammetry and laser scans for the larger bones. Modeled bones were then articulated to produce complete skeletons, with missing bones being replaced by scaled versions of adults or closely related taxa. Each skeleton was wrapped in convex hulls or more anatomically realistic shapes, which were used to estimate body mass and center of mass, and to conduct sensitivity analyses of these calculations. Both methods show consistent results that *Mussaurus* rapidly grew from about 60 g at hatching, to ~7 kg at one year old, and reaching ~1430 kg at adulthood. During this time, the body's center of mass moved from a position in the mid-thorax to a more caudal position nearer the pelvis, consistent with a shift from quadrupedalism to bipedalism that might have occurred early in ontogeny in *Mussaurus* and other early sauropodomorphs. Our findings offer important new insights into the evolution of locomotion across Sauropodomorpha, consistent with a heterochronic shift to quadrupedalism near Sauropoda.

Grant Information
European Research Council: DAWNDINOS 695517

Technical Session X (Friday, October 19, 2018, 10:45 AM)

TESTING ECOLOGICAL HYPOTHESES OF EXTANT AND CRETACEOUS COASTAL FLOODPLAIN FOREST SYSTEMS USING STABLE ISOTOPE ANALYSES

CULLEN, Thomas M., University of Toronto, Toronto, ON, Canada

Stable isotope analyses allow for a direct measure of the diet, physiology, and habitat of organisms. Previous stable isotope studies of dinosaurs have proposed niche partitioning based on habitat preference, and that dinosaur diet-tissue trophic enrichment factors (TEFs) were greater than those found in most extant vertebrates. In order to test these hypotheses, 16 taxa were collected from a single vertebrate microfossil bonebed in the Oldman Formation of Alberta, including dinosaurs (n=8), mammals, reptiles, and fish, and analyzed in the largest stable C and O isotope study of a Mesozoic system to date. Variation in isotopic distribution was quantified and, most importantly, compared to the results of an extant analogue system sampled using the same procedures. The Atchafalaya River Basin of Louisiana was selected to establish an isotopic baseline of a coastal floodplain forest ecosystem to evaluate results of the fossil dataset, based on climate and habitats similar to the inferred paleoenvironment. A large-scale field-collected sample resulted in the analysis of 20 extant vertebrate taxa, including numerous taxa that share a close phylogenetic relationship and ecological niche to those in the fossil assemblage.

Broad overlap exists in isotopic distributions between taxa in both the fossil and extant datasets, particularly among those in similar ecological roles, though some differentiation is detectable in C signal between terrestrial and aquatic taxa. No niche partitioning was detected between herbivorous dinosaur taxa. Similarly, all 5 analyzed theropod taxa were found to have isotopic distributions consistent with mixed-feeding faunivores in the extant sample, despite more divergent diets being previously hypothesized for some taxa (e.g., troodontids and *Richardoestesia*). The hypothesis that large TEFs explain higher than expected stable C values previously found in dinosaurs is refuted, as similarly enriched values are found in all sampled fossil vertebrate taxa including overlapping taxa such as crocodilians, gar, and metatherians, suggesting instead that they are related to changes in local isotopic baseline and do not reflect a unique aspect of dinosaur physiology. The broad isotopic overlap between taxa in both datasets suggests a high degree of resource mixing and terrestrial-aquatic connectivity exists in coastal floodplain forest ecosystems. It is possible that whatever niche partitioning exists may not be detectable using C or O isotopes, although it may also indicate a lack of ecological saturation in such systems.

Grant Information
NSERC CGS & QEII-GSST grants to TMC for Ph.D. research

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

MID-CENOZOIC EMBALLONURIDAE (MAMMALIA, CHIROPTERA) FROM PENINSULAR FLORIDA: DEMISE OF AN ARCHAIC LINEAGE AND THE ORIGIN OF NEOTROPICAL DICLIDURINES

CZAPLEWSKI, Nicholas J., University of Oklahoma, Norman, OK, United States of America; MORGAN, Gary S., New Mexico Museum of Natural History, Albuquerque, NM, United States of America

The entire published Paleogene–Neogene fossil record of the pantropical Emballonuridae in the western hemisphere consists of seven teeth: two molars of *Diclidurus* and a canine of an indeterminate genus from the middle Miocene La Venta fauna, Colombia, and four undescribed teeth from three localities near Contamana, Peru, of late Oligocene, early Miocene, and late Miocene age. New finds of emballonurids from several local faunas (LF) in Florida, U.S.A., of Oligocene and Miocene age greatly enhance this record. The fossils appear to represent two different lineages of Emballonuridae. A new genus with two new

species from two Oligocene LFs, I-75 and Brooksville 2, represents an archaic emballonurid lineage. These bats are dentally more derived than Taphozoinae (eastern hemisphere Eocene emballonurids and recent taphozoines) and are possibly related to Emballonurinae. A single M1 from the late Oligocene Buda LF may represent a third new species in, and is the last known appearance of, the same clade. A second new genus and species from the early Miocene Thomas Farm LF is more derived than the Oligocene taxa and appears to represent a member of crown Diclidurini. This taxon is similar to *Saccopteryx* and comprises the oldest known diclidurine. The presence of these taxa in extreme southeastern North America suggests that the evolution of the diclidurin clade occurred in tropical North America in the late Oligocene or early Miocene. These bats subsequently dispersed to South America presumably about the same time as did noctilionoids based on other fossils including speonycterids from I-75 and Brooksville 2 and new finds of phyllostomids from the early Miocene of Panama.

Grant Information
This project was funded in part by NSF grant DEB 99-81512.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

SCANNING METHODOLOGY AND MEASUREMENT ERROR IN DENTAL TOPOGRAPHIC ANALYSES: A COMPARISON OF MICROCT AND SURFACE LIGHT SCANNING METHODS

DALY, E. Susanne, Arizona State University, Tempe, AZ, United States of America; CATLETT, Kierstin K., Normandale Community College, Bloomington, MN, United States of America; LOCKE, Ellis, Arizona State University, Phoenix, AZ, United States of America; MORSE, Paul E., University of Florida, Durham, NC, United States of America; ORTIZ, Alejandra, Arizona State University, Tempe, AZ, United States of America; SCHWARTZ, Gary, Arizona State University, Tempe, AZ, United States of America

Dental topography is widely used to quantifying three-dimensional (3D), biological aspects of tooth form and has been applied to the fossil record to reconstruct important aspects of paleobiology, such as dietary adaptations, character displacement, and ecological niche partitioning. Micro-computed tomography (microCT) is the most commonly used method for capturing tooth anatomy, but other techniques such as structured light, touch-probe, and multi-sensor laser scanning are less costly, easier to transport, and can more rapidly acquire surfaces. Prior research has shown the impact of different retriangulation protocols (i.e., simplification, remeshing, and smoothing) on mesh measurements from microCT scan data, but to date no work has tested whether meshes derived from different scanners or different scanning resolutions are comparable when retriangulation protocols are held constant.

We used model hemispheres of known diameter to test whether meshes created with structured blue light (SBL) and microCT scanners produce similar results at the same resolution when retriangulation protocols are standardized. Subsequently, we compared microCT-derived meshes scanned at different resolutions (18 to 65 microns) and quantified the measurement error of the most frequently used dental topographic metrics: 2D and 3D surface area, Relief Index, Dirichlet Normal Energy (DNE), and Orientation Patch Count Rotated (OPCR).

Results confirm previous recommendations that retriangulation is needed to reduce measurement error from microCT-derived meshes; however, measurement error from SBL scanner-derived meshes is unaffected by retriangulation. SBL scanning produces meshes with measurement errors comparable to or less than those produced using microCT, demonstrating that different scanning methods are comparable with standardized mesh retriangulation procedures. Of the examined variables, DNE and OPCR are more sensitive to object dimensions and scanning resolution. We verify these results by replicating these these scanning methods with a primate dental sample and conclude that SBL scanning is a viable alternative to microCT scanning. Our study provides a methodology to ensure accuracy and precision when compiling scans obtained from different technologies to quantify biologically relevant aspects of the dentition. Combining SBL scans with microCT datasets of equal or higher resolution will enable paleontologists to use larger data sets to improve our knowledge of the dental functional biology of extinct species.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

COMPARATIVE LONG BONE HISTOLOGY OF ORNITHISCHIAN DINOSAURS

DAMDINSUREN, Idersaikhan, Institute of Paleontology and Geology, Ulaanbaatar, Mongolia; ZORIGT, Badamkhatan, Institute of Paleontology and Geology, Ulaanbaatar, Mongolia; TSOGTBAATAR, Chinzorig, Institute of Paleontology and Geology, Ulaanbaatar, Mongolia

Paleohistology has been utilized for exploring life history of dinosaurs. Hindlimb elements including femur, tibia, and fibula have been widely used for skeletochronology of dinosaurs because of the highest potential to preserve most of the lines of arrested growth (LAGs). Due to high rate of bone remodeling, forelimbs have been ignored for histological analysis. We hypothesize that histology of fore- and hindlimb bones of quadrupedal dinosaur taxa could be comparable and exhibit similar skeletochronological information. In this project, we examined histology of the humerus, tibia, fibula, and femur from three individuals of three ornithischian dinosaur species including *Protoceratops andrewsi*, *Psittacosaurus mongoliensis*, and *Haya griva*. Fore- and hindlimb microstructures of bipedal taxa including *P. mongoliensis* and *H. griva* exhibit different microstructures such as incomparable degree of vascularity, bone wall thickness, and number of LAGs. Histology of long bones from *P. andrewsi* including humerus, tibia, fibula, and femur presents similar number of LAGs and bone tissue type. This study demonstrates that fore- and hindlimb bones of bipedal dinosaur taxa including *P. mongoliensis* and *H. griva* are showing weak histological correlation for relative age assessment. Histology of both fore- and hindlimb bones of *P. andrewsi* present similar growth pattern. Therefore we suggest forelimb elements including humerus could have potential to provide skeletochronological and growth information of quadrupedal ornithischian dinosaurs.

Grant Information
FY2017 34th Research Grant Program for Foreign Doctoral Candidates in Japan funded by Kobayashi Fund, Fujifilm Xerox Co.Ltd. Tsogtbaatar Chinzorig - Ref#959.

Technical Session XII (Friday, October 19, 2018, 2:00 PM)

TOOTH MORPHOLOGY LINKED TO BODY SIZE AND PREY COMPLIANCE IN THE SNAKE TRIBE THAMNOPHIINI, AND ITS SIGNIFICANCE IN RECONSTRUCTING TROPHIC LINKS IN FOSSIL ECOSYSTEMS.

D'AMORE, Domenic C., Daemen College, Amherst, NY, United States of America; JUAREZ, Hugo C., Daemen College, Amherst, NY, United States of America

Snakes are important predators in modern ecosystems, but their trophic significance in paleocommunities has been difficult to determine. Fossil evidence is often scarce, with paleoecological conclusions based on co-occurring taxa, paleoenvironment, and/or functional morphology. Fossil snake teeth have been recovered several times, but only qualitative comparisons to modern taxa have been made. This may be because even though diet is well understood in numerous modern snakes, few studies have quantified dental form and linked it to diet. The goal of this study was to measure tooth size and shape in a modern clade of snakes, and determine if they correlated with diet. Snakes belonging to the tribe Thamnophiini were surveyed from dry skeletal material, as this clade has a wide variety of diets. 956 maxillary and dentary teeth were photographed from the labial perspective. The margins of the teeth were digitally outlined, and converted into equidistant semilandmarks. A GLS Procrustes superimposition was carried out, and centroid size was calculated. Dietary data was taken from existing literature. Snake species were significantly different from one another in both size and shape as indicated by ANOVA. Canonical variate analysis showed the majority of interspecific shape variance was represented by how narrow/wide the tooth was, followed by degree of distal curvature and taper. Tooth form correlated well with snake size, and the compliance and mobility of their prey. Snake teeth displayed significant positive size and shape allometry. The teeth of larger taxa were relatively large, thin, and untapered. With generalist diets including frogs, fish, and annelids, these teeth were ideal for puncturing compliant, struggling prey. The much smaller *Nerodia clarkii* ate primarily fish, resulting in abnormally large teeth for a similar function. Species that rely heavily on hard-shelled, crustaceans, such as *Regina alleni,* had small, wide, peg-like teeth for durophagy. Congenerics specialized on softer prey such as molted crustaceans and amphibian larvae had more curved gracile teeth. The narrow, needle-like teeth of *Storeria dekayi* were ideal for securing slow-moving prey that incorporate mucus as a defense, such as slugs, snail, and earthworms. As a clear link exists between the mechanical properties of prey and dentition, future work should directly compare the teeth of these and other modern snakes to fossil genera such as *Pachyrhachis*, *Sanajeh*, *Wonambi*, and *Yurlunggur* to derive more rigorous conclusions about prey characteristics.

Technical Session VI (Thursday, October 18, 2018, 9:00 AM)

THE IMPLICATION OF THE VERTEBRAL DEVELOPMENT ON THE ORIGIN OF LISSAMPHIBIANS

DANTO, Marylene, Museum für Naturkunde, Berlin, Germany; WITZMANN, Florian, Berlin, Germany; TRIEPEL, Sandra, Berlin, Germany; MITGUTSCH, Christian, Berlin, Germany; FROEBISCH, Nadia B., Museum für Naturkunde, Berlin, Germany

Despite increasing knowledge about the fossil record of lissamphibians (frogs, salamanders, and caecilians), their origin is still unresolved and different origins within Paleozoic early tetrapods are proposed. As vertebral body construction is similar between certain early tetrapods groups and lissamphibians, vertebral morphology as well as the ossification sequence of the vertebral elements are commonly important character traits within these hypotheses. In lissamphibians, a vertebral segment consists of a monospondylous vertebral centrum, whereas early tetrapods display a wide spectrum of different vertebral types which range from multipartite up to monospondylous centra. In this study, we sought to investigate if the ossification sequence of neural arches and centra and the mode of centrum formation in extinct and extant forms could be indicative of phylogenetic relationships. For that, growth series of three different salamander taxa were examined and we compared the results with existing studies on vertebral development in frogs, caecilians, and early tetrapods. Here we demonstrate that the mode of centrum formation is highly variable in early tetrapods and lissamphibians and cannot be used to determine the origin of lissamphibians within early tetrapods. In early tetrapods, salamanders, and caecilians, the vertebral centrum develops by chordacentral (induced by the notochord) and perichordal (induced by the perichordal tube) centrum formation. In frogs, however, no chordacentral centrum formation has been observed so far. In the salamander taxa studied here, the following chondrification and ossification sequences are observed: chondrification first of the neural arches and then of the centra followed by ossification first of the centra and then of the neural arches. In frogs, whereas, the neural arches ossify prior to the vertebral centra and it can be assumed that this developmental sequence represents the ancestral condition for tetrapods, as it characterizes some stem-tetrapods and all temnospondyls from which growth series are known. However, the ossification sequence of the vertebral column is only incompletely known in stem-amniotes which makes a comparison with extant lissamphibians difficult.

Podium Symposium (Wednesday, October 17, 2018, 8:45 AM)

KEEPING YOUR DATA ALIVE WITH HARMONIZED REPOSITORIES

DAVIS, Edward B., University of Oregon, Eugene, OR, United States of America

Most data are already dead, but there is hope for the future. Despite abundant data in the preparation of their research, many authors present only summary statistics or scatterplots in their publications. If the underlying data are lost, the papers have the same value as anecdotes, as it is impossible to completely reconstruct the original dataset from figures or summaries. Replication, an essential part of scientific best practice, would require resampling the original natural population, and that resampling is sometimes impossible. Data in published tables are little better, requiring researchers to rip the data for re-use, potentially introducing keystroke errors or errors from optical character recognition. Online archives and supplemental files leave data primarily discoverable through papers, the data are not presented in context, and the data files are not kept in current formats.

Harmonized repositories can keep your data alive. Data are kept in an up-to-date format, linked to ontologies that make sense of the values, harmonizing your data with other data sources. Ontologies allow sensible linkages to other repositories, enabling contextual discovery without additional effort on the part of the end user. Researchers on one system can discover relevant data from others, data they might never have looked for intentionally.

Current data harmonization efforts, like ePANDDA and ELC, seek to ease access to records in the complex ecosystem of online databases that have grown to support paleobiological and paleoecological research. New databases can take advantage of the computer science concept of ontologies: storing data not in tabular format, but in subject- verb-object connections designed to facilitate discovery by both human users and machine- learning algorithms. As this methodology become established, all data collected by paleontologists will be able to find a home in a harmonized repository, even if that data type has never been collected and published before.
Wouldn't you want your life's work available forever? Don't let your data die with you: put them in a harmonized repository.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

INCREASING THE TRIASSIC DISPARITY OF SAUROPTERYGIA: A NEW BIZARRE SIMOSAURID FROM THE UPPER TRIASSIC OF SPAIN
DE MIGUEL CHAVES, Carlos, UNED, Madrid, Spain; ORTEGA, Francisco, UNED, Madrid, Spain; PÉREZ-GARCÍA, Adán, UNED, Madrid, Spain
Several well-preserved eosauropterygian specimens from the Upper Triassic levels (Keuper Facies) of El Atance fossil site (Sigüenza municipality, Guadalajara Province, Spain) allow the definition of a bizarre new eosauropterygian. It is identified as Simosauridae, a clade up to now exclusively compose by a valid species: *Simosaurus gaillardoti,* from the Ladinian (Middle Triassic) of France and Germany.
The new Spanish simosaurid presents several characters so far considered as exclusive of *S. gaillardoti*, including a posteriorly displaced mandibular articulation, a small anterolateral process of the clavicle and the presence of infraprezygapophyses and infrapostzygapophyses. A new diagnosis for Simosauridae is proposed. In addition, the review of *S. gaillardoti*, including the study of 25 skulls, provides a better knowledge about the anatomy and intraspecific variability of this taxon, and allows a detailed comparison with the new simosaurid from El Atance. Thus, an emended diagnosis for *S. gaillardoti* is also proposed.
In spite of the characters shared by *S. gaillardoti* and the new simosaurid from El Atance, remarkable differences which imply a radically different way of life are also recognized. The postcranial skeleton of this new form is highly pachyostotic, with robust vertebrae and ribs. The skull of the simosaurid from El Atance is dorsoventrally compressed, with a relatively long snout and a very gracile mandible, with a poorly reinforced symphysis. In addition, both the skull and the jaws present numerous small teeth attached in a pleurodont implantation, which would conform to a sieve-like structure. We propose a filter feeding lifestyle for this new simosaurid taxon. This is a completely different ecological role to that for its sister taxon *Simosaurus gaillardoti*, which is interpreted as an active piscivore predator. The study of the new form increases the already high ecological disparity known for the Triassic marine reptiles.
Grant Information
FPI UNED (0271864713 Y0SC001170), SYNTHESYS project (FR-TAF-5710, DE-TAF-5955), Viceconsejería de Cultura de Castilla - La Mancha (SBPLY/15/180601/000044).

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE PALEOENVIRONMENT OF THE VERTEBRATE FOSSIL-BEARING ALLISON MEMBER OF THE MENEFEE FORMATION (UPPER CRETACEOUS, EARLY CAMPANIAN), EASTERN SAN JUAN BASIN, NEW MEXICO, U.S.A.
DEANS, Austin M., Appalachian State University, Boone, NC, United States of America; LUCAS, Spencer G., Albuquerque, NM, United States of America; LEWIS, Caleb, Pueblo, CO, United States of America; HECKERT, Andrew B., Appalachian State Univ, Boone, NC, United States of America
The Allison Member of the Menefee Formation in the San Juan Basin of northwestern New Mexico is understudied, but has recently yielded several important new localities. Yet rarely have studies focused on the geology of those localities. Here we describe the paleoenvironment of a particularly fossiliferous portion of the unit using a variety of techniques, including sedimentology, taphonomy, geochemistry, and stratigraphy. The sediments of the fossil-bearing interval are largely composed of bentonitic mudstone and interbedded, intermittently crossbedded, lithic wacke, indicating an alluvial setting. We observed occasional siderite nodules and lignite coal layers, which indicate an anoxic swampy or bog-like setting. The majority of the vertebrate fossils come from a localized, poorly-sorted, polymictic intraformational clay-pebble conglomerate lag in a channel complex that is locally bone-bearing and referred to as NMMNH L-5636. We also collected fossils from a nearby site called L-5635. Geochemical analysis of siderite in the Menefee is consistent with a freshwater setting. We analyzed siderite samples using a scanning electron microscope and found them to have a relatively pure Fe component, with little Mg- or Ca-replacement, indicating a freshwater setting. The taphonomy of fossil teeth from these localities support a more aquatic depositional environment. There is significant taphonomic abrasion on teeth of terrestrial elements of the assemblage, but relatively little such wear on aquatic taxa, particularly sharks and rays. These same taxa represent freshwater, saltwater, and terrestrial assemblages, indicating a mixing of the ecosystems. At the same horizon at a locality ~50 m southwest of L-5636 there is a petrified tree log with numerous trace fossils of *Teredolites* (shipworm burrows), indicating a brackish, estuarine setting. The log sits in a channel sandstone oriented north 65° east, which indicates paleoflow to the ENE. An additional line of evidence for the paleoenvironment in the Menefee Formation is from a dinosaur track identified as that of an ornithopod, possibly a hadrosaur, from a locality two hundred meters from L-5636 and at a slightly (< 5m) higher stratigraphic level. This indicates terrestrial animal activity nearby, so the teeth are autochthonous rather than transported there. These factors all support the idea of an alluvial deltaic setting on the edge of the Western Interior Seaway. The system is predominantly freshwater, but with significant marine influence.
Grant Information
We will be seeking funding from the Appalachian State University Dept of Geological and Environmental Sciences, as well as from the Office of Student Research.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

NEW MIOCENE LARGE MAMMAL FOSSILS FROM THE SEVIER RIVER FORMATION ON THE WESTERN MARGIN OF THE COLORADO PLATEAU OF CENTRAL UTAH
DEBLIEUX, Donald D., Utah Geological Survey, Salt Lake City, UT, United States of America; THOMPSON, Mary E., Idaho Museum of Natural History, Pocatello, ID, United States of America; FLORA, Holley, University of Oregon, Eugene, OR, United States of America
The uplift and erosion of the Colorado Plateau over the past 15 million years has exposed sedimentary rocks that provide one of the world's greatest records of Mesozoic and early Cenozoic vertebrate life. However, because of this geological history, rocks of Neogene age are poorly represented and, therefore, our knowledge of vertebrate faunas on the Colorado Plateau during this time is limited. Since 2002, the Utah Geological Survey has periodically collected mammal fossils from a Miocene-age locality in the Sevier River Formation (SRF) of central Utah. Two species of heteromyine rodents (*Metaliomys sevierensis* and *Diprionomys* sp., cf. *D. minimus*), two cricetid rodents (*Paronychomys lemredfieldi* and *Basirepomys robertsi*), and one lagomorph (*Hypolagus vetus*) have been described. We are now working to describe the larger fossil mammals. We have recovered material belonging to proboscidians, camelids, antilocaprids, equids, and carnivorans. Most abundant are cranial and postcranial remains of at least two genera of camels. One of these is a large camel, cf. *Megatylopus* and a smaller taxon, cf. *Pleiolama*. Several partial mandibles of a small artiodactyl referable to the antilocaprid cf. *Plioceros* have been found. Horse teeth have been recovered including incisors and a deciduous P2 attributable to *Dinohippus* sp. Carnivores are represented by fragmentary jaws, teeth, and postcrania belonging to felids, canids, and mustelids. Previous geological investigations have estimated that the rocks of the SRF range in age from 14 to 7 Ma and age estimates for rocks near the fossil site range from 9 to 7 Ma, which places it in the Hemphillian Land Mammal Age (~ 10–5 Ma). The rodents and lagomorphs are consistent with a Hemphillian age. These fossils provide a rare opportunity to characterize the Neogene mammalian fauna of the western Colorado Plateau during this poorly known time interval. Comparisons of the new fauna with other Miocene faunas of western North America will constrain the age of these rocks and help refine estimates of the timing of uplift and volcanism in this region.

Technical Session II (Wednesday, October 17, 2018, 10:45 AM)

A NEW CAPTORHINID AND ITS CONTRIBUTION TO OUR UNDERSTANDING OF TAXIC DIVERSITY IN THE EARLY PERMIAN CAVE SYSTEM OF RICHARDS SPUR, OKLAHOMA
DEBRAGA, Michael, University of Toronto, Mississauga, ON, Canada; REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada
The Richards Spur locality in Oklahoma is noted for its diverse terrestrial vertebrate assemblage of early Permian age preserved within a complex cave system. Nearly 40 vertebrate taxa have been collected at this locality, but among the amniotes, captorhinid eureptiles are particularly abundant. Captorhinid remains are comprised primarily of the multi-tooth rowed *Captorhinus aguti*, and single tooth-rowed *Captorhinus magnus*. Recently, two other captorhinids have been recognized, *Opisthodontosaurus,* and *Labidosauriscus*. The former is represented by several skulls and numerous dentigerous jaw elements, the latter is known from a partial skull and a few dentigerous elements. Here we describe a new single-tooth rowed captorhinid from Richards Spur, represented by a nearly complete skull, which is preserved in almost perfect condition without any significant crushing. The material is comprised of dark brown bone embedded in a chalky matrix that is typical of the Dolese quarry material. The right mandible is preserved and in articulation with the skull while the left mandible is preserved in association with a large trematopid specimen and is at present difficult to extricate. As in *C. magnus*, this specimen represents an immature captorhinid.
Comparative study of the newly described specimen with various other captorhinids, including the holotypes of *Captorhinus magnus* and *C. laticeps,* along with a comprehensive phylogenetic analysis using the latest published data has yielded a topology that places this new taxon with *C. laticeps,* previously known from the McCann Quarry in Oklahoma, and the Mitchell River locality, Baylor County, Texas. This brings to seven the number of captorhinid species (including the enigmatic *Baeotherates, Opisthodontosaurus, Labidosauriscus,* and an unnamed basal captorhinid) known from the productive Richards Spur cave-fill locality, of which at least three are variants of the genus *Captorhinus*: *C. aguti, C. laticeps,* and *C. magnus*. Each of these seven species exhibit a combination of variation in post-caniniform tooth morphology and in skull size, ranging from 45–120 mm in length, indicating that there was fine resource partitioning among the small to medium sized faunivorous and omnivorous captorhinids at Richards Spur. As a natural trap of the surrounding terrestrial vertebrate community, the cave system at Richards Spur provides a unique view of early reptilian diversification in an upland environment.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

FLIGHTS OF FANCY: MODELING POWERED FLIGHT VERSUS GLIDING IN THE BIZARRE THEROPOD *YI QI* AND ITS BEARING ON THE QUESTION OF THE ORIGINS OF FLIGHT ACROSS PENNARAPTORA.
DECECCHI, Thomas A., University of Pittsburgh at Johnstown, Johnstown, PA, United States of America; HABIB, Michael, Keck School of Medicine of USC, Los Angeles, CA, United States of America; LARSSON, Hans C., McGill University, Montreal, QC, Canada
Flight is a locomotor strategy that has evolved independently more than 30 times across vertebrates. Powered flight, a subset of this, is much more restrictive, evolving only three times, in pterosaurs, bats, and paravian theropods. Only in this last group do we have enough of a dataset that we can begin to address the question of what is sufficient to allow flight and did it evolve more than once within the group. This last issue became more tangible with the discovery of the bizarre membranous winged theropod *Yi qi*. *Yi* is different from other winged and potential volant pennaraptorans because it built its primary wing structure using a skin based membrane, as opposed to the feathered flight structure seen in birds. Using methods derived from extant birds and bats on flight potential, force production and take off ability, we seek to determine which method of flight, powered active flight or non-powered gliding, *Yi* could employ, and the ecological setting it inhabited. By taking several permutations of mass and wing area, to encompass the

biological plausible range that *Yi* could have inhabited based on several proxies of body size, we show that powered flight was unlikely for *Yi* and ground based take off was almost impossible. We find that it is much more parsimonious to reconstruct *Yi* as a glider. Comparing this to reconstructions of several similarly-sized paravians such as *Microraptor, Anchiornis*, and *Archaeopteryx*, we find a significantly different pattern in take off potential and force generation that suggests that *Yi* differed in flight ability and behaviour compared to feathered winged paravains. This finding helps inform us on the minimal requirements for the origins of powered flyers as well as illustrate how gliders and flapping-based fliers differed morphologically and ecologically around the origins of avian flight. Our findings reinforce the idea that in the Late Jurassic and Early Cretaceous small derived theropods were diversifying morphologically, ecologically, and behaviorally, and raises the question of what the drivers were during this period that facilitated multiple lineages to independently explore aerial niches for the first time.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

TAPHONOMY OF VERTEBRATE FOSSILS ON A MARINE SEQUENCE BOUNDARY IN THE UPPER CRETACEOUS (CAMPANIAN) JUDITH RIVER FORMATION, MONTANA

DECKMAN, Max E., Macalester College, St. Paul, MN, United States of America; ROGERS, Raymond R., Macalester College, St Paul, MN, United States of America; CURRY ROGERS, Kristina A., Macalester College, Saint Paul, MN, United States of America

Large-scale patterning of the fossil record in relation to sequence stratigraphy is now generally understood, and models of the stratigraphic distribution of fossils in relation to key surfaces in marine depositional sequences have proven insightful. Here we explore the taphonomy of vertebrate fossils concentrated along a sequence boundary in the Woodhawk Member of the Campanian Judith River Formation in north-central Montana. The shallow marine sandstones that host the sequence boundary and associated fossil occurrences accumulated in the shoreface during early stages of the Bearpaw transgression. The sand-on-sand erosional surface marking the sequence boundary was initially recognized due to its distinctive fossiliferous nature (fossils are relatively rare in surrounding strata), with concentrations of bioclastic debris, including mollusk shells, shark teeth, and fish and marine reptile bones, preserved in localized meter-scale scours. It can be further identified by: (1) a shift to finer grained sandstone above the boundary; (2) an anomalous abundance of amphibole grains preserved immediately below the boundary (presumably due to early cementation); and (3) distinctive diagenesis (ferroan dolomite cement).

We studied two localized concentrations of fossil debris to investigate the taphonomic quality of vertebrate fossils associated with the sequence boundary. The localities are separated by ~3 km, and together have yielded more than 7000 specimens. Fossils from both sites exhibit evidence of abrasion and rounding, with larger bioclasts showing more advanced stages of modification. To standardize comparisons, we focused on the characterization of vertebrae and skate teeth, which are plentiful in both sites. Preliminary data indicate that the more offshore of the two sites, based on position along a west (onshore)—east (offshore) transect, exhibits more evidence of rounding and abrasion. This potential disparity presumably reflects variations in energy and perhaps different transport and burial potentials along the transect. Another enigmatic aspect of the sample is the occurrence of terrestrial and freshwater fossils (dinosaur, mammal, gar) in what is otherwise a decidedly marine assemblage. The origin of the terrestrial fossil component could relate to exposure of the shelf during development of the sequence boundary, or perhaps offshore transport of carcasses. Diagenesis of the fossil material may be the key to resolving this question of sourcing.

Grant Information

This research was funded by NSF (EAR-1052673) and the David B. Jones Foundation.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

GEOCHEMICAL ANALYSES AND PETROGRAPHIC OBSERVATIONS OF UPPER TRIASSIC (ADAMANIAN) COPROLITES FROM THE MONITOR BUTTE FORMATION, LOWER CHINLE GROUP, NEAR WINGATE MESA, SOUTHEASTERN UTAH.

DELGADO, Yanelis, Appalachian State University, Boone, NC, United States of America; HECKERT, Andrew B., Appalachian State University, Boone, NC, United States of America; FOSTER, John R., Museum of Moab, Moab, UT, United States of America

We report here on ~1,500 coprolites collected in 2016 and 2017 from 11 localities low in the Upper Triassic Monitor Butte Fm of southeastern Utah. We examined the surface of these coprolites microscopically and were able to identify osteichthyan scales, bones, tooth plates, and mandibles. Most of the coprolites have a spiral morphology that is diagnostic of *Heteropolacopros*, usually attributed to a xenacanth shark or lungfish based on the presence of a spiral valve in these taxa, although we hold reservations on this identification based on the size of the coprolites.

For this project, we used Energy Dispersive X-Ray Spectroscopy (EDS) in a Scanning Electron Microscope (SEM) to determine the chemical composition of the coprolite matrix and the microfossils found inside them. We analyzed three coprolites, two with an assortment of microvertebrates on their surfaces and a third one with what appeared to be plant material. We also used an optical microscope to make petrographic observations and identify the microfossils and any possible textures seen in a cross-sectional view of the coprolite specimens.

Our EDS analysis indicates that the coprolite matrix is composed largely of apatite, and, while the microfossils appear to have a different composition than the coprolites on the outer surface, the EDS data indicates that these have an apatite composition as well. In cross-section, some of the bones embedded in the coprolites have a thin layer of barite surrounding them and, in the case of one of the microfossils, the barite appears to have crystallized in a central cavity. While many of the coprolites exhibit a spiral morphology macroscopically, the petrographic observations gave no indications of spirals in the matrix. Two of the sectioned coprolites have thin layered spirals around them that can be seen macroscopically, but the center of the coprolite has accumulated matrix with no identifiable textures. We analyzed a third coprolite with a different morphology that appears to indicate that its perpetrator digested plant material. The microfossils observed in the thin sections of microvertebrate-bearing coprolites are mostly osteichthyan scales, but a limb bone was also identified along with the proximal/distal(?) end of a separate limb bone near it, and several other bone fragments. Of the microvertebrate-bearing coprolites, one appears to have microvertebrates throughout its interior while the other appears to have the microfossils aggregated on the outer layers and a large mass of matrix in its center.

Technical Session IX (Friday, October 19, 2018, 9:00 AM)

NICHE PARTITIONING, TAPHONOMY, AND THE DISTRIBUTION OF HEMPHILLIAN RHINOCEROTIDS AND EQUIDS

DELPLANCHE, Rémy A., Gonzaga University, Beaverton, OR, United States of America; ORCUTT, John D., Gonzaga University, Spokane, WA, United States of America

Localities from the Hemphillian North American Land Mammal Age have yielded copious amounts of rhinocerotid and equid fossils. However, it has been suggested that any one locality does not yield large amounts of both taxa, instead preserving plentiful fossils of one and almost none of the other. A nonrandom distribution of horses and rhinos between Hemphillian localities could be the result of preservational bias or of niche partitioning driven by competitive exclusion. There is evidence of niche partitioning between rhinos and zebras in modern Africa based on length of grass grazed, and it is possible that competitive exclusion also occurred between rhinos and horses in the Miocene. We compared equid and rhinocerotid distribution and abundance within Hemphillian faunas to determine whether that distribution truly is nonrandom and compared horse and rhino relative abundance between paleoenvironments to test taphonomic and ecological hypotheses of perissodactyl abundance. Occurrence and abundance data (minimum number of individuals and number of individual specimens) were obtained from MIOMAP and published literature. A chi-squared test showed that the observed distribution of rhinocerotid fossils differs significantly from a random distribution. A Kruskal-Wallis Test was used to compare rhinocerotid abundance in different paleoenvironments and demonstrated that rhinos were significantly more abundant than horses in lacustrine environments and significantly less abundant in fluvial environments. These results do not rule out the possibility that preservation bias explains Hemphillian perissodactyl distribution. However, if this were the case, most of the larger, denser rhino fossils would be expected in fluvial sediments, where they would be less prone to winnowing than smaller, less dense horse fossils. The abundance of rhino fossils in low-energy environments and the preponderance of horses in fluvial deposits suggests an ecological rather than taphonomic cause. Ongoing analyses of geographic patterns in Hemphillian equid and rhinocerotid distribution will further test whether these patterns are the result of niche partitioning due to competitive exclusion.

Technical Session II (Wednesday, October 17, 2018, 11:45 AM)

NEW RHYNCHOCEPHALIAN (REPTILIA, LEPIDOSAURIA) MATERIAL FROM THE UPPER JURASSIC MORRISON FORMATION, NORTH-CENTRAL WYOMING, U.S.A. CONSOLIDATES A CLADE OF AMERICAN SPHENODONTINAE

DEMAR, David G., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; JONES, Marc E., University of Adelaide, London, United Kingdom; CARRANO, Matthew T., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America

Rhynchocephalia, of which the New Zealand *Sphenodon* is the sole surviving taxon, is known from at least the Middle Triassic, attained its peak taxonomic diversity during the Jurassic, and reached a nearly global distribution by the end of the Cretaceous. However, much of its fossil record, particularly in North America, is based on incomplete specimens (e.g., isolated dentaries). These include the type specimens of *Opisthias rarus* and *Theretairus antiquus* from the Upper Jurassic Morrison Formation (MF) of the US Western Interior, making it difficult to assess their morphology, phylogenetic relationships, ecology, and validity. Subsequent attributions of partial skulls and postcrania from the MF to *Opisthias* remain questionable given the nature of the types. Here we report on new rhynchocephalian material from the MF at Fox Mesa, Big Horn Basin, north-central Wyoming,that is beginning to clarify many of these issues.

Among this material is an articulated partial skull and skeleton (“Fox Mesa taxon”), which is complete up to the pelvic region. The excellent preservation includes palmar sesamoids in the right manus, the first known in any fossil rhynchocephalian. Unlike *“Opisthias*” material from Colorado, the Fox Mesa taxon has an isolated palatine tooth in additional to the single lateral row. The specimen also provides conflicting indications of ontogenetic stage: it exhibits moderate tooth wear and small body size (snout-vent length ~8.5 cm) but also three consecutive vertebrae (axis–C4) with unfused neural arches.

Our parsimony analysis produced a strict consensus topology that recovered a sister-taxon relationship between the Fox Mesa taxon and *Theretairus*. This pairing, in turn, was recovered as the sister taxon of *Sphenovipera* from the late Lower Jurassic of Mexico and together are nested within Sphenodontinae, which includes *Sphenodon*. All three of these former taxa are small (skull length ≤20 mm) and united by two unambiguous character states: dentary possesses: (1) two or more posterior successional teeth; and (2) inclination of its symphysis >50°.

Further study will clarify if the Fox Mesa taxon is a new species. Regardless, our results support the validity of both *Theretairus* and *Opisthias*, indicating ecomorphological diversity within the MF. Variation among specimens assigned to *Opisthias* suggests that some may be mis-assigned, and others may represent species-level diversification within the genus. Finally, ontogenetic indicators among Rhynchocephalia need to be more thoroughly assessed, especially tooth wear and body size.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

MODELING TOOTH FORMATION TIME TO PREDICT TOOTH REPLACEMENT RATES IN *MAJUNGASAURUS* AND OTHER THEROPOD DINOSAURS

D'EMIC, Michael, Adelphi University, Garden City, NY, United States of America; O'CONNOR, Patrick M., Ohio Univ, Athens, OH, United States of America; GAVRAS, Joanna, Adelphi University, Garden City, NY, United States of America; MARDAKHAYAVA, Elizabeth, Adelphi University, Garden City, NY, United States of

America; LUND, Eric K., Heritage College of Osteopathic Medicine, Athens, OH, United States of America
The abelisaurid theropod dinosaur *Majungasaurus crenatissimus* is known from abundant material from the latest Cretaceous (Maastrichtian) of Madagascar. The species was cannibalistic and lived in a harsh, seasonal paleoenvironment. *Majungasaurus* and other abelisaurids had small teeth and a dorsoventrally tall, anteroposteriorly short skull relative to the condition in other theropods. In order to investigate the distinctive craniodental anatomy of *Majungasaurus*, we thin sectioned a large sample of isolated teeth and CT scanned over a dozen dentigerous elements collected over broad geographic exposures across northwest Madagascar. Daily deposited incremental lines of von Ebner in *Majungasaurus* have thicknesses in the range of other dinosaurs, but owing to their small size, *Majungasaurus* teeth formed relatively quickly. We present a model of tooth age based on tooth size that allows for calculation of tooth formation and replacement rates without further destructive sampling. CT scans reveal multiple generations of replacement teeth in each alveolus in *Majungasaurus*. There is only a small size discrepancy between successive replacement teeth, indicating much more rapid tooth replacement rates than found in other theropods, perhaps related to a specialized diet and/or feeding style in *Majungasaurus*. We place our findings in a phylogenetic context with novel CT and histological data from other theropods, tracing the evolution of tooth formation times and replacement rates through the clade.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

DINOSAUR HUNTING IN THE KINGDOM OF LESOTHO: NEW DISCOVERIES FROM THE EARLY JURASSIC UPPER ELLIOT FORMATION
DENARIE, Shawn L., The George Washington University, Washington, DC, United States of America; CHOINIERE, Jonah, University of the Witswatersrand, Johannesburg, South Africa; STIEGLER, Josef, The George Washington University, Washington, DC, United States of America; MOORE, Andrew, The George Washington University, Washington, DC, United States of America; CLARK, James M., The George Washington University, Washington, DC, United States of America
The Elliot Formation of Lesotho and South Africa constitutes the central layer of the Stormberg Series, a sedimentary geological formation of Late Triassic to Early Jurassic age located in the Karoo Basin region of Southern Africa. The upper Elliot Formation is notable for preserving one of the best-known records of terrestrial vertebrates from the Early Jurassic, with the formation having yielded numerous fossils of early mammals, dinosaurs, crocodylomorphs, and a variety of other taxa representing major groups that survived the end-Triassic extinction. However, while the upper Elliot Formation has been prospected at several sites in South Africa in recent years, the formation has remained less explored in Lesotho, and several known fossil-bearing localities in Lesotho have not been appreciably surveyed at any point since their initial discovery and documentation by A. W. Crompton and others in the 1960s. Our team, co-led by Dr. James Clark and Dr. Jonah Choiniere, and including geologists and paleontologists from the George Washington University, the University of the Witwatersrand, and Cape Town University, returned to several of these fossil-bearing localities, and found articulated remains at three: Likhoeli, Mohales Hoek, and Quthing. We collected many fossils at each of these localities, with notable specimens including a nearly-complete articulated skeleton of a prosauropod dinosaur (cf. *Massospondylus*); a complete skull of a small crocodyliform; a partial skull and associated postcrania of an ornithischian; associated bones possibly of a mammaliaform; and a nest of dinosaur eggs with embryonic remains. We also collected volcanic tuff samples for radiometric dating from the lower and upper Elliot Formation, and identified many additional outcrops for future investigation.
Grant Information
Field work supported by the National Geographic Society.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

TINY GIANTS: PROBABLE *SHONISAURUS POPULARIS* EMBRYOS FROM BERLIN-ICHTHYOSAUR STATE PARK
DEPOLO, Paige E., University of Edinburgh, Edinburgh, United Kingdom; KELLEY, Neil P., Vanderbilt University, Nashville, TN, United States of America
Ichthyosaurs were among the first vertebrates to attain gigantic proportions (>10 m body length) and did so repeatedly during their evolution. The Late Triassic species *Shonisaurus popularis* is an iconic example of this pattern and belongs to a clade of generally large-bodied ichthyosaurs, Shastasauria. *S. popularis* is known principally from outcrops of the Luning Formation in the vicinity of Berlin-Ichthyosaur State Park (BISP), Nevada, U.S.A. The majority of these remains, including those within a mass-mortality assemblage preserved *in situ* at the park, represent large adults ranging 11–15 m in size. However, the original description of *Shonisaurus* briefly noted the presence of much smaller, embryonic remains associated with one of the type specimens. Unfortunately, no figures or photographs are known for these putative *Shonisaurus* embryos and their existence has remained unconfirmed.
We report two small (~2-cm diameter) ichthyosaur vertebrae, one found as surface float from a horizon near the Carnian-Norian boundary at BISP and one associated with material from the type series excavated by Camp in the 1950s and now housed in the collection at the Nevada State Museum, Las Vegas. Both vertebrae show features consistent with *Shonisaurus* including a porous bony texture and an hourglass cross-section with concave anterior and posterior surfaces. These specimens are much smaller than vertebrae from adults which range from 15–25 cm in diameter. Additionally, one of the small vertebrae shows evidence of an open notochordal canal. Although these small vertebrae were not found in direct association with a larger skeleton, a comparison of scaling relationships between *in-situ* embryos and adults known from other ichthyosaur species indicates that these vertebrae likely represent *Shonisaurus* embryos or neonates.
In addition to these two vertebrae, an additional embryonic or neonatal *Shonisaurus* occurrence in the Luning Formation was previously reported. This very small jaw fragment (2.5 cm long) has alveoli bearing the remains of infolded roots, a typical ichthyosaurian feature. Although these isolated remains provide limited information about the early ontogeny of *Shonisaurus*, their presence at multiple localities and stratigraphic levels within the park, together with the abundance of adult specimens and the apparent absence of intermediate ontogenetic stages (larger juveniles or subadults), is consistent with previous hypotheses that the unique *Shonisaurus*-dominated assemblage at BISP represents an ichthyosaur birthing ground.

Technical Session V (Thursday, October 18, 2018, 10:30 AM)

ARIDIFICATION AS A POTENTIAL DRIVER OF THE EXTINCTION OF THE MARSUPIAL LION IN AUSTRALIA
DESANTIS, Larisa, Vanderbilt University, Nashville, TN, United States of America; PRICE, Gilbert, University of Queensland, Brisbane, Australia; ARCHER, Michael, University of New South Wales, Maroubra, Australia
The dietary ecology of marsupial carnivores has been debated for decades. Most notably, the marsupial lion *Thylacoleo carnifex* evolved from herbivorous ancestors to become one of the most formidable predators on the landscape. Prior work has demonstrated that while *Thylacoleo* was only 30% of the body size of African lions, it had a nearly similar bite force (70%). Further, its postcranial morphology has been described as being more 'bear- like' and well suited for ambush hunting. Stable isotopes in carnivores can help clarify the habitat of consumed prey, and hence where predators hunted. Here, we examined the stable isotopes of marsupial carnivore tooth enamel including *Thylacoleo*, *Thylacinus*, and *Sarcophilus* from eastern Australia. Stable carbon isotopes demonstrate that *Thylacoleo* consumed primarily prey that occupied forested environments, with significantly lower $\delta^{13}C$ values than both *Thylacinus* ($p = 0.030$) and *Sarcophilus* ($p = 0.002$) specimens from Wellington Cave in New South Wales (NSW)—suggesting that *Thylacoleo* specialized on forest dwelling prey that occupied the densest forests available in the Pleistocene. However, all marsupial carnivores here examined show a reliance on prey that consumed primarily C_3 resources (all taxa, $n = 55$, have $\delta^{13}C$ values < -10.3‰, equivalent to prey-values of ~-9‰ and modern plant values of ~-24‰). As mammals from higher latitude localities in Queensland (QLD) consume a higher percentage of C_4 resources than at lower latitudes, we also examined *Thylacoleo* specimens from QLD which demonstrate the consumption of prey in significantly more open environments than further south ($p < 0.0001$). In NSW, *Thylacoleo* values range from -17.5‰ to -13‰ while individuals in QLD range from -14.9‰ to -10.8‰. This shift suggests that *Thylacoleo* consumed prey that consumed a larger proportion of C_4resources than further south, yet still demonstrates their reliance on forest-dwelling prey. While *Thylacoleo* may have been constrained by mode of hunting, it was fully capable of eating both flesh and bone (and clearly did this based on a broad range of complexity and anisotropy values that span the range of modern African carnivorans), in contrast to *Thylacinus*, which consumed primarily flesh and/or soft organs. Even so, the aridificaiton of the continent (with pronounced changes occurring since ~350,000 years ago) may have detrimentally impacted the hunting effectiveness or prey-base of *Thylacoleo* contributing to its extinction, in contrast to *Thylacinus* and *Sarcophilus*, which both survived into the 20th century.
Grant Information
NSF 1455198 (to DeSantis) and Vanderbilt University

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PALEONEUROANATOMY OF THE AETOSAUR *NEOAETOSAUROIDES ENGAEUS* (ARCHOSAURIA, PSEUDOSUCHIA): FIRST NATURAL AND DIGITAL ENDOCASTS
DESOJO, Julia Brenda, CONICET-Museo de la Plata, La Plata, Argentina; VON BACZKO, Maria Belen, CONICET - Museo de La Plata, La Plata, Argentina; TABORDA, Jeremias R., CONICET-CICTERRA, Cordoba, Argentina
The paleoneuroanatomy of pseudosuchian archosaurs is poorly known, based on direct examination of the internal morphology of braincases and a few artificial endocasts. Among aetosaurs, only one endocast has been described almost a century ago by Case based on a resin cast, it corresponding to *Desmatosuchus spurensis* from the Chinle Formation (Norian) of Texas, U.S. We describe the first natural endocast of an aetosaur, *Neoaetosauroides engaeus* from the Los Colorados Formation (Norian) of NW Argentina, and also developed the first digital endocast of this taxon including the encephalon, cranial nerves, inner ear, and middle ear sinuses.
This study was based on three skulls referred to *Neoaetosauroides engaeus*: PULR 108, PVL 5698, and PVL 4363. The neuroanatomy of *Neoaetosauroides engaeus* exhibits several differences from that of *Desmatosuchus spurensis* despite their phylogenetic proximity. The location of the cranial nerves VII, VIII and XII was different between these two species. The olfactory region of *Neoaetosauroides engaeus* had elongated olfactory tracts and narrow, elliptic bulbs contrasting with the short tracts and wide rounded bulbs of *Desmatosuchus spurensis*, which may be a reflection of their different feeding habits. When orienting the skull on its alert or neutral position, the snout is tilted anteroventrally at 27º from the ground and the lateral semicircular canal of the inner ear is anterodorsally inclined at 5º from the horizontal.
This information provided by the endocasts of *Neoaetosauroides engaeus* about its olfactory region and the orientation of its head could support an animalivorous diet previously suggested by the biomechanical studies of other authors, instead of an herbivorous diet as is inferred for most aetosaurs (*e.g., Desmatosuchus spurensis*, *Stagonolepis robertsoni*, *Typothorax coccinarum*). The new information here obtained contributes to the knowledge of the neuroanatomical diversity of pseudosuchians and more specifically among aetosaurs and their paleobiological roles in the Late Triassic continental communities.
Grant Information
Funded by PICT 2014-609, PICT 2016-481 and PICT 2016-159

Preparators' Session (Thursday, October 18, 2018, 2:30 PM)

CRACKS, GREEN FOSSILS, AND MELTED BONE: CHARACTERIZATION OF PREPARATION DAMAGE USING SEM AND TOF-SIMS
DI GIACOMO, Mariana, University of Delaware, Newark, DE, United States of America; GOODWIN, Christopher M., University of Delaware, Newark, DE, United States of America
Mechanical and acid preparation have been the most common methods for preparing fossil bones since the 19th century. They have been very successful, and have shaped how fossils are interpreted and stored. The consequences of their use have only been analyzed after

issues have occurred, forcing changes in the methodologies. For example, the coating of fossils before an acid bath began as a recommendation if there was doubt that the acid would affect them. In the present, coating is a required step that must be followed. In addition to these techniques, preparators have been developing their own innovative approaches, sometimes using practices from other disciplines like conservation. The goal of this work was to understand the consequences of using three techniques: mechanical preparation, acid preparation, and laser treatment.
The samples used were small, unidentified bone fragments from the Cloverly Formation, Wyoming. The mechanical preparation was done using an air scribe, and one of the bones was intentionally damaged with three markings invisible to the naked eye. Acid preparation was performed using a 5% V/V acetic acid solution in water. Samples were coated with a thin solution of Paraloid B67, acetone and methyl-ethyl ketone, except for one of them, to evaluate the effect of the acid on it. Finally, a Nd:YAG (neodymium-doped yttrium aluminum garnet) 1064 nm laser system was employed for treatment. Samples were analyzed with a Scanning Electron Microscope (SEM), and one of them was further analyzed using an SEM with energy-dispersive X-ray spectroscopy capabilities (SEM-EDS). Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS), operated in static mode, was employed to study the chemical composition of the surface of the samples.
SEM analysis determined that the area damaged with the air scribe contains micro cracks that can become future areas of damage if the specimen is not housed in proper environmental conditions. The uncoated sample treated with acetic acid shows severe cracking that is not observed with the naked eye. Laser-treated samples show variations in color with the naked eye, and under the SEM, the bone surface appears damaged. TOF-SIMS analysis reveals chemical localization in the samples treated with the laser, but not in the others. These results indicate that fossil preparation can be a damaging agent to specimens if not done correctly. For this reason, it is important that institutions recognize the value in this profession, for both the long-term stability of their collections, as well as for future scientific analyses.
Grant Information
Smithsonian Postgraduate Fellowship in Conservation of Museum Collections

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A NEW ENCHODONTID FISH *ENCHODUS*-LIKE FROM CENOMANIAN DEPOSITS FROM THE EL CHANGO QUARRY (CINTALAPA MEMBER, SIERRA MADRE FORMATION), CHIAPAS, MEXICO.

DÍAZ-CRUZ, Jesús A., Universidad Nacional Autónoma de México, Mexico City, Mexico; ALVARADO-ORTEGA, Jesus, Universidad Nacional Autónoma de México, Mexico City, Mexico

Enchodus is the genus that groups about 30 species from all around the world. This marine group, well-known as predators, has a temporal range that goes from Albian– Cenomanian to Maastrichtian in the Late Cretaceous. Many *Enchodus* species are erected upon fragmentary material, and few of them are known by complete specimens. Most of the species of this genus correspond to those found in Europe, North America (United States) and Middle-Eastern localities, where it is believed this group arose. The study of fossils in Cretaceous Mexican localities has recently increased and as result of that, it has been recognized the presence of two *Enchodus* species: *E. zimapanensis* from Muhi, Hidalgo, and *Enchodus* cf. *venator* from Vallecillo, Nuevo León. In addition to these records, the presence of undetermined *Enchodus* is known from many Late Cretaceous deposits including those outcrops near Múzquiz-Piedras Negras area, Coahuila, northern Mexico; San José de Gracia quarry, Puebla, and Xilitla quarry, San Luis Potosí, Central Mexico; Las Bocas quarry, Guerrero, and El Chango quarry, in Chiapas, southern Mexico. In this work, we report the presence of an almost complete *Enchodus*-like fish from the El Chango quarry. This Mexican specimen shows many of the diagnostic characteristics for *Enchodus:* mid-dorsal scutes, interpercle absent, articulation between quadrate and mandible laterally exposed, opercle and subopercle ornamented, lateral strengthening bar in the opercular and anteroventral prongs. All these characteristics resemble those of the *Enchodus* species. Nevertheless this specimen shows some characteristics that make it different from other *Enchodus* species (including the Mexican ones), such as its general body shape, the slightly elongated stout, the presence of three postcleithra, three supraneurals and two dermopalatine teeth. Previously, another *Enchodus*-like taxon was reported from the El Chango locality, but additional studies positioned it as a different taxon. Despite the close affinity that the specimen reported in this work shows with *Enchodus,* further analysis is necessary to determine its clear phylogenetic position and confirm its taxonomic category. With the report of this new specimen, the number of enchodontids in the El Chango quarry has increased. This fact highlights the importance of the study of Mexican localities to better understand the origin and diversification not only of *Enchodus* but for the Enchodontidae family as well.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A NEW THEROPOD ICHNOTAXON FROM THE LOWER CRETACEOUS ENCISO GROUP (CAMEROS BASIN, SPAIN)

DÍAZ-MARTÍNEZ, Ignacio, Instituto de Investigación en Paleobiología y Geología UNRN-CONICET, General Roca, Argentina; PÉREZ-LORENTE, Felix, Universidad de La Rioja, Logroño, Spain; NAVARRO-LORBÉS, Pablo, Universidad de La Rioja, Logroño, Spain; GARCÍA-ORTÍZ, Esperanza, Instituto de Estudios Riojanos, Logroño, Spain; CANUDO, Jose I., Universidad de Zaragoza, Zaragoza, Spain; PEREDA-SUBERBIOLA, Xabier, University Del Pais Vasco/EHUFacultad de Ciencia & Tecnologia, Bilbao, Spain; TORICES, Angelica, Universidad de La Rioja, Logroño, Spain

The Cameros Basin (northern Spain) is one of the most important places in the world to study Early Cretaceous dinosaur footprints with more than 10,000 tracks. The Enciso Group that crops out only in La Rioja Province, is Barremian–Aptian in age and is related with a siliciclastic to carbonate mixed lacustrine system. Sauropod, ornithopod, and theropod tracks have been found in its rocks, with the last ichnotype being the most abundant, with about 5,000 specimens. Although some of these theropod tracks have been included in previously known ichnotaxa (e.g., *Megalosauripus*, *Buckeburgichnus*, *Irenesauripus*, etc.), some others are not related to any of them.
Here, we report a new theropod ichnotaxon from the Enciso Group. It is composed of tridactyl and mesaxonic tracks, with two phalangeal pad impressions in the digit II, three in the digit III and three in the digit IV. The shape of the heel impression and the size of the second digit claw impression are the main characters of this new ichnotaxon. The heel impression is wide, bilobate and includes at least two metatarsophalangeal pads, with the lateral one bigger than the medial. Digit II claw impression is very well marked, individualized, and more developed than digit III and IV claw impressions. The tracks vary between 25 and 40 cm in length and are longer than wide. These tracks are different in shape from other known theropod ichnotaxa and they can be related with the Eubrontidae ichnofamily. They have been found in at least four different tracksites. The special distribution of their trackways has been related with a gregarious behaviour. Although the Cameros Basin is rich in dinosaur tracks, the osteological record is scarce. Most of the theropod bones and teeth belong to basal tetanurans such as carcharodontosaurids and spinosaurids. This fact confirms the presence of large predatory animals in this area, and they can be considered the potential candidates for the trackmaker of this new ichnotaxon.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

A CASE STUDY IN CONDUCTING AN ONLINE LEARNING EXPERIENCE IN VERTEBRATE PALEONTOLOGY

DICKSON, Margaret, University of Illinois at Chicago, Chicago, IL, United States of America; DEANS, Austin, Appalachian State University, Boone, NC, United States of America; THOMAS, Henry, University of California Berkeley, Berkeley, CA, United States of America; VOSS, Blaire, University of Wyoming, Laramie, WY, United States of America; MCCALLUM, Maya Jade, Evergreen State College, Olympia, WA, United States of America; CHEN, Albert, University of Bath, Taipei, Taiwan

The internet presents a unique environment in which to spread knowledge and skills to people who may not have had the opportunity to receive more traditional forms of education. Previously we have demonstrated that utilizing social media platforms can lead to significant learning experiences in the realm of paleontology and paleobiology, primarily through connectivism. We have also demonstrated that utilizing social media based platforms can lead to the inclusion of traditionally disprivileged groups in these learning environments. Here we present the results of a case study in utilizing social media and other internet-based platforms to conduct a more formal course in vertebrate paleontology, specifically the evolutionary historyofdinosaurs. This course was conducted entirely online, utilizing the Google Suite of programs and the chatting client Discord. Students primarily consisted of individuals from the community from our previous study, who do not have access to traditional classroom environments due to a variety of socioeconomic factors. This course demonstrates that significant learning experiences can occur through online courses and that this may serve as an alternative form of education outside of established academic institutions. Though methods of evaluating such courses are available, means of accreditation are still elusive. Continued investigation of using both connectivism and more traditional learning environments in the form of online courses could serve as a method of expanding education in vertebrate paleontology beyond those groups who receive access to in-person learning environments. Expansion of education to disprivileged groups would be invaluable to increased understanding of scientific principles and concepts amongst the general populace.

Technical Session XVII (Saturday, October 20, 2018, 3:15 PM)

SECONDARY PALATE EVOLUTION IN EARLY CROCODYLOMORPHS: FUNCTIONAL AND PHYLOGENETIC IMPLICATIONS

DOLLMAN, Kathleen N., University of Witwatersrand, Johannesburg, South Africa; CHOINIERE, Jonah, University of Witwatersrand, Johannesburg, South Africa; CLARK, James M., George Washington Univ, Washington, DC, United States of America; VIGLIETTI, Pia, University of Witwatersrand, Johannesburg, South Africa; NORELL, Mark, American Museum of Natural History, New York, NY, United States of America; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

A fully closed secondary palate is an apomorphic feature of eusuchian crocodyliforms, and stages in its evolution feature strongly in hypotheses of broad-scale phylogenetic relationships within Crocodylomorpha. However, there is surprising variation in the secondary palate at the base of the crocodylomorph tree (e.g., in 'sphenosuchians' and 'protosuchians'), and the phylogenetic relationships of early branching taxa remain poorly understood relative to their meseoucrocodylian descendants. In order to more fully understand how the palates of early branching crocodylomorphs were constructed and to develop a detailed hypothesis for changes in its construction over evolutionary timescales, we CT- scanned and digitally reconstructed the individual bones of the palate of a number of crocodylomorph taxa from South Africa, Mongolia, China, and the U.S.A., including *Dibothrosuchus*, *Sphenosuchus*, *Litargosuchus*, *Protosuchus*, *Shartegosuchus*, *Orthosuchus*, *Nominosuchus*, *Paleosuchus*, and *Osteolaemus*. In order to test phylogenetic relationships of early branching members of the crocodylomorph lineage, we used our CT data to revise and add cranial and palatal characters to a large, broadly sampled phylogenetic data matrix, which includes 'Sphenosuchia', 'Protosuchia', and Meseoucrocodylia. The results from this study confirm, and fully document, the occurrence and macroevolutionary development of a eusuchian-type secondary palate in Shartegosuchidae. Additionally, we uncover previously unrecognized crocodyliform features in *Litargosuchus.* Furthermore, this study discusses the biomechanical motivation for the evolution of a closed secondary palate together with platyrostry, given the presence of both oreinorostry and a closed secondary palate within shartegosuchids.
Grant Information
PAST; NRF African Origins Platform 98800; Competitive Programme for Rated Researchers 98906; NSF grant EAR 1636753; NSFC 41688103; Centre of Excellence-Pal

Technical Session XII (Friday, October 19, 2018, 3:00 PM)

A NEW VARANID FROM THE EARLY EOCENE OF CHINA, WITH IMPLICATION ON THE EVOLUTION OF THE VARANIDAE

DONG, Liping, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; WANG, Yuan, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; WANG, Yuanqing, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of

Sciences, Beijing, China; EVANS, Susan E., University College London, London, United Kingdom

The family Varanidae, represented by the living monitors *Varanus* spp., is of considerable interest to both public and academic communities. Varanids are thought to have evolved from the Late Cretaceous Varaniformes of the Gobi Desert, and their close kin were widely distributed from Europe to North America in the early Paleogene, most notably the Eocene *Saniwa*. However the Paleogene record of Varanidae is very limited in Asia. Here we report on a nearly complete varanid skeleton from the Lower Eocene Yuhuangling Formation, Liguanqiao Basin, Hubei Province, China. The new specimen has many varanid features including: the strongly retreated naris; fused and elongated nasal; two lacrimal foramina; narrow elongate vomer; widely spaced, recurved sharp marginal teeth with basal plicidentine; quadrate with weak tympanic crest; and vertebral centra with precondylar constriction. The new specimen differs from *Varanus* and *Saniwa* in the presence of teeth on the palatine and pterygoid, the complete postorbital bar, and the weaker development of the frontal subolfactory crests. A new phylogenetic analysis finds that the new varanid from Liguanqiao Basin is the sister taxon of *Varanus*, with *Saniwa* as the successive sister taxon. Taken together with the global Late Cretaceous and Paleogene record of Varaniformes, the new Chinese specimen suggests that there were probably two dispersals from Asia during the evolutionary history of Varanidae: (1) the first from Central Asia to North America, Europe, and East Asia in the Late Cretaceous to Paleocene, giving rise to Varanidae, with subsequent extinction of the North American and European descendants of that dispersal; (2) a second dispersal westwards and southwards from East Asia to Europe, Africa, and Australia, from Eocene times.

Grant Information

Supported by the fund from the State Key Laboratory of Palaeobiology and Stratigraphy (No. 163106) and the National Natural Science Foundation of China (Grant No. 41702019)

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

I.C.E. AGE PROJECT: COMBINING OUTREACH WITH EXHIBIT PRODUCTION

DOOLEY, Brett S., Western Science Center, Hemet, CA, United States of America; STONEBURG, Brittney E., Western Science Center, Hemet, CA, United States of America; DOOLEY, Alton C., Western Science Center, Hemet, CA, United States of America

The International Collaborations in Education (I.C.E.) AGE Project is the Western Science Center's new outreach effort that combines K–12 outreach with exhibit production by partnering schools from across the world to create a museum exhibit about each region's respective Ice Age fauna. A museum educator serves as a facilitator of the process providing technical and pedagogical support along with exhibit designexperience.

For the inaugural partnership, a class of sixth-grade, science students in Hemet, California, U.S.A. worked with second-year, high school English language learners in a school in São Paulo, São Paulo, Brazil. Students worked on the project for a month communicating with international peers about their research and cultural topics. Students wrote and shared their work on Google Docs and Google Slides that enabled asynchronous peer editing and comments. Google Hangouts was used for face-to-face communication in three video conferences over the month.

The result was a three-panel exhibit depicting nine unique taxa. Included in the exhibit were four drawings of animals done by the sixth-grade students and a photograph taken on the smartphone of one of the Brazilian students. Both students and teachers were pleased with the results of the project and found immense satisfaction in the Hangout sessions. The Brazilian students were happy to speak with native English speakers, and the US students were awed by talking with high school students from another country. Both sets of students valued the opportunity to learn about their geologic past.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A RANCHOLABREAN VERTEBRATE FAUNA FROM TEMECULA VALLEY, CALIFORNIA

DOOLEY, JR., Alton C., Western Science Center, Hemet, CA, United States of America; SCOTT, Eric, California State University, Bloomington, CA, United States of America; DOOLEY, Brett S., Western Science Center, Hemet, CA, United States of America; STONEBURG, Brittney E., Western Science Center, Hemet, CA, United States of America

The Plio-Pleistocene fossil record of southwestern Riverside County, California is dominated by Blancan and Irvingtonian mammalian fossils from two formations: an unnamed sandstone and conglomerate formation and the overlying Pauba Formation. A mitigation collection recovered in 2002–2004 from an unnamed sandstone unit overlying the Pauba Formation in the Harveston neighborhood of northern Temecula appears to represent a rare Rancholabrean fauna from the area, based upon the presence of *Bison antiquus*. The Harveston fauna also includes numerous remains of *Equus occidentalis*, and much rarer small horse fossils, as well as *Mammuthus columbi*, *Camelops hesternus*, *Hemiauchenia* sp., an antilocaprid comparable in size to *Antilocapra*, *Odocoileus* sp. cf. *O. virginianus*, and *Microtus* sp. The possible presence of *Odocoileus* sp. cf. *O. virginianus* is significant, as this taxon is not currently found in southern California, while the larger *O. hemionus* inhabiting the region today has not been identified from the Harveston fauna. The presence of *Equus*, *Bison*, *Mammuthus*, and *Microtus* in the Harveston fauna, coupled with the absence of *Mammut* and *Tapirus* (both recorded from the older Pauba Formation), suggests that Temecula Valley may have shifted to a more open and drier habitat at the beginning of the Rancholabrean. Late Rancholabrean deposits from the West Dam of Diamond Valley Lake, located less than 10 km NE of Harveston, include abundant mastodons, suggesting that diverse habitats large enough to sustain distinct megafaunal populations were present in close proximity to each other during the Pleistocene.

Preparators' Session (Thursday, October 18, 2018, 3:30 PM)

EVALUATION OF NOVEL VISUALIZATION SOFTWARE FOR VIRTUAL PALEONTOLOGY

DOUGAN, Lindsay G., Denver Museum of Nature and Science, Denver, CO, United States of America; KRAUSE, David W., Denver Museum of Nature & Science, Denver, CO, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America; SULLIVAN, Patrick, Denver Museum of Nature and Science, Denver, CO, United States of America; GROENKE, Joseph R., Ohio University, Athens, OH, United States of America

In early 2017, the Denver Museum of Nature & Science (DMNS) established a Digital Imaging Laboratory to perform paleontological research through the visualization of anatomical details as 3-dimensional models extracted from CT data. As a new, grant-funded lab, we had a small list of requirements that visualization software platforms needed to meet. First, we needed a powerful program capable of handling very large µCT datasets with ease and efficiency. Second, we wanted to employ a platform that was relatively user-friendly, as we utilize a volunteer corps to perform digital segmentation. The third limitation was cost; we hoped to utilize a platform that would absorb minimal grant funds. After a brief review of available options, Dragonfly (Object Research Systems, Montreal, Canada), a new visualization and image-processing platform, was selected as the primary platform pending an assessment period. Over the course of one year and several software updates, the DMNS Digital Imaging Lab exclusively uses Dragonfly for our virtual paleontology projects. Here we present our observations of the advantages and disadvantages encountered during the evaluation period. Several advantages of the Dragonfly platform were immediately apparent: an ability to handle large datasets up to 21GB; an intuitive interface that allowed users of all backgrounds to quickly learn the protocols for segmentation and meshing; and the free-of-charge non-commercial license to academic institutions. At the same time, some disadvantages became clear: mesh processing was almost non-existent; there was no communication with other common visualization programs (e.g., Avizo); and our license did not provide support help. Some issues required creative problem solving. Collaboration with external researchers and facilities required the development of a crossover protocol for sharing content between Dragonfly and Avizo. As the software evolved, more of our issues were resolved within the platform, whether fixing a particular software bug or creating a new application for mesh processing. Despite the issues encountered, the ease of teaching the program to new users and the powerful, yet straightforward segmentation capabilities allowed us to train a dozen volunteers and three interns in the first 10 months. As our work expands and evolves, we will continue to push the limits of the Dragonfly platform as a useful tool in paleontological research.

Grant Information

National Science Foundation grant EAR-1664432

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A DIVERSE LISSAMPHIBIAN FAUNA FROM THE FITTERER RANCH LOCALITY (OLIGOCENE 32.5 TO 30 MA) OF NORTH DAKOTA

DRIEBERGEN, Julie, South Dakota School of Mines and Technology, Rapid City, SD, United States of America; BOYD, Clint, North Dakota Geological Survey, Bismarck, ND, United States of America; PERSON, Jeff, North Dakota Geological Survey, Bismarck, ND, United States of America; PAGNAC, Darrin, South Dakota School of Mines and Technology, Rapid City, SD, United States of America

The Oligocene of North America has a poor lissamphibian fossil record. Fitterer Ranch (Brule Formation, North Dakota), a productive Oligocene mammal site (32.5–30 Ma), preserves anunderstudied lissamphibian assemblage. To date, one lissamphibian species has been described from Fitterer Ranch: *Scaphiopus skinneri*. Only two other Oligocene occurrences of Anura in the Great Plains are documented (Scaphiopodidae, Pelodytidae). There are only five other Oligocene lissamphibian occurences outside of the Great Plains in North America, which include bufonid, pelobatid, ranid, and salamandrid species.

Using element measurements and morphological comparisons with modern and fossil taxa, over 500 lissamphibian bone elements were identified from Fitterer Ranch to establish taxonomic identity. Several caudatan vertebrae are present, marking the first reported occurrence from Oligocene sediments in the Great Plains region of North America. Anuran cranial elements referable to Scaphiopodidae and a large ilium from Rhinophrynidae are also present. Additional taxa include possible Ranidae and Hylidae elements noted through limb bone identification.

Understanding the diversity of lissamphibians at Fitterer Ranch reveals the paleoecology of the area, at a time of climatic change during the Eocene–Oligocene transition. Lissamphibian fossils from the Eocene are more often described in literature than are those from the Oligocene, which may be due to collection or preservation biases. However, the prevalence of Eocene descriptions may also indicate higher abundance due to a due to a change from warm, humid conditions to cooler, arid conditions. The Calf Creek locality of Saskatchewan (late Eocene, 38.0–33.9 Ma) contains scaphiopodid, hylid, and rhinophrynid anurans and ambystomatid caudatans, which resemble the fauna identified at Fitterer Ranch. However, earlier Eocene lissamphibian fauna in North America consisted of a more diverse set of taxa, including leptodactylid anurans and dicamptodontid, batrachosauriodid, amphiumid, and sirenid caudatans, reflectinga higher diversity of taxa adapted to mesic environments. Thus, the fauna from Fitterer Ranch suggests a much drier and cooler environment than that encountered in the early to middle Eocene, but still maintained a wet enough climate to support a diverse lissamphibian fauna, suggesting environmental conditions similar to those of the late Eocene.

Technical Session II (Wednesday, October 17, 2018, 9:30 AM)

THE (ALMOST) DEATH AND RESURRECTION OF MESOZOIC MARINE REPTILES: THE MID-CRETACEOUS (EARLY CENOMANIAN–MIDDLE SANTONIAN) DIVERSITY "BOTTLENECK"; IS IT AFFECTED BY FOSSIL COMPLETENESS?

DRISCOLL, Daniel A., University of Bristol, Pueblo, CO, United States of America; STUBBS, Tom, University of Bristol, Bristol, United Kingdom; DUNHILL, Alexander, University of Leeds, Leeds, United Kingdom; BENTON, Mike, University of Bristol, Bristol, United Kingdom

Diversity changes in marine reptiles following the late Cenomanian have been well noted, but not well understood. An analysis of specimen fossil completeness is explored for Dolichosauridae, Mosasauroidea, and Plesiosauria, within groups and over all species. 1,452 specimens were sorted; 242 were exactly dated to single substages. Fossil completeness metrics (TCM and QCM) were measured using the latter specimens. Sea level and average sea surface temperature (SST) were compared in time series with species

richness and other variables using Spearman rank order correlations and generalized differencing.
Average fossil completeness of all marine reptiles was not significantly correlated with sea level or SST. No correlations could be made within the aigialosaur subgroup. Other subgroups showed no significant correlations for any variables, including diversity, fossil completeness, sea level or SST. There was a decoupling of correlations between total marine reptile species richness, using completeness of specimens named to species vs. all specimens. Taphonomic completeness (TCMsp, Spearman; S=22, p=0.046, rho=0.738) and phylogenetic completeness (QCMsp, Spearman; S=20, p=0.037, rho=0.762) of named specimens correlated with species richness in overall marine reptiles. There were no significant correlations between completeness of all specimens (TCMall, QCMall) and richness. In contrast, within the mosasaur and plesiosaur subgroups, no significant correlations for richness and completeness were seen.
Total marine reptile species richness significantly correlated with SST (Spearman, S= 48, p=0.0275, rho=0.710); but not with sea level.
In summary, marine reptile diversity in the mid Cretaceous cannot be explained by lack of preserved specimens, as overall completeness of specimens does not correlate with species richness in marine reptile subgroups. Naming ofdolichosaurs and aigialosaurs is based on complete material but lacks named incomplete material. Mosasaur and plesiosaur naming is not biased by completeness. Sea Level or SST has no effect on completeness. A significant correlation between SST and total marine reptile species richness is detected. Results suggest a true ecological "bottleneck" in marine reptile diversity with a genuine low abundance of marine reptiles in Early-Middle Coniacian. The lack of correlation with SST in individual subgroups makes for interesting speculation on the mechanisms of these macroevolutionary patterns.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A HIGH LATITUDE FRESHWATER ICHTHYOFAUNA FROM THE LATE CRETACEOUS PRINCE CREEK FORMATION (MAASTRICHTIAN) OF NORTHERN ALASKA

DRUCKENMILLER, Patrick S., University of Alaska Museum, Fairbanks, AK, United States of America; BRINKMAN, Donald B., Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; ERICKSON, Gregory M., Florida State University, Tallahassee, FL, United States of America; LOPEZ, J. A., University of Alaska Museum, Fairbanks, AK, United States of America

The Prince Creek Formation (PCF.) of northern Alaska provides exceptional insight into terrestrial high latitude ecosystems that existed during the latest Cretaceous. The formation preserves a rich assemblage of dinosaurs and mammals, of which, all named species are endemic polar denizens. Microfossil analyses reveal additional ecologically important components of the community, including freshwater fishes. However, a comprehensive taxonomic analysis of the ichthyofauna has not occurred. Here we provide results of such an analysis and compare these data to those from lower latitude Campanian to Maastrichtian-aged deposits and test the hypothesis that the PCF. ichthyofauna was unique to the Arctic. The PCF. was deposited in a coastal/alluvial plain environment at high paleolatitudes (80–85 °N). Rich fish-bearing localities are early Maastrichtian in age. The remains primarily consist of tooth bearing elements, vertebral centra, teeth, dermal scales, and fin spines that accumulated in fluvial lag deposits. Two acipenseriforms are recognized. These include at least one species of sturgeon as well as a species of paddlefish represented by denticles differing from those found at other North American localities. At least one osteichthyian of uncertain phylogenetic relationships exhibits branchial elements bearing two distinct tooth morphologies, one being blade-like and the other pillar-like. Numerous small esocoid and/or salmoniform fossils suggest these were the numerically dominant teleosts. Based on dentaries, at least one species is referable to *Oldmanesox*, and two species of undescribed esocoids or salmoniforms are also present. A toothed esocoid palatine was also recovered that is likely from one of the taxa represented by dentaries. Finally, a teleost with rod-like dentaries and maxillae that are unlike those known in any Western Interior taxon is also present. At least five teleost centrum morphotypes are recognized, most of which conform to those of esocoids and/or salmoniforms. In addition, a fin spine of an indeterminate acanthomorph is recognized. Relative to other Campanian to Maastrichtian-aged Western Interior assemblages, species richness is lower in the PCF. This is in part due to the conspicuous absence of groups that are common at lower latitudes such as elasmobranchs, taxa with ganoid scales, and amiids. The degree of endemism and overall taxonomic composition indicate the existence of a distinct polar ichthyofauna in this region in the Late Cretaceous.

Grant Information
This research was supported by National Science Foundation grants EAR 1226730 and 1736386.

Podium Symposium (Wednesday, October 17, 2018, 2:00 PM)

ASSESSING PATTERNS OF CROCODYLIFORM DIET USING GEOMETRIC MORPHOMETRICS, NEONTOLOGY, AND ICHNOLOGY

DRUMHELLER, Stephanie K., University of Tennessee, Knoxville, TN, United States of America; WILBERG, Eric W., Stony Brook University, Setauket, NY, United States of America

When attempting to understand diet and feeding behavior in extinct members of Crocodyliformes, paleobiologists often turn to modern crocodylians to serve as proxies. Through direct observations of trophic interactions, in vivo tests of feeding mechanics, and other neontological methods, broad patterns linking crocodylian snout shape and prey preference have been established. These ecomorphotypes help guide paleobiological interpretations of not only other crocodyliforms, but also of more distantly related groups such as phytosaurs, choristoderes, and dinosaurs. However, snout shape across Crocodyliformes is more diverse than that seen within Crocodylia alone, and even among living members of the crown group, recent analyses of bite force, rotational feeding, and trophic interactions do not always align with established concepts of generalist vs. specialist ecomorphotypes. Here we present an expanded ecomorphological classification scheme, based on a geometric morphometric analysis of 130 species of extant and extinct crocodyliforms and a non-hierarchical cluster analysis of the ensuing shape data with added dental characters. These analyses resulted in seven distinct ecomorphotypes, building upon the previously established five groupings (e.g., blunt-snouted, duck-faced, ziphodont) by splitting the slender-snouts and generalists into four distinct groups. Patterns of dietary preferences then were explored by testing the correlation between maximum predator size vs. maximum prey size within the shape groupings. Dietary evidence for some of the ecomorphotypes is currently too sparse for detailed analysis (e.g., duck-faced, heterodont), but for those groups with adequate sampling, there are statistically significant differences in prey-size preferences, including between the newly separated generalist classifications. Regressions of these datasets provide methods for predicting maximum potential prey size for extinct groups and to differentiate certain examples of scavenging from predation in the fossil record. Use of this multipronged approach, incorporating morphometric analyses, neontological observations, and ichnological evidence, provides a more synthetic take on the interplay of form and function in the fossil record.

Grant Information
This research was supported by a National Science Foundation, Division of Environmental Biology grant, #1754596.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

TENNESSEE GEOPATHS: EXPERIENTIAL LEARNING AS A TOOL FOR RECRUITING AND RETENTION OF COMMUNITY COLLEGE STUDENTS

DRUMHELLER, Stephanie K., University of Tennessee, Knoxville, TN, United States of America; SUMRALL, Colin D., University of Tennessee, Knoxville, TN, United States of America

With the rise of government programs meant to reduce, or completely eliminate, the cost of community college tuition in the United States, transfer students are becoming an increasingly important demographic at four-year institutions. However, the transition between institutions is not always smooth. While universities often have programs in place to help recruit and retain incoming freshman, transfer students typically enter their programs as juniors without similar, built-in support networks of their peers. A recent partnership between geoscience faculty at the University of Tennessee (UT) and four community college (CC) institutions is exploring the effectiveness of using experiential learning methods in the recruitment and retention of CC students into four-year programs. Named the Tennessee GEOPATHS project, this program seeks to build community between faculty and students among the participating institutions through field experiences and research opportunities. This has the dual outcomes of supporting transfer student success by fostering relationships between peer- and faculty-mentors and providing critical insights into existing institutional barriers to student success and faculty collaborations. Each fall, all participating faculty and students are invited to participate in a weekend retreat at the Great Smoky Mountains Institute at Tremont. The retreat focuses on introducing participants to a diversity of geoscience disciplines, including paleontology, through hands-on activities and team-based data collection and field exploration. At the end of the retreat, research opportunities are made available for both UT and CC students. The most popular paleontological research project has involved a long-term study experimentally replicating the conditions under which the invertebrate feeding trace *Gnathichnus pentax* is left on vertebrate bones. As the GEOPATHS project enters its third year, student participation in research is high, and participant feedback indicates that the experience is helping to integrate transfer students into UT's four-year geoscience programs.

Grant Information
This program is funded by a National Science Foundation, GP-IMPACT grant, #1600376.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ONTOGENETIC VARIABILITY OF DIAGNOSTIC CHARACTERS IN *PROSAUROLOPHUS MAXIMUS* (HADROSAURIDAE; SAUROLOPHINAE): IMPLICATIONS FOR THE RECOGNITION OF JUVENILE INDIVIDUALS

DRYSDALE, Eamon T., University of Calgary, Calgary, AB, Canada; THERRIEN, Francois, Drumheller, AB, Canada; ZELENITSKY, Darla K., University of Calgary, Calgary, AB, Canada

Cranial ornamentation is common among dinosaurs, and associated characters are often involved in the diagnosis of different species. However, juvenile members of many dinosaur species exhibit drastically different cranial morphology than their adult conspecifics, historically leading juvenile specimens to be classified as separate species. Whereas this issue has been encountered amongst ceratopsians and lambeosaurines, it has received less attention in saurolophine hadrosaurs, which generally have less elaborate cranial ornamentation. This study examines an ontogenetic series of the saurolophine *Prosaurolophus maximus*, comprised of juvenile through adult individuals, to determine the impact of ontogenetic growth on the diagnostic characters of the taxon. Previously identified diagnostic features for *P. maximus*, based on the study of adult specimens, included a ridge-like nasal crest formed entirely by the nasals and the pocket-like caudal end of the circumnarial depression, two characters associated with cranial ornamentation. Examination of juvenile *P. maximus* specimens reveals that these diagnostic morphological features are ontogenetically variable. In the smallest juvenile, the nasal crest is poorly developed, represented only by a slight swelling of the caudal region of the nasal, whereas the crest of larger juveniles possesses the shape, but lacks the robustness and rugosity seen in adults. In juvenile specimens, the circumnarial depression lacks the "pocket-like" morphology, as the lateral lappet that forms the rim of the pocket is absent. The pocket-like morphology of the circumnarial depression only develops in sub-adult individuals and persists into adulthood. The ontogenetic variability of the features used to diagnose *P. maximus* suggests that it may be challenging to definitively identify young individuals of the species. However, our study of the *P. maximus* ontogenetic series reveals that a novel character, a caudally-tapering circumnarial depression that terminates rostral to the orbit, is consistent through ontogeny. Furthermore, the relative amount of tapering and caudal extent of the depression in *P. maximus* differs from the condition seen in all other saurolophine species. As such, the relative shape of the circumnarial depression appears to be a novel character that is more reliable than characters associated with the crest to diagnose *P. maximus* as it is present in a wider range of ontogenetic stages.

Grant Information
This research is funded by the Alberta Lottery Fund, Alberta Culture and Tourism, the Royal Tyrrell Museum Cooperating Society, and NSERC Discovery Grant to DKZ.

Podium Symposium (Wednesday, October 17, 2018, 11:30 AM)

ASSESSING MAMMALIAN DIVERSITY IN RELATION TO HOMININ EVOLUTION IN THE OMO-TURKANA BASIN, EASTERN AFRICA

DU, Andrew, The University of Chicago, Chicago, IL, United States of America, 60637; ALEMSEGED, Zeresenay, The University of Chicago, Chicago, IL, United States of America; BOBE, Rene, Universidad de Chile, Santiago, Chile; BEHRENSMEYER, Anna K., Smithsonian Institution, Washington, DC, United States of America

The importance of large-scale environmental forcing in faunal change and human evolution in the African Plio-Pleistocene is a topic of ongoing debate. Ecological processes act at multiple scales, requiring different types of data to examine hypothesized cause and effect. Paleoanthropologists have traditionally studied site-specific fossil collections, limiting questions about faunal diversity and human evolution to restricted spatial and temporal scales (e.g., reconstructing paleoenvironments at one site). With current initiatives to assemble large paleontological databases, however, data from multiple sites can be collated and standardized, enabling large-scale paleoecological analyses over space and time. The Turkana Database (TDB) has figured prominently in understanding how paleocommunities in this region have changed at various spatiotemporal scales and holds additional importance because this basin has produced some of paleoanthropology's most significant hominin and archaeological finds. The TDB comprises fossil vertebrate specimens from the late Cenozoic (7–1 Ma) of the Turkana Basin, Kenya, and was assembled by a collaboration between the Smithsonian National Museum of Natural History, the Evolution of Terrestrial Ecosystems (ETE) Program, the National Museums of Kenya, and the Turkana Basin Institute. We also include in our analysis the French and American Omo Databases (collected by the International Omo Research Expedition), representing the northern, Ethiopian portion of the Omo-Turkana Basin. We examine how large mammal (>1 kg) diversity and composition changes from 4 to 1 Ma on the north, west, and east sides of the basin. We take advantage of these specimen-based databases and use subsampling methods (i.e., coverage-based rarefaction), which can account for sampling biases and the patchy nature of the fossil record through time and across space. We find diversity was quite stable through time, but taxonomic composition shows notable amounts of turnover. Given the strong trends in environmental proxies (e.g., $\%C_4$ biomass) in this region and time period (potentially driven by increasingly arid climatic conditions), this suggests taxonomic composition responded to environmental change, but species diversity was an emergent property regulated by other factors (i.e., resource availability and competition). These results suggest ancient hominins at Turkana had to adapt to ongoing environmental change and faunal turnover while competing in a community that maintained a stable carrying capacity for 3 million years.

Technical Session XVII (Saturday, October 20, 2018, 3:00 PM)

THE MORPHOLOGY AND FUNCTION OF THE INNER EAR OF *CHAMPSOSAURUS* (DIAPSIDA, CHORISTODERA)

DUDGEON, Thomas W., Carleton University, Ottawa, ON, Canada; MADDIN, Hillary C., Carleton University, Ottawa, ON, Canada; EVANS, David, Royal Ontario Museum, Toronto, ON, Canada; MALLON, Jordan, Canadian Museum of Nature, Orleans, ON, Canada

Champsosaurus was a small to medium-sized (1–3 m), gharial-like reptile that lived during the Late Cretaceous in what is now western Canada and the U.S.A. Although these animals are well represented in the fossil record, little is known about their internal cranial anatomy (e.g., brain endocast, inner ear) due often to poor preservation of their delicate skulls. Clarification of these structures promises to inform reconstructions of the animal's elusive life habits. Our research describes the internal cranial anatomy of *Champsosaurus* using computed tomography (CT) scanning of well-preserved skulls of *C. lindoei* (CMN 8920) and *C. natator* (CMN 8919) housed at the Canadian Museum of Nature (Ottawa). CT scan data of the extant *Tomistoma schlegelii* (USNM 211322) and *Gavialis gangeticus* (UF118998) were used for comparison as they are morphologically similar to *Champsosaurus* and likely occupied a similar niche. The resulting CT data were segmented using Amira v.5 software to produce a three-dimensional model of the brain endocast and inner ear. Preliminary findings demonstrate that the three semicircular canals of *Champsosaurus* are approximately orthogonal, and roughly circular in outline. The strongly curved semicircular canals indicate that *Champsosaurus* was sensitive to angular movement of the head in each major axis of motion, supporting previous hypotheses that champsosaurs were agile when in the water. The opening between the brain endocast and inner ear is substantial in *Champsosaurus*, suggesting that the medial wall of the auditory capsule was cartilaginous in life. Additionally, the fossa for the pars inferior is unusually large when compared to that of the extant taxa, suggesting that it also housed the pharyngotympanic sinus. This is supported by the location of the canal that transmitted cranial nerve IX, which exits through the posterior wall of the auditory capsule. Interestingly, there is no evidence of a cochlear duct in *Champsosaurus*, suggesting that the cochlea was highly reduced. The fenestrae ovalis open ventrally, a highly unusual feature that differs from the extant taxa where these openings face laterally. This unique morphology is likely due to the dramatically expanded temporal foramen of *Champsosaurus*, which have displaced the fenestrae ovalis ventrally. Taken together, these new neurological data suggest that *Champsosaurus* was an agile predator in the water, but likely had a very limited sense of hearing.

Grant Information
Funding for this project was provided by an NSERC Discovery Grant awarded to JCM.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

AN ASSOCIATED DENTITION OF *AGASSIZODUS* (CHONDRICHTHYES, EUGENEODONTIFORMES) FROM THE UPPER CARBONIFEROUS OF MISSOURI

DUFFIN, Christopher, Surrey, England; WARD, David J., Orpington, United Kingdom; LAUER, Bruce H., Wheaton, IL, United States of America; LAUER, Rene L., Wheaton, IL, United States of America

The Lauer Foundation for Paleontology, Science, and Education has recently come into possession of an associated, but largely disarticulated, dentition of the edestoid eugeneodontiform fish, *Agassizodus*. The dentition (LF 3199), scattered over several blocks, comes from the Pennsylvanian (Late Carboniferous) Hushpuckney Shale Member (Swope Limestone Formation, Bronson Sub-Group, Kansas City Group) of Kansas City, Missouri. The genus *Agassizodus* was originally raised by St John and Worthen in 1875 in honour of Jean Louis Rodolphe Agassiz (1807–1873), the famous Swiss palaeoichthyologist who had emigrated to America in 1846.

An articulated revolver of four robust symmetrical symphyseal teeth, each with a high upright central cusp, is supplemented by two disarticulated specimens from the same tooth family. Prominent labial nodes, low down on the crown, are buttressed with root tissue and are a distinctive characteristic of the teeth. The post-symphyseal components of the dentition show linear gradient monognathic heterodonty, with tooth size increasing from small, stud-like parasymphyseals, through low-crowned, elongate and increasingly robust laterals, to smaller posterolaterals. The disarticulated nature of the dentition permits detailed description of the 3-D morphologies of most tooth positions which will prove useful in defining the heterodonty more closely and comparing the dentition with those of other edestoids.

Much confusion currently exists concerning the nomenclatural validity of the genus. The Belgian palaeontologist and chemist from Louvain, Laurent-Guillaume de Koninck (1809–1887), erected *Campodus agassizianus* in 1844, based upon isolated teeth from the Late Carboniferous of Liège. Further material was described by Maximin Marie Joseph Lohest (1857–1926), Professor of Geology at the University of Liège, in 1885. During the intervening years Lt-Col Hennadius Romanowsky (dates unknown) of St Petersburg had defined the genus *Lophodus*, with several species, for teeth which he noted resembled those of *Helodus,* and which were collected from the Carboniferous of Tula in Central Russia. Romanowsky's generic name was used by Newberry and Worthen in 1870 to define *L. variabilis*, a species which was then adopted by St John and Worthen as the type species of *Agassizodus*. It is hoped that further work on LF3199 will help to unravel some of this taxonomic confusion.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

NEW SPECIMENS OF RODENTS AND PRIMATES FROM THE SAND WASH BASIN CORROBORATE AN EARLIEST UINTAN AGE

DUNN, Rachel H., Des Moines University, Des Moines, IA, United States of America; ANDERSON, Deborah K., St Norbert College, De Pere, WI, United States of America The age of the fauna of the Sand Wash Basin in northwestern Colorado has been debated since the 1970s, in large part due to the observation that the large mammals within the fauna resemble those from Uintan localities whereas the small mammals appear to more closely correspond to those from late Bridgerian localities. This, together with the fact that most large mammals were predominantly collected from the northern and western parts of the basin and small mammals from the southern and eastern parts of the basin, also led to speculation that the north and west contained Uintan faunas, and that the south and east contained late Bridgerian faunas, with the Bridgerian–Uintan boundary lying somewhere in between. Uncertainty about the precise age of the Sand Wash Basin in northwestern Colorado stems from several factors: 1) the lack of continuous exposure precludes stratigraphic correlation within the basin, 2) fossil distribution is relatively 'clumped,' with most fossils coming from two main regions, and 3) the fossils recovered are of relatively poor quality and richness. Renewed collecting efforts and surveys of museum collections from the basin have resulted in the identification of new specimens of small mammals that corroborate an early Uintan (Ui1b) age for the fossil assemblage at Sand Wash. Most notable are the identification of the eomyid rodent *Metanoiamys* sp. cf. *M. agorus*, a species common in the early Uintan (Ui1b of southern California) and a species of the ischyromyid genus *Microparamys* that shows strong affinities for a new species identified from the earliest Uintan (Ui1a) Turtle Bluff Member of the Bridger Basin. In addition, the discovery of a previously unidentified jaw of the omomyid primate *Ourayia uintensis* in the collections at the Carnegie Museum of Natural History represents the first jaw of an omomyid primate ever identified from the Sand Wash Basin. *Ourayia uintensis* occurs throughout the Uintan (Ui1b–Ui3) and is considered a biochronological indicator of the Uintan NALMA. Altogether, the combined presence of these taxa confidently places the fauna in the early Uintan and excludes a late Bridgerian age. Unfortunately, locality data is lacking for the specimen of *O. uintensis* but both of the early Uintan rodents hail from a single locality in the eastern portion of the Sand Wash Basin, representing the first documentation of early Uintan mammals from this region, further decreasing the likelihood that the two regions of the basin represent different land mammal ages.

Grant Information
Funding for this project was provided by Des Moines University IOER Grant 09-15-07.

Podium Symposium (Wednesday, October 17, 2018, 9:00 AM)

LATE TRIASSIC TETRAPOD DIVERSITY, CLIMATE, AND THE RISE OF DINOSAURS

DUNNE, Emma M., University of Birmingham, Birmingham, United Kingdom; FARNSWORTH, Alexander J., University of Bristol, Bristol, United Kingdom; GREENE, Sarah E., University of Birmingham, Birmingham, United Kingdom; LUNT, Dan J., University of Bristol, Bristol, United Kingdom; BUTLER, Richard J., University of Birmingham, Birmingham, United Kingdom

The Late Triassic was a key interval in tetrapod evolution, encompassing the radiations of major extant lineages, such as mammals, crocodylomorphs, and dinosaurs. Spatiotemporal patterns of dinosaur diversity during their rise to ecological dominance are hypothesized to have been intrinsically linked to environmental conditions. For example, sauropodomorph dinosaurs are proposed to have been absent from low latitude regions due to 'unstable' climatic conditions (e.g., fluctuating aridity). Many other hypotheses propose similar climate-driven paleolatitudinal structuring of Late Triassic terrestrial faunas, but remain largely untested.

We explored the relationships between Late Triassic tetrapod diversity, distribution and paleolatitude using comprehensive occurrence data from the Paleobiology Database. Using sampling standardization to estimate relative diversity, we found that Late Triassic tetrapods do not conform to a modern-type latitudinal biodiversity gradient (instead

diversity is highest at mid-paleolatitudes), and that communities are paleolatitudinally-structured, supporting previous hypotheses that tetrapod faunas tracked global climate zones.
To further assess the drivers of this pattern and explicitly test hypotheses about the links between dinosaur diversity and climate regimes, we utilised the results of a spatially-explicit general circulation climate model (HadCM3L) for the Norian (the best sampled stage of the Late Triassic). For each tetrapod-bearing locality, we extracted a range of climatic data from the model, including mean annual surface air temperatures (MAT) and precipitation (MAP), as well as seasonal variation, then made statistical comparisons between climate and paleolatitude, and between climatic conditions within which major tetrapod groups are found. At the global level, our results support the previous assumption that paleolatitude of Late Triassic tetrapod localities is a good proxy for MAT (modelled MAT correlated with latitude; lower latitudes had higher temperatures but less seasonal range). When compared to all tetrapod data, we find that dinosaurs preferentially occupied drier and hotter environments, with less seasonal variation in precipitation. Sauropodomorphs, however, occupied areas with significantly lower MAT and high seasonal temperature ranges. These results provide the first quantitative support for paleoclimate as a major control on the distribution of Late Triassic tetrapods, including early dinosaurs.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

ASSESSING THE USABLE LIFETIME OF TIN AND PLATINUM-BASED SILICONE RUBBERS UNDER HIGH AND LOW STRESS ENVIRONMENTS.
EADS, Matthew S., Appalachian State University, Boone, NC, United States of America; HECKERT, Andrew B., Appalachian State University, Boone, NC, United States of America
The goal of this project was to assess differences in quality and production of tin-based (TB) and platinum-based (PB) silicone rubber molds while also considering their respective rigidities under high and low stress environments. PB molds are advertised as ideal for shelf life, but are not intended for mass production, whereas TB are the opposite. We compared two PB rubbers (Mold Star 16 FAST and Dragon Skin 10 FAST) along with three TB rubbers (Mold Max 10, Mold Max 27T and Mold Max 40). These are abbreviated MS, DS, MM10, MM27, and MM40 hereafter. The casting agent was Smooth-Cast 320 urethane resin and a tooth of *Carcharocles megalodon* was used for our comparison. A one part mold was made for each mold material, and the roots of the tooth served as the pour hole for the casting agent. Every mold was cut between the roots of the tooth to create an opening to remove the casts. Two tests of quality and mold lifespan were done on each of the five mold types—a short-term, high-stress and a long-term, low-stress test. For the short-term, "torture-test", we poured the mold every eight minutes for 8–10 hours a day until the mold was exhausted to simulate a "rush production" prior to a major event. In contrast, for the long-term test we poured the mold at most twice a day to emulate occasional use in a museum. During curing, the resin reaches 60° C, which slowly causes the inside of the mold to become dry, rigid, and more susceptible to tearing. This process is exacerbated during the short-term test due to the interior of the mold constantly being subjected to high temperatures. Over the torture-test PB molds performed significantly worse than TB molds. MS16 was only able to produce 13 quality casts while MM10 produced 42 quality casts over the short-term testing. Over the long-term testing PB molds perform significantly better than in the short-term test. Initially the TB products MM27 and MM40 were noticeably more rigid when compared to MM10 or the PB products MS16, DS10. We thought the higher rigidity would result in greater resolution in the casts initially, but would then degrade like the more flexible molds. Instead we found that the more rigid materials performed significantly more poorly than the flexible molds and conclude that, due to the nature of one part molds, high rigidity materials should not be used. Our results suggest that TB molds significantly outperform PB molds over short-term testing and that the more flexible materials perform much better than rigid molding agents.
Grant Information
Thank you to the Department of Geological and Environmental Sciences and the Office of Student Research at Appalachian State for funding my project.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

ASSESSING THE UTILITY OF BRAIN ENDOCASTS AS PROXIES FOR INTERNAL NEUROANATOMY AND FUNCTIONAL CAPABILITIES IN EXTINCT BIRDS
EARLY, Catherine M., Ohio University, Athens, OH, United States of America; WITMER, Lawrence M., Ohio University, Athens, OH, United States of America
Avian brain endocasts are relatively faithful representations of the external morphology of the brain, and in extinct birds, they are the only source of information on brain anatomy. As such, they are often used to infer neuroanatomy, function, and behavior in extinct birds. However, the correlations between brain structure and function in extant birds are based on the volume of neural tissues, whereas the size metric for endocast structures is surface area. The assumption has been that the surface area of an endocast structure is a fair proxy for the volume of the underlying neural structure, but this needs to be tested in extant birds in order for functional inferences based on endocasts of extinct birds to be valid. The optic lobe and Wulst, endocast structures that overlie corresponding neural structures (optic tectum and hyperpallium, respectively), are good candidates for this study due to their presence on avian endocasts across a broad taxonomic sample. In addition, the relationship between size and function in their corresponding neural structures has been well-studied in the extant literature. The extent to which the endocast structures can serve as proxies for their neural counterparts is unknown. To assess this relationship, optic tectum and hyperpallium volumes of extant avian taxa were compiled from the literature. Endocasts of 40 of the same species were generated from CT scans of their skulls, and the surface areas of the corresponding endocast structures, the optic lobe and Wulst, were measured using Avizo and Maya. For each species, the volumes of the neural structures were regressed on the surface areas of the endocast structures. Results indicate a strong positive relationship between Wulst and hyperpallium, but that the surface area of the optic lobe may not be as strong a predictor of the volume of the optic tectum. These relationships were used to infer the volumes of one or both of these brain structures, depending on degree of preservation, in 10 extinct avialan taxa (*Archaeopteryx*, "*Buteo*" *grangeri*, *Dinornis*, *Llallawavis*, *Lithornis*, *Paraptenodytes*, *Presbyornis*, *Psilopterus*, and two undescribed specimens). Going forward, the extant taxonomic sample will continue to be expanded to more robustly test the validity of these two endocast structures as proxies for their corresponding neural structures. The resulting inferred neural structure volumes for extinct birds will allow comparisons with extant birds to establish relative functional and behavioral capabilities of organisms in which such information can no longer be observed.
Grant Information
CME: NSF GRFP & GRIP Awards, Jurassic Foundation, OU Student Enhancement Award, AMNH Chapman Ornithology Grant. LMW: NSF IOB-0517257, IOS-1050154, IOS-1456503.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

GOING BACK TO OUR ROOTS: ZYGOMATIC ARCH ROOT POSITION IN RELATION TO DIET IN LIVING AND FOSSIL PRIMATES
EDMONDS, Hallie M., Arizona State University, Tempe, AZ, United States of America; DALY, E. Susanne, Arizona State University, Tempe, AZ, United States of America; SMAIL, Irene E., Arizona State University, Tempe, AZ, United States of America
Considerable variation in zygomatic root positioning exists across living and extinct primates. This variation is exemplified in the primate fossil record by the extreme anterior placement in *Paranthropus* and posterior placement in *Theropithecus*. The anterior–posterior positioning of the masseter muscle origin (skeletally represented as the zygomatic root), along with other key craniofacial elements, affects the magnitude and efficiency of bite forces generated during chewing. Anterior positioning of the root over the premolars in taxa such as *Paranthropus* is frequently used to indicate a mechanically challenging (i.e.,, hard and/or tough) diet; whereas, extreme posterior positioning may reflect a tradeoff between gape and diet. As a broad comparative analysis of arch root position and diet in living primates is needed to explain this morphology in the fossil record, this study tests whether primates that consume more mechanically resistant foods possess relatively more anteriorly positioned arches in relation to their dental arcade, when compared to those consuming less mechanically resistant (i.e., soft) foods.
Zygomatic root position (defined by the landmark zygomaxillare) was scored from digital photographs of skulls for 40 species of extant haplorhines and recent fossil catarrhines (hominins and cercopithecids) (n = 600). Diet was assigned based on total consumption percent reported in the literature. Pairwise comparisons of closely related taxa were utilized to mitigate the influence of phylogeny when evaluating the association between diet and zygomatic root position. Arch position between species pairs with sample sizes greater than 10 were compared using permutation tests (resampling, without replacement, 9999 times). Zygomatic root position varied across species and by diet, with a general trend for more anterior zygomatic roots to occur in extant taxa that consume hard and/or tough foods. Some cercopithecids, however, have much more posteriorly positioned roots than expected for their diets, a pattern also reflected in many fossil taxa. These exceptions suggest that some taxa can process mechanically challenging diets without more anteriorly placed zygomatic roots and may exemplify adaptive tradeoffs with chewing efficiency. Our examination of zygomatic root position contributes to current models of craniofacial function and adds additional data to the understanding of feeding mechanics in primate fossil taxa.
Grant Information
Funding provided by the Elizabeth H. Harmon Research Endowment, School of Human Evolution and Social Change, Graduate and Professional Student Association of ASU

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

AN UNUSUAL NEW MARINE TURTLE (TESTUDINES, PANCHELONIOIDEA) FROM THE LATE CRETACEOUS, MAASTRICHTIAN COON CREEK FORMATION OF TENNESSEE, U.S.A.
EHRET, Dana J., New Jersey State Museum, Trenton, NJ, United States of America; GENTRY, Andrew D., University of Alabama Birmingham, Birmingham, AL, United States of America; HARRELL, JR., T. Lynn, Geological Survey of Alabama, Tuscaloosa, AL, United States of America
Diversity of marine turtles (Panchelonioidea) in the Late Cretaceous dropped significantly across the Campanian–Maastrichtian boundary. Taxa including *Toxochelys*, *Ctenochelys*, and the protostegids, commonly found in Campanian strata, are conspicuously absent in the Maastrichtian. Thus, Maastrichtian sea turtles from the Western Interior Seaway, the Mississippi Embayment in particular, are not well known. Here we report on an unusual new panchelonioid from the Maastrichtian Coon Creek Formation (70 million years old) of Tennessee.
This new taxon is represented by two partial carapaces that were collected by amateur paleontologists from a locality known as the "Sawmill site" in Decatur County, Tennessee (U.S.A.) and donated to the Pink Palace Museum in Memphis, Tennessee. The Sawmill site is located on the U.S. Gulf Coastal Plain near what was the northeastern shore of the Late Cretaceous Mississippi Embayment, which was part of the Western Interior Seaway. The strata exposed at the site are early Maastrichtian beds of the upper Coon Creek Formation and consist of dark, organic-rich, micaceous, glauconitic, sandy to silty muds and clays. Other vertebrate species collected from the site include chondrichthyans (ex. *Squalicorax pristodontus*), bony fish (ex. *Enchodus ferox*), several unidentified marine and freshwater turtles, marine reptiles (ex. *Mosasaurus hoffmanni*, *Cimoliasaurus magnus*, and *Eothoracosaurus mississippiensis*) and a hadrosaurid dinosaur. The geology and fossil assemblage of the Sawmill site suggest a low energy, near-shore, perhaps back-barrier depositional environment.
The turtle specimens have some characteristics reminiscent of *Allopleuron hoffmani* including a deeply excavated nuchal, raised peripheral keels and the lack of most scute sulci. However, it is distinct from *Allopleuron* as well as other described panchelonioids. Characteristics of this new taxon include: a deeply excavated nuchal, a large bony protuberance present on the dorsal side of each of the first peripherals, highly keeled neurals, with epineural ossifications present at the junctures neurals 1–2, 3–4, and 5–6, a prominent peripheral keel that runs along the dorsal surface of peripherals 2–6 and a lack of posteromedial nuchal fontanelles. The straight carapace length of the larger specimen is estimated at 90 cm. The large size, presence of large neural and peripheral keels and nuchal

protuberances make this an unusual, highly ornamented turtle unlike any others currently recognized.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

TOOTH-TO-BALEEN TRANSITION IN MYSTICETES: NEW CT EVIDENCE OF VASCULAR STRUCTURES ON THE PALATE OF *AETIOCETUS WELTONI* (MYSTICETI, CETACEA)

EKDALE, Eric G., San Diego State Univ, San Diego, CA, United States of America; DEMÉRÉ, Thomas A., San Diego Natural History Museum, San Diego, CA, United States of America

The tooth-to-baleen transition in Mysticeti (baleen whales) is a topic that is currently under vigorous debate. Although all extant baleen whales are fully edentulous at birth, the earliest diverging members of the mysticete lineage possessed well-developed teeth into adulthood. Aetiocetidae, a clade of Oligocene toothed mysticetes, plays a central role in the debate. Aetiocetids possess a series of palatal foramina immediately medial to the postcanine dentition. The openings have been homologized with lateral nutrient foramina that deliver neurovascular structures to the baleen organ in living species, thereby implying a co-occurrence of teeth and baleen (or 'proto-baleen') in aetiocetids. However, the homology of those structures has been questioned. Using high resolution X-ray computed tomography (CT), the identity of the lateral palatal foramina is explored in the best-known aetiocetid, *Aetiocetus weltoni*.

The CT images reveal that the lateral palatal foramina of *A. weltoni* are connected internally via small-diameter canals to the large bony canal within the maxilla that supplies feeder branches to the dental alveoli. Through comparison with living mysticetes, that large bony canal likely contained the superior alveolar nerves and arteries, which innervate and supply blood to the baleen in extant mysticete species. Furthermore, the lateral palatal foramina of *A. weltoni* are distinctly separate from the more medially positioned bony canal for the greater palatine artery, which delivers blood to the hard palate in extant mammals. These results provide critical evidence that the lateral palatal foramina in *A. weltoni* are homologous with lateral nutrient foramina in extant mysticetes. As such, the lateral nutrient foramina in *A. weltoni* provide strong support for the hypothesis that aetiocetids possessed both teeth and some form of baleen.

Grant Information
National Science Foundation, Grant Number DEB-0743861

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A PHYLOGENETIC ANALYSIS OF THE CYATHASPIDIDAE (AGNATHA, HETEROSTRACI)

ELLIOTT, David, Northern Arizona Univ, Flagstaff, AZ, United States of America; LASSITER, Linda S., Northern Arizona Univ, Flagstaff, AZ, United States of America

The Heterostraci is an order of jawless vertebrates in which the head was completely sheathed in bony armor. They were diverse, with more than 300 species described to date, and inhabited shallow marine and brackish environments around the Old Red Sandstone Continent (now North America, the Canadian Arctic, and Western Europe) from the middle Silurian (Wenlock) to the Late Devonian (late Frasnian). They have been used extensively in biostratigraphic schemes for the Early Devonian due to the common occurrence of heterostracan plates and scales in sediments that often yield little other organic remains. Although the bony armor is known the internal anatomy has not been preserved in any heterostracan and attempts to develop a phylogeny for the group are based entirely on the number and arrangement of the armor plates. Cladistic analysis has only recently been applied to this group using the best-known taxa, the Pteraspidiformes and the Cyathaspididae, with varying levels of success. Here we carry out an analysis of the Cyathaspididae, a taxon that includes the earliest occurring members of the Heterostraci and also has the simplest arrangement of plates, with a single dorsal and ventral and paired branchial plates. Previous analyses have also included taxa that do not have the basic characters of the Cyathaspididae, in particular the presence of the paired branchial plates. These were excluded from the ingroup in our analysis. The matrix was composed of 32 taxa and one outgroup taxon and 39 characters. All characters were unordered and equally weighted. The resulting consensus trees produced from PAUP and TNT showed a number of trends through the family that were not apparent in previous analyses. Firstly, a simplification of the dorsal shield through time by the loss of scale-like elements was supported. Secondly, a reduction and then loss of epitega (separate growth areas of the dorsal plate) could be recognized through time. Thirdly, although evidence from this part of the shield is limited, a simplification of the oral plates appears to take place, reducing from a complex arrangement of oral plates to a simplified system that in some cases consisted of only one plate. The resulting strict consensus resolves the Cyathaspididae in close congruence with the subfamilies erected in the original description ofthe family.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

MICROFOSSIL SORTING FOR A "MOUSE'S EYE VIEW" OF RANCHO LA BREA

ELLWOOD, Elizabeth R., Los Angeles, CA, United States of America; GRAHAM, Noel, Los Angeles, CA, United States of America; LINDSEY, Emily, Los Angeles, CA, United States of America; TAKEUCHI, Gary, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; PORTER, Molly, Los Angeles, CA, United States of America

The La Brea Tar Pits might be best known for the saber-toothed cats, dire wolves, and mammoths that have been excavated from our grounds, but it is in the matrix surrounding the fossils of these large animals that we find innumerous “microfossils” critical to understanding past ecosystems. In the collaborative “Mouse’s Eye View” research project, we are using these microfossils to reconstruct food webs in order to shed light on how organisms at various trophic levels interacted during the late Pleistocene, with an emphasis on small mammals and plants.

For decades, volunteers in the Fossil Lab at the La Brea Tar Pits Museum have helped sort through matrix, pulling out microfossils such as seeds and bits of wood, bird vertebrae, turtle shell fragments, lizard jaws, insect wings, and mouse leg bones, that are valuable for various research applications. As an engaging, educational activity, sorting matrix is also perfect for community scientists and students. We partnered with teachers in Los Angeles to involve middle and high school students in sorting microfossils for use in the Mouse’s Eye View project. To do this, we developed a microfossil sorting kit that is mailed to classrooms, completed, and returned to the museum. Naturally, we don’t expect our student community scientists or their teachers to be expert microfossil identifiers from the start, so we developed an online La Brea Webs iNaturalist project to aid in identification.

Microfossil sorting kits are currently in classrooms, reaching over 600 students across Los Angeles. Over time, we aim to grow and expand this project to more schools, to learn more about how best to engage individuals of all ages in microfossil sorting, and how to ensure accurate sorting from minimally-trained contributors.

Technical Session XIV (Saturday, October 20, 2018, 11:45 AM)

SOME LIKE IT HOT: REVEALING PALEOTROPICAL FISH DIVERSITY DURING THE PALEOCENE–EOCENE THERMAL MAXIMUM

EL-SAYED, Sanaa E-S., Mansoura University Vertebrate Paleontology Center, Mansoura, Egypt; FRIEDMAN, Matt, University of Michigan, Ann Arbor, MI, United States of America; SALLAM, Hesham, Mansoura University Vertebrate Paleontology Center, Mansoura, Egypt

At the end of the Paleocene and the beginning of the Eocene, a series of extreme warming events led to the increase in global temperature during a time known as the Paleocene–Eocene Thermal Maximum (PETM). Due to a combination of the rate of temperature increase and relative geological proximity of this interval to the modern day, the PETM represents the best ancient analogue for predicting the consequences of contemporary climate change. The implications of the PETM for marine fishes are unclear due to the clustering of known fossil fish sites at mid-latitudes, well outside the paleotropics. Therefore the direct consequences of the most extreme temperatures on marine fishes remain poorly constrained. We have identified fish-bearing horizons associated with the PETM in the Eastern Desert, Egypt, at a locality corresponding to a paleolatitude of 12.2, well within the paleotropics. The fish-yielding beds are located in the top part of the Esna Formation (late Paleocene/early Eocene based on planktonic foraminiferal zonation) and consists of 50 cm of thin layers of dark brown shale. We sampled this fish horizon in order to assess taxonomic composition and diversity at the new site. The shale contains a fish fauna in a good state of preservation and approximately 100 samples have been collected. The most abundant identifiable member of the fauna is the percomorph *Mene* (Menidae). This genus is today confined to the Indo-Pacific but appears to have had a substantially larger geographic range in the Paleogene, with fossils known from all continents apart from Australia and Antarctica. The recovery of *Mene* from this new low latitude assemblage indicates that at least some cosmopolitan taxa were able to tolerate conditions in the tropics at the PETM, potentially characterized by sea surface temperatures in excess of 35 C. We anticipate that this research will make an important first step toward constraining the impacts of past global warming on a major component of vertebrate biodiversity and understanding the implications of contemporary climate change for marine fishes.

Grant Information
National Geographic, young explorers grant CP-023ER-17

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

ARTISTS AND PALEONTOLOGISTS EXPLORE SCIENCE ENGAGEMENT THROUGH NARRATIVE IN A SYMPOSIUM AT A SCIENTIFIC CONFERENCE

ELSHAFIE, Sara J., University of California, Berkeley, Berkeley, CA, United States of America; SUMIDA, Stuart S., California State University San Bernardino, San Bernardino, CA, United States of America

Art plays an important role in the public face of paleontology. Paleontologists collaborate with paleoartists to reconstruct fossil organisms and the worlds they lived in. Paleontology has long enjoyed wide public appeal thanks to dramatic depictions of dinosaurs and other fossil animals in popular media. But artists have more to offer scientists than just visual stimulation for the public. Artists can help scientists understand how to engage audiences both intellectually and emotionally through narratives.

To this end, we organized a symposium, “Science Through Narrative: Engaging Broad Audiences,” to facilitate exchange between scientists and artists. This two-day symposium took place at the 2018 Annual Meeting of the Society for Integrative & Comparative Biology (SICB) in San Francisco. Many of the speakers were paleontologists and paleoartists, ranging from art director to museum director. Presentations spanned disciplines as diverse as film, dance, and game design, to evolution and biomechanics. From this motley of perspectives, the presenters arrived at several shared conclusions: (1) both artists and scientists distill complexity to reveal truth; (2) when communicating with broad audiences, relatability must take precedence over volume of information; and (3) to engage an audience, you must find the right balance between accuracy and believability. The symposium attracted hundreds of attendees, including many non-academics from arts, education, and business sectors. In a follow-up survey of attendees, the majority (83%) of respondents indicated that this was their first time to attend a symposium on science communication at a scientific conference. Most also said that they had not previously seen artists from outside of academia presenting at a scientific conference. Many indicated that learning directly from artists in this context helped them to improve their communication skills. Several gave examples of specific strategies or influences that they have since taken from some of the symposium presentations (e.g., using stories to introduce new information; thinking about how people process narratives vs. facts). All respondents said that they would consider attending another symposium in this series. We hope that this symposium can serve as a model for other initiatives that bring communication programming to scientific platforms and include artists in the exchange.

Grant Information
This symposium was sponsored by SICB; Science Sandbox; The Walt Disney Family Museum; Science World at TELUS World of Science; COPUS; Spacetime Labs; and an anonymous donor.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

DIETARY ECOLOGICAL NICHE DISPERSION IN AN ECOMORPHOSPACE OF PLATYRRHINE PRIMATES AND ITS ASSOCIATION WITH CRANIAL INTEGRATION

ELY, Ricardo C., Indiana University, Bloomington, IN, United States of America

Morphological integration and modularity are concepts describing the degree of interdependence between traits in an organism. Integration describes a high degree of interdependence, while modularity describes relative independence of traits. A greater magnitude of interdependence (integration) among traits hampers evolutionary response, while trait independence (modularity) facilitates evolutionary flexibility, suggesting that modularity facilitates the evolution of ecological specializations and the ability for modular clades to occupy a wider array of niches. I tested this in platyrrhine primates by constructing a three-dimensional ecomorphospace based on dental topographic measures using principal component analysis (PCA). The breadth of dietary niche occupation in this ecomorphospace was measured using the Euclidean distance between each platyrrhine genus and a 'generalist' condition of the average dental shape of all genera. Indices measuring the degree of modularity (r^2, ICV, and p_{max}) were collected from the literature for each genus. Linear regression and correlation was used to assess the relationship between modularity and niche dispersion. No significant correlations between PCA Euclidean distance and each integration index was detected. This indicates modularity may not have a strong influence on dietary niche dispersion (at least not in platyrrhines). Alternatively, the potential for modularity to allow clades to exploit ecological opportunities occurs at broader phylogenetic and ecological scales than those considered here. This hypothesis can be tested by broadening the taxonomic scope of the analysis presented here.

Technical Session IX (Friday, October 19, 2018, 9:30 AM)

A PRELIMINARY PHYLOGENETIC ANALYSIS OF TRUNK EVOLUTION IN OREODONTS (ORDER CETARTIODACTYLA, SUPERFAMILY MERYCOIDODONTOIDEA)

EMERY-WETHERELL, Meaghan, Central Washington University, Ellensburg, WA, United States of America; CANADA, Spencer, Central Washington University, Ellensburg, WA, United States of America; GRANDE, Keilah, Central Washington University, Ellensburg, WA, United States of America

Trunks are a convergently-evolved mammalian morphology of diverse function, including facilitating selective feeding behavior, filtering out dust particles, enhancing vocalization, and regulating heat loss. The skulls of modern trunk-bearing mammals all contain some degree of nasal retraction, an osteological indicator that is also abundant in fossil lineages including litopterns, astrapotheres, oreodonts, and others. Nasals of most mammals are delicate and break during fossilization, but the robust skulls of oreodonts frequently preserve their nasals, making them ideal for the study of osteological trends in trunk evolution.

Our preliminary phylogenetic analysis of 52 individuals of 21 genera of oreodonts shows nasal retraction occurred independently in three subfamilies (Brachycrurinae, Merycochoerinae, and Ustatochoerinae). In all groups, nasal retraction was preceded by retraction of the nasal notch (anterior-most meeting point of the nasals and maxilla), and enlargement of the infraorbital foramen. Development of nasal retraction also correlated with posterior extension of the palate, enlargement of the pterygoids, and lateral expansion of the occipital crest in all taxa.

The end-member trunk types consist of a lineage typified by *Brachycrus*, with muscle attachment scars along the premaxilla, a deep maxillary fossa, and vertically oriented nasal bones; a lineage typified by *Merycochoerus*, with a smooth premaxilla, a small lacrimal fossa but no maxillary fossa, and horizontally oriented nasal bones with a maxillary strut; and a lineage typified by *Ustatochoerus*, with a smooth premaxilla, a large lacrimal fossa and lacrimal vacuity but no maxillary fossa, and horizontally oriented nasal bones without a maxillary strut. These different end members indicate potentially different uses for trunks: expansion of the maxillary fossa and strong muscle attachments are consistent with a muscular trunk used for selective foraging in *Brachycrus* (similar to tapirs), while the nasals of *Merycochoerus* and *Ustatochoerus* are more consistent with the heat regulation and air filtration trunks of modern dik-diks or saiga antelope.

Grant Information
Theodore Roosevelt Grant (AMNH), Doris O. and Samuel P. Welles Fund (UC Berkeley), Ernst Mayr Grant (Harvard), Thomas Condon Scholarship and Smith Scholarship (U Oregon)

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

DIFFERENTIATION IN DENTAL MORPHOLOGY AND FUNCTION OF PALEOCENE SMALL MAMMALS AFTER THE CRETACEOUS–PALEOGENE MASS EXTINCTION

ENGLER, Thomas, Universität Bonn, Bonn, Germany; MARTIN, Thomas, Universität Bonn, Bonn, Germany

The evolution of the tribosphenic molar is considered as an important step for the evolutionary success of mammals. The development of the talonid basin at the lower molars, with which the newly formed protocone occludes like a pestle into a mortar, adds a crushing and grinding to the plesiomorphic piercing and cutting function. This functional modification made a wider range of diets accessible and increased the adaptability of mammals after the Cretaceous–Paleogene mass extinction. Early modifications of the tribosphenic pattern are additional cusps, such as paraconulus, metaconulus, and the distolingual hypocone.

We have studied the functional change from the plesiomorphic tribosphenic pattern to the quadritubercular condition in early Paleocene mammals from the Walbeck site in Germany and Porcupine Hill Formation of Canada. For a better understanding of the functional changes, the molar patterns were classified in four morphotypes: (1) triangular crown with small para- and metaconulus, (2) hypocone present, (3) hypocone absent, and (4) quadrangular crown with equally-sized para-, metaconulus, and hypocone.

With the occlusal fingerprint analyzer software, the mastication paths were virtually reconstructed and the contact areas between antagonistic teeth were quantified for functional comparison of the different morphotypes. The reconstruction of the masticatory path is based on three-dimensional surface models (µCT data) of the teeth and the wear facets including striations.

In all morphotypes, a two-phased power stroke was reconstructed, which is typical for tribosphenic molars. The morphotypes differ in directional and inclination changes of the lower jaw between phase I and phase II. With the size increase of para- and metaconulus, the directional change decreases due to the more bunodont tooth crowns (*Elpidophorus*). In quadrangular bunodont molars (*Prolouisina*) inclination decreases, along with a reduction of the crown relief. In triangular molars (*Adapisorex*), the hypocone originates from the distolingual postprotocingulum. In this type, the hypocone occludes mesially along the paraconid in the trigonid basin and performs additional grinding, besides the protocone-talonid occlusion of the tribosphenic groundplan condition.

These various changes reflect new dietary adaptations and were confirmed by dental topography analysis using the R package molaR.

Grant Information
DFG-Project number: MA 1643/21-1

Technical Session XIII (Friday, October 19, 2018, 3:45 PM)

GROWTH CURVE FOR THE ARCTIC HADROSAURID *UGRUNAALUK KUUKPIKENSIS* FROM THE EARLY MAASTRICHTIAN PRINCE CREEK FORMATION OF NORTHERN ALASKA

ERICKSON, Gregory M., Florida State University, Tallahassee, FL, United States of America; ANDERSON, Katherine L., University of Alaska Fairbanks, Fairbanks, AK, United States of America; DRUCKENMILLER, Patrick S., University of Alaska Museum, Fairbanks, AK, United States of America

The discovery of non-avian dinosaurs in polar environments provides natural biological tests of their physiology, migration and provinciality. Prominently factored into such analyses is the hadrosaurid *Ugrunaaluk kuukpikensis* from the early Maastrichtian Prince Creek Formation (PCF.) of northern Alaska. This taxon lived in a coastal/alluvial plain environment situated at 80–85 °N. The region experienced approximately four months of constant polar darkness and a mean annual temperature of 6.3±2.2 °C, with snowfall likely. It has been proposed that *U. kuukpikensis* was either: (1) a year-round polar denizen; or (2) migratory, making annual 2000+ km treks between higher and lower latitudes thereby avoiding lean Arctic winter conditions. Conspicuous growth lines in *U. kuukpikensis* teeth provide support for the former hypothesis. Chinsamy and colleagues reached the same conclusion after finding that long bone vascularization cycles are rare in lower latitude *E. regalis* but commonplace in *U. kuukpikensis* (then thought to be the same taxon). Their samples (femora, tibiae, and humeri) curiously lacked LAGs. Our survey of multiple elements of *U. kuukpikensis* reveals their presence in radii, making aging of the taxon possible. We histologically analyzed ten radii from a growth series spanning a seven-fold range of circumference and constructed a growth curve. We used these data to determine the adult size for the taxon and test for environmental effects on its growth by contrasting developmental patterns with those of hadrosaurids from more climatically equable lower latitudes. The largest *U. kuukpikensis* individuals are approximately 12 years of age. Haversian remodeling, EFS structuring and the growth curve asymptote show they are nearly full-grown and considerably smaller than adults of *E. regalis*. Growth data for lower latitude hadrosaurids such as *Maiasaura peeblesorum* fall within the 90% confidence interval for *U. kuukpikensis* and both taxa were nearly identical in size throughout ontogeny. Assuming *U. kuukpikensis* is not a dwarfed taxon (growth data for salient outgroups are pending), it was not strongly affected by the severe climatic effects of high latitude occupation. This is unlike many extant ectothermic reptiles that show stunted growth rates and smaller adult sizes. Notably, ectothermic crocodilians, champsosaurs, turtles and squamates have not been recovered from the PCF. suggesting the climate precluded their occupation. These data, coupled with the growth results suggest *U. kuukpikensis* was endothermic.

Grant Information
This research was generously funded by NSF EAR 1226730 and 1736386

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

EARLIEST PALEOCENE MULTITUBERCULATES FROM THE CAMEL BUTTE LOCALITY OF THE FORT UNION FORMATION, SOUTHEASTERN MONTANA

ERMER, Henry W., Brooklyn College, City University of New York, Brooklyn, NY, United States of America; SARGIS, Eric J., Yale Peabody Museum, New Haven, CT, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America; LYSON, Tyler R., Denver Museum of Nature and Science, Denver, CO, United States of America; CHESTER, Stephen G., Brooklyn College, City University of New York, Brooklyn, NY, United States of America

The Cretaceous–Paleogene (K–Pg) mass extinction event and subsequent faunal recovery in the earliest Paleocene were defining moments in mammalian evolution. Patterns of mammalian recovery have been well documented in the Hell Creek area of northeastern Montana, but few productive earliest Paleocene vertebrate localities are known from elsewhere in the region. Here we report the multituberculate composition from the Camel Butte fossil locality, Tullock Member, Fort Union Formation, Fallon County, southeastern Montana. This locality is at the base of a structureless, uncapped, coarse-grained channel lag deposit that lies 29 cm above the Fort Union-Hell Creek formational contact and 125 cm above the palynologically defined K–Pg boundary. Surface collecting and screenwashing have yielded nearly 1,000 mammal teeth, of which more than half represent multituberculates. The presence of the eucosmodontid multituberculate *Stygimys* and the 'archaic ungulates' *Protungulatum*, *Oxyprimus*, *Mimatuta*, and *Baioconodon* warrants assignment of this locality to the early Puercan (Pu1) North American Land Mammal Age interval zone. More specifically, Camel Butte may be from middle or late Pu1 given that (1) the taxonomic diversity is higher than typical Pu1 disaster faunas (e.g., Worm Coulee 1) and (2) the presence of certain taxa (e.g., cf. *Baioconodon cannoni*, cf. *Procerberus andesiticus*) that resemble species otherwise known only from the Littleton fauna, Denver Formation, Colorado, which has been considered late Pu1 in age. At least four multituberculate species (*Stygimys kuszmauli*, *Cimexomys minor*, *Mesodma formosa*, and *M. thompsoni*) are present at Camel Butte, and *M. thompsoni* makes up an overwhelming majority of the multituberculate sample. However, given the great range of

variation among p4s attributed to *M. thompsoni* and morphological similarities among taxa within Ptilodontoidea, some of these specimens may belong to a closely aligned taxon previously unknown from Pu1. Although a sampling bias toward recovery of larger specimens might explain the absence of some Pu1 multituberculates (e.g., *Acheronodon garbani* and *M. hensleighi*) and the scarcity of *M. formosa*, it does not explain the absence of the relatively large *Catopsalis*. Camel Butte appears to provide an intermediate stage between the disaster and recovery faunas previously documented in eastern Montana and contributes to our broader understanding of the taxonomic patterns and tempo of diversification of multituberculates and other mammals in the earliest Paleocene.

Grant Information
Yale Peabody Museum of Natural History Division of Vertebrate Paleontology, PSC CUNY Award jointly funded by The Professional Staff Congress and The City University of New York

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

STRONTIUM ISOTOPE RATIOS REVEAL DISPARATE GEOGRAPHIC ORIGINS FOR MEGAFAUNA AT WACO MAMMOTH NATIONAL MONUMENT (TX, U.S.A.)

ESKER, Donald A., Baylor University: Geo Dept, Waco, TX, United States of America

Waco Mammoth National Monument (WMNM) is a konzentrat lagerstätte in Central Texas, which dates to the Marine Isotope Stage (MIS) 4/5 transition ~67 ka. The site is most notable for preserving at least one nursery herd of *Mammuthus columbi*, but it also contains remains from a diverse assemblage of Pleistocene vertebrates. The previously accepted kill mechanism—a flooding event—has been called into question. The time is right to re-examine the site with new analytical tools. One such tool is serial dental isotope analysis, where small samples of enamel are collected from along the growth axis of a tooth. Serial samples can produce long records, from a few months to over a decade. A pilot study looked at the O, C, and Sr isotopes of a single mammoth tooth from WMNM, mammoth 'N.' $\delta^{18}O$ was used to reconstruct a seasonal signal in the evaporative balance of the mammoth's drinking water, and $\delta^{13}C$ was used to reconstruct the C3:C4 balance of their diet. ^{87}Sr:^{86}Sr ratios were used to show the range of the mammoth. This is possible because ^{87}Sr:^{86}Sr ratios in mammal teeth reflect the ^{87}Sr:^{86}Sr ratios in their diet, which reflect the ratios in the soil, which reflect the ratios in the bedrock, which are ultimately determined by rock age and lithology. The pilot study showed that mammoth 'N' spent most of the seven years before its death roughly 170 km SW of Waco, in the Llano Uplift. Last spring, five teeth from WMNM and the surrounding area were taken to Eastern Tennessee State University for serial sampling with their high-precision micromill. Mammoths 'L' and 'M' from WMNM and mammoth 'P1600' from a nearby gravel pit were all sampled. In addition, serial samples were taken from *Equus* '1229,' and *Bison* '1190.' The control, mammoth 'P1600,' had a strontium signature similar to plants grown in soil rich in Cretaceous carbonate, as did the *Equus* and *Bison*. ^{87}Sr:^{86}Sr ratios like these can be found in modern plants growing above Cretaceous limestone from Dallas to San Antonio, including Waco. It is thus possible that they were all 'locals.' Mammoths 'L' and 'M,' however, had ^{87}Sr:^{86}Sr ratios that differed both from 'local' mammoth 'P1600' and Llano mammoth 'N' from the pilot study. Rather, their ^{87}Sr:^{86}Sr ratios closely resemble that of vegetation growing on Paleogene sandstone, which can be found no closer than 60 km to the east. One potential explanation is that there is not one nursery herd of mammoths entombed at WMNM, but two or three. Multiple herds from disparate areas converging on a single point suggest the animals were congregating around a diminishing resource, perhaps water.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

USING HISTORICAL PHOTOGRAPHS TO LOCATE FOSSIL LOCALITIES OF EARLY VERTEBRATE PALEONTOLOGISTS: EXAMPLES FROM THE BRIDGER BASIN IN SOUTHWEST WYOMING AND THE WHITE RIVER BADLANDS OF SOUTH DAKOTA

EVANOFF, Emmett, University of Northern Colorado, Greeley, CO, United States of America; BRILL, Kathleen A., Longmont, CO, United States of America; MOXNESS, Levi, North Dakota Geological Survey, Bismarck, ND, United States of America

One of the inherent problems of historic collections in the long-established museums, such as the American Museum of Natural History and Yale Peabody Museum, is that many of the early specimens have poor or incomplete locality data. Fortunately, the early geological and paleontological surveys after the Civil War included photographers that recorded places of paleontological interest. The locality information that the paleontologists recorded was generalized since they had no detailed topographic maps, aerial photographs, or GPS units. The photographs showed where they made their geologic observations, and where they collected important fossils including type specimens.

Many of the historic photographs from these expeditions are now available online through organizations such as the U.S. Geological Survey, the National Park Service, and major museums. To locate the photographs in complex badland topography it is necessary to have an intimate knowledge of the field area. Paper copies of the historical images are used to search for prominent features in the landscape that match those in the original photograph. When a photo site is found, the original photographic image is duplicated using modern digital cameras, typically using a wide-angle lens ranging from 18 mm to 25 mm covering an area slightly wider than the original photograph. The date and time of day of the new image is recorded along with GPS readings for the site in latitude/longitude and UTM coordinates. The azimuths of prominent features in the landscape at the photo sites are measured using a Brunton compass. The sites are plotted on topographic maps in the field and these locations are checked in the office using modern topographic map data-bases and GPS data. Fossil localities shown in the historic photographs are measured into modern detailed stratigraphic sections. From this data all the modern provenance information is recorded for the locality.

Examples of this technique is provided from images by three historical photographers, William H. Jackson and Albert Thompson who worked in the Bridger Basin of southwestern Wyoming in 1870 and 1903, and Harold R. Wanless who worked in the White River Badlands of South Dakota in 1920. These historic photos include the localities of type specimens of Bridgerian and Orellan fossils and camp sites of early paleontologists.

The repeat photos show how once-productive fossil localities have been buried under alluvium or in other cases how little the badlands outcrops have changed in over a century. Grant Information
This study has been conducted with the paleontological permits issued through Rachel Benton at Badlands National Park and Brent Breithaupt of the Wyoming BLM. No grant funds have been used.

Technical Session VIII (Thursday, October 18, 2018, 3:45 PM)

BLADE RUNNER: FUNCTIONAL PERFORMANCE OF BLADED TEETH IN *THYLACOLEO* AND *PROPLEOPUS*

EVANS, Alistair R., Monash University, Victoria, Australia; POLLOCK, Tahlia I., Monash University, Victoria, Australia; OLAH, Angela, Monash University, Victoria, Australia

Elongated bladed teeth are found in many mammal groups and come in a variety of shapes. The longest of these bladed teeth belongs to the marsupial lion *Thylacoleo carnifex*, which is weakly concave and differs from the typical smooth V-shaped blade of placental carnivorans. Another bladed tooth form in mammals is the serrated plagiaulacoid tooth. Plagiaulacoid teeth have evolved independently in three mammal groups: marsupials, carpolestid plesiadapiformes, and multituberculates. The Pleistocene kangaroo *Propleopus* has a well-developed serrated plagiaulacoid blade. Amongst all of these bladed teeth, shape is reasonably variable, and so presumably would be their performance in fracturing and fragmenting food. Here we examine functional characteristics of blade shape in mammal teeth, including rake angle and approach angle. We constructed idealised 3D models of several blade configurations varying these functional characteristics and the presence/absence of serrations, as well as scaled models of real 3D tooth shapes. Using 3D prints of these models, we used force testing to examine their performance, measuring the force and energy required to fracture and fragment a variety of foods. Performance was generally improved for stiff plant foods with higher rake angles, and for ductile foods with higher approach angle. These results allow us to make functional predictions of the cutting ability of *Thylacoleo* compared to placental carnivorans as well as interpret the likely diet of *Propleopus*.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

ONTOGENETIC CHANGES IN THE FEMUR OF *TAWA HALLAE* AND IMPLICATION FOR SPECIES DIVERSITY OF LATE TRIASSIC DINOSAURS

EVANS, Elizabeth L., Virginia Tech, Blacksburg, VA, United States of America; GRIFFIN, Christopher T., Virginia Tech, Blacksburg, VA, United States of America; SMITH, Nathan, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America; IRMIS, Randall B., University of Utah, Salt Lake City, UT, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America

Analysis of growth patterns can provide critical insight to the paleobiology of vertebrates and solidify taxonomic identifications. Recent studies have shown that early dinosaurs exhibit many morphological changes through ontogeny and some of these traits have been used to diagnose new species. However, ontogenetic series in dinosaurs are rare because a robust ontogenetic analysis requires a relatively large sample size of individuals to document growth at different stages of maturity. We collected morphometric data (e.g., proximodistal length, width of proximal head) from 22 femora of the Late Triassic early dinosaur *Tawa hallae*, and scored qualitative characters (e.g., proximal head orientation, size of trochanter shelf) into an ontogenetic matrix to compare features across the individual. These femora from the Hayden Quarry are ideal to examine ontogeny in a single species because they are three-dimensionally preserved and have pristine surfaces that preserve features associated with maturity. From these data, we hypothesized that the femora assignable to *Tawa* and those previously assigned to cf. *Chindesaurus*, which are found in the same locality, are a single species that sample different maturity states. Generally, the smaller femora pertain to *Tawa* and the largest pertain to the *Chindesaurus*-like morphotype, however, there is a significant zone of overlap in the middle (i.e., there are larger *Tawa* femora and smaller *Chindesaurus*-like femora). In support of our hypothesis, we documented several femora with morphological features characteristic of both *Tawa* and *Chindesaurus*-like femora within the same individual, providing evidence of an intermediate stage between the more immature *Tawa*-like morphology and the more mature *Chindesaurus*-like morphology. Furthermore, the order of appearance of growth characters from smaller *Tawa* to the larger *Chindesaurus*-like morphology generally mirrors that in other dinosaurs such as the neotheropod *Coelophysis* and other more poorly sampled taxa. Our results pinpoint a number of ontogenetic characters that are not robust for species identification in early dinosaurs. Furthermore, *Chindesaurus*-like femora are found with smaller *Tawa*-like femora throughout both the Chinle Formations and Dockum Group sequences; we conclude that these occurrences likely represent the same species. Grant Information
NSF EAR 1349667 to SJN, NSF EAR 1349654 to AHT, NSF EAR 1349554 to NDS, NSF EAR 1349650 to RB

Poster Session III (Friday, October 19, 2018, 4:15 – 6:15 PM)

A SKULL AND ASSORTED POSTCRANIA OF *ENALIARCTOS* (PINNIPEDIMORPHA) FROM THE PYSHT FORMATION OF WASHINGTON, U.S.A.

EVERETT, Christopher, University of California, Santa Barbara, Santa Barbara, CA, United States of America; WYSS, Andre, University of California Santa Barbara, Santa Barbara, CA, United States of America; DEMÉRÉ, Tom, San Diego Natural History Museum, San Diego, CA, United States of America

The early pinnipedimorph *Enaliarctos* is known from the late Oligocene and early Miocene of the eastern Pacific of North America. The genus contains five recognized species that exhibit considerable morphological diversity. The specimen of *Enaliarctos* presented here is the first formally described from the Pysht Formation of Washington, though other unnamed 'enaliarctine' specimens were previously collected. The specimen was not recovered in place, making its stratigraphic provenance uncertain. The age of the unit is poorly constrained between 30.5 to 23.7 Ma. Despite geochronological uncertainty, this discovery extends the geographic range of *Enaliarctos* northward into Washington. The upper dentition, zygomatic arch, and basicranium are well preserved, allowing for critical diagnostic assessment. This specimen shares many similarities with *Enaliarctos mitchelli*, the smallest *Enaliarctos* species, previously known only from California and Oregon. The skull is smaller than other described *E. mitchelli* specimens, yet closed sutures indicate the individual was an adult, suggesting it may reflect ontogenetic, sexual, or regional variability within the species. An associated right humerus and cervical vertebra from this specimen represent the only known postcranial elements from *E. mitchelli*. X-ray computed tomography scans of the skull illuminate previously unobserved auditory ossicle and otic capsule morphology. These features have the potential to shed light on the phylogenetic position of *E. mitchelli* within Pinnipedimorpha and on the functional morphology of the earliest members of this group.

Technical Session XVI (Saturday, October 20, 2018, 10:15 AM)

A DINOSAURIAN ORIGIN FOR THE AVIAN SINGLE OVIDUCT

FABBRI, Matteo, Yale University, New Haven, CT, United States of America; YOUNG, Tzu-Rei, University of Bonn, Bonn, Germany; WIEMANN, Jasmina, Yale University, New Haven, CT, United States of America; BHULLAR, Bhart-Anjan S., Yale University, New Haven, CT, United States of America; NORELL, Mark, American Museum of Natural History, New York, NY, United States of America

The avian reproductive system is among the most sophisticated in the animal kingdom. One of the key characteristics is supposedly the presence of a single functional oviduct involved in egg formation, a unique trait among diapsids. This trait was pointed out as an apomorphy of crown birds and linked to the origin of powered flight. The fossil record supported this hypothesis with indirect evidence: clutches attributed to non-avian theropod dinosaurs, such as oviraptors and North-American troodontids, show a paired arrangement of the eggs, suggesting that two reproductive tracts were present in these taxa. Direct evidence comprises the finding of two eggs preserved in the pelvic region of an oviraptor skeleton from China, supporting the hypothesis of a single origin of the avian oviduct in the crown and validating the methodologies previously used on clutches to test for single or double oviducts in extinct taxa.

In the last two decades, an incredible number of dinosaur and stem bird nests were recovered from Mongolia. In light of these new findings, we tested again for the presence of a single oviduct in the stem of the bird branch looking at the arrangement of the eggs in the clutches. Our dataset includes clutches belonging to two oviraptors, three different troodontid taxa from Mongolia, a troodontid nest from North America, and ten nests belonging to an undescribed enantiornithine taxon. The taxonomic and systematic attribution of the nests are based on morphological and microstructural morphology of the eggs, such as disposition of the eggs within the nests and ornamentation of the eggshell, and on the anatomical investigation of the embryonic remains and hatching individuals found within the eggs or in association with the clutches, respectively. Randomization of egg position in space and cluster analysis were performed to statistically test the probability of a paired arrangement of the eggs. Our results support the presence of paired arrangement in oviraptors. On the other hand, we found no support for paired arrangement in Troodontidae and the enantiornithine clutches. We did not find any sign of manipulation of the eggs when the sedimentological structure in the nests were investigated. Our results suggest that a single ovarian tract had evolved already in non-avian theropods and that the crown-bird oviduct tract is a plesiomorphic character in Paraves.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

STATISTICAL ANALYSIS OF DENTAL VARIATION IN OLIGOCENE HYPERTRAGULIDS (MAMMALIA, ARTIODACTYLA) OF OREGON

FAMOSO, Nicholas A., National Park Service John Day Fossil Beds National Monument, Kimberly, OR, United States of America

Three species of the extinct artiodactyl family Hypertragulidae are currently recognized from the Turtle Cove Member of the John Day Formation in central and eastern Oregon. No statistical analysis of variation in these ungulates has yet been conducted to determine if that level of diversity is warranted. Variation of the anteroposterior length (APL) and transverse width (TW) of 30 upper first molars of three hypertragulid species (*Hypertragulus hesperius*, *Hypertragulus minutus*, and *Nanotragulus planiceps*) was compared to that of modern muntjacs using their coefficients of variation (V). I used an Analysis of Variance (ANOVA) and post-hoc Tukey Test to determine if the three species could be distinguished from one another. I also used Shapiro-Wilk and Hartigan's Dip tests and a finite mixture analysis to determine if the data were normally distributed or if multiple means were present in the distribution. Finally, a Quadratic Discriminant Analysis (QDA) was used to confirm the identification of each specimen and to predict the identification of previously unidentified specimens. The V values for each of the three species, and a pooled population of all three species, are similar to that of the modern muntjac. All tests of normality indicated a normal distribution of data. The ANOVA was significant, but the Tukey Test for both APL and TW only identified *H. minutus* as being statistically different from the other two species. The QDA misidentified specimens 26.1% of the time and was 83.3% correct in identifying *H. hesperius*, but only 40% correct when identifying *H. minutus*. The sample size for *N. planiceps* is currently too small to be included in the QDA. In the end, only two species of hypertragulid can be confidently identified from the Turtle Cove Member of the John Day Formation, *Hypertragulus hesperius* and *Hypertragulus minutus*, which may suggest some over-splitting among these Oregonian hypertragulids.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ANATOMY AND FUNCTIONAL MORPHOLOGY OF THE ORAL RHAMPHOTHECAE IN HADROSAURIDAE (ORNITHISCHIA, DINOSAURIA)

FARKE, Andrew A., Raymond M. Alf Museum of Paleontology, Claremont, CA, United States of America; LIU, Yufei, The Webb Schools, Claremont, CA, United States of America; VAZQUEZ, Olivia R., The Webb Schools, Claremont, CA, United States of America

Hadrosaurids received the moniker of "duckbilled dinosaurs" after their broad, edentulous anterior oral margins formed by the premaxillae and predentary. Several specimens preserve impressions of a rhamphotheca that protruded well beyond the bony margins, imparting a scoop-mouthed life appearance radically different from that shown by the bones alone. Here, we survey the anatomy of oral rhamphothecae in hadrosaurids, assessing their function, phylogenetic distribution, and osteological correlates.

Premaxillary rhamphothecae are known in specimens of *Edmontosaurus*, *Brachylophosaurus*, and *Parasaurolophus*. Those with sufficient preservational quality show an internal surface with dorsoventrally oriented grooves (i.e., perpendicular to the bony oral margin). A partial predentary rhamphotheca with dorsoventrally oriented ridges is preserved in a single specimen of *Corythosaurus casuarius* (CMN 8676, Canadian Museum of Nature). Although it has been interpreted both as an upper and lower rhamphotheca, its intimate association with the predentary, as well as the fact that the rest of the cranium was disarticulated, strongly favors identification as the lower rhamphotheca. A grooved/ridged oral rhamphotheca is inferred as ancestral for Hadrosauridae.

Based on all available data, we hypothesize a reconstruction where the outer surface of the lower rhamphotheca was ridged, fitting within within the grooved inner surface of the upper rhamphotheca. When bony denticles occur on the predentary and premaxillary oral margins, these appear to correlate on a 1:1 basis with grooves in the rhamphotheca; however, not all specimens with a grooved rhamphotheca have bony oral denticles. Based on the broader distribution of oral denticles in Iguanodontia, a grooved/ridged rhamphotheca probably was widespread outside of Hadrosauridae.

In order to better understand anatomical and functional relationships between bone and rhamphotheca, we examined a sample of extant turtles with varying diets. Subtle bony crenulations and denticles often correspond with keratinous denticle and groove/ridge structures (e.g., *Caretta caretta* and *Gopherus agassizii*), but a 1:1 correspondence between the bone and keratin does not always occur. These structures are not associated with any particular diet, occurring in herbivorous turtles as well as omnivorous and carnivorous species. Thus, extant analogs can only be used with caution for interpreting the function of the beak complex in hadrosaurids.

Grant Information
David B. Jones Foundation

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

FOOTFALL PATTERN OF A BOTTOM-WALKING CROCODILE (*CROCODYLUS ACUTUS*)

FARLOW, James O., Indiana Purdue University Fort Wayne, Auburn, IN, United States of America; ROBINSON, Nathan J., Cape Eleuthera Institute, Eleuthera, Bahamas; TURNER, Morgan L., Brown University, Providence, RI, United States of America; BLACK, Jenell, Purdue University Fort Wayne, Fort Wayne, IN, United States of America; GATESY, Stephen M., Brown Univ, Providence, RI, United States of America

Drone footage of a large American crocodile bottom-walking in shallow coastal water off Costa Rica was used to estimate pace and stride lengths and pace angulations from autopodial touchdowns. The crocodile's pes stride lengths were longer but more variable than expected for an individual of comparable size high-walking on land, due in part to punting locomotion, but also to wave action moving the reptile's body. Pace angulations were also longer than expectations for a crocodile high-walking on land. These features are also seen in fossil trackways, suggesting that trackways ascribed to "swimming" crocodylomorphs might better be characterized as made by bottom-walking and punting reptiles.

Technical Session I (Wednesday, October 17, 2018, 8:00 AM)

QUANTIFYING CRANIAL CONVERGENCE, EVOLUTIONARY RATES, AND DISPARITY IN THE DINOSAUR SKULL

FELICE, Ryan N., The Natural History Museum, London, United Kingdom; WATANABE, Akinobu, Natural History Museum, London, London, United Kingdom; CUFF, Andrew, Royal Veterinary College, Hatfield, United Kingdom; WITMER, Lawrence M., Ohio Univ, Athens, OH, United States of America; NORELL, Mark A., American Museum of Natural History, New York, NY, United States of America; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom; GOSWAMI, Anjali, University College London, London, United Kingdom

The high phenotypic disparity and taxonomic diversity of crown birds is frequently attributed to the acquisition of key innovations (e.g., flight) and ecological opportunity following the K–Pg mass extinction. Recent research into the links between ontogeny and evolution have begun to demonstrate that intrinsic factors, including cranial modularity and heterochronic shifts in developmental programs, have also been a major factor shaping the evolution of phenotypic diversity in the avian cranium. Here, we investigate how the strength of interactions among phenotypic traits have changed through dinosaur evolution and how these changes have influenced macroevolutionary patterns. Using high-dimensional 3D geometric morphometrics (757 landmarks), we quantify cranial variation in avian (n = 352) and non-avian dinosaurs (n = 47). We demonstrate that birds and non-avian dinosaurs have divergent distributions of variation (Procrustes variance) across the skull. Birds are most variable in the premaxilla and the frontal bone. The posterior and ventral skull regions including parietal, occipital, squamosal, and basicranium have low disparity and evolutionary rates. In contrast, the premaxilla of non-avian dinosaurs exhibits

low disparity and evolutionary rates, with the jugal bone and the temporal fenestrae being the most variable. These results suggest that cranial variation in non-avian dinosaurs is driven primarily by modifications of the adductor chamber and the geometry of jaw musculature in response to evolution in feeding ecology, whereas birds primarily modify the rostrum to accommodate different foraging behaviours. This difference is likely due to a combination of factors, including the increased contribution of the premaxilla to the facial skeleton in birds and increased priority of the brain over jaw musculature for utilizing available space in the braincase. We also compare the slope of the empirical rate/disparity relationship to that of a null model derived from Brownian motion simulations to understand which structures are characterized by high convergence across dinosaur groups. Among birds, the anterior face shows low convergences, achieving high disparity relative to rate of evolution. Non-avian dinosaurs exhibit higher convergence in these regions, perhaps as a consequence of the repeated acquisition of herbivory and edentulism. Together, these findings demonstrate the importance of intrinsic factors on shaping the direction and magnitude of phenotypic evolution and the diversification of majorclades.

Technical Session X (Friday, October 19, 2018, 11:00 AM)

MERCURY CHEMOSTRATIGRAPHY AS A DISTAL INDICATOR OF DECCAN VOLCANISM RECORDED IN THE HELL CREEK REGION, MONTANA

FENDLEY, Isabel M., UC Berkeley, Berkeley, CA, United States of America; SPRAIN, Courtney J., University of Liverpool, Liverpool, United Kingdom; MARVIN-DIPASQUALE, Mark, United States Geological Survey, Menlo Park, CA, United States of America; RENNE, Paul R., Berkeley Geochronology Center, Berkeley, CA, United States of America; TOBIN, Thomas S., University of Alabama, Tuscaloosa, AL, United States of America; WEAVER, Lucas N., University of Washington, Seattle, WA, United States of America

The mass extinction at the Cretaceous–Paleogene boundary (KPB) coincided with a period of major environmental change, due in part to the Chicxulub bolide impact. However, other climatological and ecological changes, such as pre-boundary climate change and the slow post-boundary recovery, have been tentatively attributed to the boundary-spanning Deccan Traps (DT) volcanism. Despite significant progress directly dating the DT with radioisotopic techniques, we still lack knowledge of the timing and pacing of the individual DT eruptions at a resolution comparable to environmental records. Mercury (Hg) has been proposed as a tracer of large-scale volcanism, since eruptions are its primary non-anthropogenic source and it is capable of global dispersion and deposition in sedimentary environments. Therefore, measurements of Hg concentration in sedimentary rocks can allow a direct comparison of eruption timing with biological or paleoenvironmental records.

We have assembled Hg chemostratigraphy in the Hell Creek region (HCR) of Montana, where a high-resolution chronostratigraphy through the KPB extinction and recovery interval has been established. The HCR's extensive paleontological and paleoclimatological records show several climatic and biotic changes both pre- and post-KPB in addition to the extinction event. The DT eruptions occurred in a one million year window spanning the K–Pg boundary, which has been correlated to the HCR using magnetostratigraphy (C29R) and radioisotopic data. We directly compare this Hg record, one of the first from a terrestrial environment, with the climatic and biotic data, explicitly testing the link between terrestrial faunal changes and volcanism in the KPB interval.

Hg concentration data spanning this interval reveal several peaks which suggest distinct eruptive events, as well as elevated (~2x) Hg background relative to post-DT time. The multiple large (~3x background) peaks in Hg include one within centimeters of the KPB, as well as several in the early Paleogene, and are uncorrelated with organic carbon deposition. Our data suggest several large DT eruptive intervals immediately post-KPB, with ongoing volcanic activity through the interval, making it very likely that DT volcanism influenced ecological recovery rates.

Grant Information

Funding provided by an NSF Graduate Research Fellowship, NSF grant EAR1615203, and the Esper S. Larsen Fund.

Technical Session X (Friday, October 19, 2018, 12:00 PM)

IMPLICATIONS OF C_4 PLANTS TO FAUNAL ADAPTATIONS DURING THE EARLY TO MIDDLE MIOCENE IN NORTH AMERICA

FERANEC, Robert S., New York State Museum, Albany, NY, United States of America; PAGNAC, Darrin C., South Dakota School of Mines and Technology, Rapid City, SD, United States of America; CROWLEY, Brooke E., University of Cincinnati, Cincinnati, OH, United States of America; MAGUIRE, Kaitlin C., Caldwell, ID, United States of America; DESANTIS, Larisa G., Vanderbilt University, Nashville, TN, United States of America

The Great Transformation during the Miocene of North America, as described by G.G. Simpson, is marked by the spread of grasslands and the coincident evolution of adaptations by mammals adjusting to this new habitat. Previous isotopic investigations have suggested that the expansion of these grasslands solely involved taxa that utilized the C_3 photosynthetic pathway, and that it wasn't until the Rapid Increase in C_4 Ecosystems (RICE; ~7 Ma) that C_4 grasslands spread in North America. The absence of C_4 taxa in grasslands during the Great Transformation implies that C_4 plants, and their unique characteristics such as bundle sheath cells, were not a selective agent for coeval faunal adaptations. Interestingly, genetic analyses of C_4 plants have shown they evolved much earlier than the RICE. Further, recent investigations examining phytoliths assert localized presence of C_4 plants at a few locations in North America during the Great Transformation interval. Here, we examine hundreds of published and unpublished carbon stable isotope ($\delta^{13}C$) values from equid tooth enamel from the early to middle Miocene of North America to explore the implications of the presence and distribution of C_4 plants prior to the RICE. Equids were the archetypal taxon for the Great Transformation and are known to consume representative proportions of grass within ancient ecosystems that can be evaluated by analyzing tooth enamel $\delta^{13}C$ values. To critically evaluate the data, we created conservative baselines for identifying the presence of C_4 plants grounded on isotopic values observed in modern grassland ecosystems corrected for atmospheric isotopic differences observed at specific times in the geologic past. Examination of the horse $\delta^{13}C$ values indicates that C_4 plants were conclusively present and accounted for up to about 20% of the diet of equid taxa in southern California during the Barstovian Land Mammal Age (~14 Ma). While these data show that equids in other regions across North America, outside of southern California, did not consume C_4 plants during this period, the confirmed, albeit limited, presence of C_4 vegetation in equid diets requires that C_4 taxa be considered as a selective agent for the evolutionary changes observed in mammals during the Great Transformation.

Podium Symposium (Friday, October 19, 2018, 10:30 AM)

UNRAVELING THE EVOLUTIONARY HISTORY OF THE AVIAN BRAIN THROUGH BEHAVIORAL NEUROIMAGING

FERRER, Elizabeth A., Stony Brook University Hospital, Stony Brook, NY, United States of America; SALERNO, Michael, Stony Brook University Hospital, Stony Brook, NY, United States of America; WEI, Shouyi, Stony Brook University Hospital, Stony Brook, NY, United States of America; GAO, Wenrong, Stony Brook, NY, United States of America; LI, Xiang, Stony Brook, NY, United States of America; VASKA, Paul, Stony Brook University Hospital, Stony Brook, NY, United States of America; BALANOFF, Amy, Johns Hopkins University, Baltimore, MD, United States of America

Despite intense research, there is still much to learn about the evolution of birds, one of only three vertebrate groups to achieve powered flight. Most research has focused on the postcranial skeleton and appendages during the transition from non-avian dinosaurs to birds, but modifications of the neuroanatomical architecture are also expected. Recent work identified neuroanatomical features considered important for flight, such as a Wulst, in avian relatives like *Archaeopteryx*. However, little is known of the neurological processing necessary for flight. In our research, we aim to understand the evolution of the avian brain using a combination of diffusible iodine-based contrast-enhanced computed tomography and positron emission tomography (PET) using ^{18}F-fluorodeoxyglucose (FDG) in extant birds. This work identifies neuroanatomical nuclei most active during behaviors including flight because FDG builds in regions of high metabolic activity. Initially, we injected FDG into anesthetized starlings and pigeons and then performed dynamic PET imaging starting at injection using the Inveon PET/CT system to study biodistribution and kinetics. As a fraction of injected dose, the brain reached a concentration 0.5% per cc on average which is similar to rats and we found that peak brain uptake of FDG occurs at around 15 minutes. In the flight study, each pigeon was injected with FDG and then prompted to fly between pedestals for 10 minutes followed by anesthesia and PET/CT imaging. Each bird was also imaged in a baseline (non-flight) conditions for pairwise analysis. Areas of the brain associated with visual pathways increased in activity during flight, and surprisingly the somatosensory Wulst, which indicate the importance of analyzing separate areas of neural pathways. We also found that flight resulted in differential activation among cerebellar lobes, which are the main motor centers associated with specific anatomical regions. Our future plans include expanding this methodology to additional birds to determine if and how activity patterns vary across Aves, providing a firmer foundation for determining the neurological capabilities necessary for powered flight. By studying the nuclei that are active during flight and their accompanying surficial anatomy, we hope to gain insight into the form and function of these anatomical structures in deep time.

Grant Information

National Science Foundation

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

PRESERVATION AND RESTORATION OF THE PALEOICHNOLOGICAL SITE "LA VIRGEN DEL CAMPO" IN ENCISO, LA RIOJA, SPAIN

FERRER VENTURA, Mireia, University of La Rioja, Valencia, Spain; TORICES, Angelica, University of La Rioja, Madrid, Spain; SAN JUAN PALACIOS, Raúl, University of Valencia, Valencia, Spain; NAVARRO-LORBÉS, Pablo, University of La Rioja, Logroño, Spain

La Rioja (Spain) has one of the best paleoichnological fossil records in the world, with almost 10,000 dinosaur footprints and around 1,000 trackways. One of the best-known sites is La Virgen del Campo, found in the Enciso locality (La Rioja, Spain). In this work, we show the preservation and restoration labors made in the summer of 2017, three years after the last field campaign.

Our first action was to complete a preliminary study of the site, locating all the points that needed intervention, and evaluating its preservation state. All the preservational concerns observed at these locations were cataloged. Secondly, all the intervention techniques used in the previous campaigns (focusing on the protocols and materials) were analyzed and the possible problems that these actions could have caused to the site. In the previous campaigns, synthetic mortars, cement, and epoxy resins were used. These materials caused color changes, stone acidification, and saline efflorescences. Finally, an intervention proposal for the 2017 campaign was done, focused on the most important needs of the site. Restoration was focused on two main points: the removal of the excess of sediment and dust (allowing us to know the real preservation state of the site) and the removal of the interventions applied in previous campaigns (which were deteriorating the site).

The inadequacy of the previously used materials and methods to the particular needs of the sites justify changing the way restoration and preservation is done in this site. Due to the lack of a clear convention on the matter, we propose for the following field campaigns the convention of the COREMANS (Intervention Criteria for Earthen Architecture) project of 2012 for the stone material intervention. This kind of intervention preserves the preservation and the integrity of the site.

It is necessary to discard the materials that have been systematically used in the site, because they are not only obsolete, but also harmful for the fossil tracks and for the site itself. We propose the use of more stable materials like natural mortars, and changes in the fieldwork dynamics. These changes will guarantee not only long-term conservation, but also they will minimize the loss of information during excavation and the subsequent consolidation of the fossils obtained.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE DIET OF CF. *HYRACODON* SP. (PERISSODACTYLA, HYRACODONTIDAE) FROM THE RANCHO GAITÁN LOCAL FAUNA, LATE EOCENE (CHADRONIAN) OF CHIHUAHUA, NORTHERN MÉXICO, INFERRED FROM CARBON AND OXYGENE STABLE ISOTOPE RELATIONSHIPS

FERRUSQUIA VILLAFRANCA, ISMAEL, Instituto de Geología, Universidad Nacional Autónoma de México, MEXICO, Mexico; PÉREZ-CRESPO, VÍCTOR ADRIAN, Instituto de Geología, Universidad Nacional Autónoma de México, MEXICO, Mexico; RUIZ-GONZÁLEZ, JOSÉ E., Instituto de Geología, Universidad Nacional Autónoma de México, MEXICO, Mexico; MORALES-PUENTE, PEDRO, Instituto de Geología, Universidad Nacional Autónoma de México, MEXICO, Mexico; CIENFUEGOS-ALVARADO, EDITH, Instituto de Geología, Universidad Nacional Autónoma de México, MEXICO, Mexico

The study of the fossil mammals of México still hinges on alpha taxonomy (essential for a better understanding of its complex faunistic and geologic makeup and evolution). However, some faunas and taxa are becoming well known and are available for other kinds of studies (such as inferring their dietary habits by means of enamel $^{13}C/^{12}C$ and $^{18}O/^{16}O$ isotopic relationship analysis, as intended here). One such is the Rancho Gaitán local fauna, a small but significant vertebrate assemblage from the Chadronian (late Eocene) Prietos Formation of northeastern Chihuahua at 29°40'-29°57' N Lat. and 104°39'-104°49' W Long.

The Prietos Formation is the lowest unit of the local Cenozoic volcaniclastic sequence, unconformably rests on a Cretaceous, sedimentary marine basement, and consists of an up to 245 m thick succession formed by four members: Basal Conglomerate (18 m thick, calcilithitic), Lower Tuff (122 m thick, felsic, interbedded by laharic breccias), Upper Tuff (73 m thick, felsic, with abundant fresh-water gastropods and mammalian remains), and Upper Conglomerate (36 m thick, calcilithitic). This formation correlates with the Chambers Tuff of West Texas, which locally underlies the Bracks Rhyolite, K-Ar dated as 37 Ma BP, thus affording a minimum age for both units. The Prietos is overlain by basaltic flows, in turn covered by the ?Mitchell Mesa Rhyolite, an ignimbrite K-Ar dated as 32 Ma. Some andesitic flows and bolson deposits unconformably cover the preceding units and complete the sequence.

The hyracodonts are medium-sized rhinocerotoid cursorial mammals that roamed North America mostly during the middle Eocene and survived (one genus) to the early Oligocene. The Chadronian Rancho Gaitán local fauna of western Chihuahua includes cf. *Hyracodon* sp. that is here used to detect its dietary habits by means of carbon and oxygen isotopic relationships of the enamel. To evaluate the degree of enamel diagenesis, we performed an FTIR analysis of it, obtaining a carbonate 2.85%, which indicates no alteration, thus rendering the isotopic values reliable. The $\delta^{13}C$ value is -8.3‰ and the $\delta^{18}O$ value is -3.4‰, indicating that this taxon had a C3/C4 mixed diet, with an important C3 plant intake (in spite of its lophodont pattern), and lived in a woodland/savanna environment, as is also reported for similar taxa of the White River Group.

Grant Information

The field work was supported by the John Simon Guggenheim Foundation and the isotopic analysis by the Instituto de Geología, UNAM, and the Grant PAPIIT IA104017 (also from UNAM).

Technical Session VII (Thursday, October 18, 2018, 3:00 PM)

COMPLETE *ICHTHYORNIS* SKULL ILLUMINATES MOSAIC ASSEMBLY OF THE AVIAN HEAD

FIELD, Daniel, University of Bath, Bath, United Kingdom; HANSON, Michael, Yale University, New Haven, CT, United States of America; BURNHAM, David A., University of Kansas, Lawrence, KS, United States of America; WILSON, Laura E., Fort Hays State University, Hays, KS, United States of America; SUPER, Kristopher J., University of Kansas, Wichita, KS, United States of America; EHRET, Dana J., New Jersey State Museum, Trenton, NJ, United States of America; EBERSOLE, Jun A., McWane Science Center, Birmingham, AL, United States of America; BHULLAR, Bhart-Anjan S., Yale University, New Haven, CT, United States of America

The skull of living birds is greatly modified from the condition found in their dinosaurian antecedents. Bird skulls have an enlarged, toothless premaxillary beak and an intricate kinetic system that includes a mobile palate and jaw suspensorium. The expanded avian neurocranium protects an enlarged brain and is flanked by reduced jaw adductor muscles. However, the order of appearance of these features and the nature of their earliest manifestations remain unknown. The Late Cretaceous toothed avialan *Ichthyornis dispar* sits in a pivotal phylogenetic position outside crown bird diversity: it is close to the extant avian radiation but retains numerous ancestral characters. Although its evolutionary importance continues to be affirmed, no substantial new cranial material of *I. dispar* has been described beyond incomplete remains recovered in the 1870s. Jurassic and Cretaceous Lagerstätten have yielded important avialan fossils, but their skulls are typically crushed and distorted. Here we report four three-dimensionally preserved specimens of *I. dispar*—including an unusually complete skull—as well as two previously overlooked elements from the Yale Peabody Museum holotype, YPM 1450. We used these specimens to generate a nearly complete three-dimensional reconstruction of the *I. dispar* skull using high-resolution computed tomography. Our study reveals that *I. dispar* had a transitional beak—small, lacking a palatal shelf and restricted to the tips of the jaws—coupled with a kinetic system similar to that of living birds. The feeding apparatus of extant birds therefore evolved earlier than previously thought and its components were functionally and developmentally coordinated. The brain was relatively modern, but the temporal region was unexpectedly dinosaurian: it retained a large adductor chamber bounded dorsally by substantial bony remnants of the ancestral reptilian upper temporal fenestra. This combination of features documents that important attributes of the avian brain and palate evolved before the reduction of jaw musculature and the full transformation of the beak.

Grant Information

NSF DDIG DEB 1500798, Wetmore Memorial Research Award, YIBS, Stephen J. Gould Award, Evolving Earth Foundation, Chapman Ornithological Research Grant

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

REDESCRIPTION AND PHYLOGENETIC ANALYSIS OF *BRAZILICHTHYS MACROGNATHUS* (OSTEICHTHYES, ACTINOPTERYGII) FROM THE EARLY PERMIAN OF BRAZIL

FIGUEROA, Rodrigo T., Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil; FRIEDMAN, Matt, University of Chicago, Oxford, United Kingdom; GALLO, Valéria, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

The South American record of Paleozoic actinopterygians is sparse and mostly composed of isolated scales and dermal bones. However, some articulated Permian specimens are known, mostly from the Paraná Basin in southern Brazil (e.g., *Santosichthys mafrensis*, *Rubidus pascoalensis*, *Roslerichthys riomafrensis*, *Angatubichthys mendesi*). *Brazilichthys macrognathus* is the only formally described species from the Paleozoic sediments of the Pedra de Fogo Formation (Permian, Cisuralian) of the Parnaíba Basin, in northeastern Brazil. Represented only by a single three-dimensionally preserved skull, *Brazilichthys* is incompletely described. We used X-ray microtomography (µ-CT) to better document its anatomy and phylogenetic affinities. µ-CT reveals parts of the internal skeleton including the palatoquadrate, parasphenoid, and branchial apparatus. Our models showed that some bones were misidentified in the original description, such as the dermosphenotic, which was incorrectly interpreted as part of the sclerotic ring. These reinterpretations, together with new data on significant features previously concealed by matrix, permitted a preliminary phylogenetic analysis. A maximum parsimony analysis of anatomical data resolves *Brazilichthys* as a stem actinopterygian, crownward of all Devonian species. This placement is supported by a dermosphenotic with distinct posterior ramus and the presence of dermal basipterygoid process. A mixture of derived (e.g., more than two infraorbitals) and primitive (e.g., premaxilla contributing to orbital margin). We therefore reject previous interpretations of *Brazilichthys* as a relative of Birgeriidae, a Triassic group consistently placed within the actinopterygian crown. *Brazilichthys* is more similar to genera such as the Triassic *Pteronisculus* based on parasphenoid morphology and arrangement of the circumorbital series. It also bears distinct extralateral gulars as in the Carboniferous *Wendyichthys* and *Beagiscus*. The morphology of *Brazilichthys* and our phylogenetic analysis indicate that despite its considerable similarities to other Permo-Carboniferous taxa, it is sufficiently distinctive to be retained in its own family (Brazilichthyidae, new usage), as originally proposed.

Grant Information

The first author receives Msc Fellowship from the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Capes) (Proc: 1683216)

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

SMALL MAMMALS OF THE CROOKED RIVER MASCALL FORMATION

FINKELMAN, Leonard, University of Oregon, Eugene, OR, United States of America; BARRETT, Paul Z., University of Oregon, Eugene, OR, United States of America; PERDUE, Genevieve, University of Oregon, Eugene, OR, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America

The Mascall Formation from the Crooked River Basin in central Oregon yields remains of a diverse late Hemingfordian mammalian fauna that differs in both species composition and abundance from the well-described type area in the John Day Basin. Following description of the assemblage from the Hawk Rim locality, ongoing collections in the area—including screenwashing in the nearby Cave Basin anthill localities—added new occurrences. Recent field collections have led to the discovery of several small-bodied members of the Carnivora. This new material includes four carnivorans previously unknown from this formation, two of which constitute new species. These are the earliest appearance in Oregon of *Leptocyon leidi*, a fox-sized canid; the procyonid *Bassariscus minimus*, previously known only from the early Barstovian of Nebraska; a new fossil member of the Mustelidae; and a new species in the feliform genus *Cryptailurus*. By comparison with contemporaneous carnivorans both from central Oregon and other localities, these specimens provide evidence for Oregon as a critical gateway to early Miocene carnivoran migration from Asia to North America as well as for niche partitioning within Oregon's Miocene terrestrial ecosystem.

Technical Session X (Friday, October 19, 2018, 8:30 AM)

COMPARATIVE VERTEBRATE ICHNOLOGY, SEDIMENTOLOGY, AND PALEOPRECIPITATION BETWEEN TWO CRETACEOUS HIGH-LATITUDE NON-MARINE ECOSYSTEMS (NANUSHUK FORMATION, CENOMANIAN, AND CHIGNIK FORMATION, CAMPANIAN–MAASTRICHTIAN), ALASKA

FIORILLO, Anthony R., Perot Museum of Nature and Science, Dallas, TX, United States of America; MCCARTHY, Paul, University of Alaska, Fairbanks, AK, United States of America; KOBAYASHI, Yoshitsugu, Hokkaido University Museum, Sapporo, Japan; TANAKA, Tomonori, Hokkaido University Museum, Sapporo, Japan; TAKASAKI, Ryuji, Hokkaido University Museum, Sapporo, Japan; TSOGTBAATAR, Chinzorig, Mongolian Academy of Sciences, Ulaanbaatar-15160, Mongolia; SUAREZ, Marina B., The University of Texas at San Antonio, San Antonio, TX, United States of America; SHIMER, Grant, Southern Utah University, Cedar City, UT, United States of America; TYKOSKI, Ronald S., Perot Museum of Nature and Science, Dallas, TX, United States of America

Here we broadly compare aspects of two non-marine Cretaceous ancient high-latitude ecosystems separated in time and geography. On the western North Slope, the Nanushuk Formation is comprised of a basal interval of dominantly shallow marine sandstone that is gradationally overlain by marginal marine to nonmarine conglomerate, sandstone, mudstone and coal. New ash dates (97–98 Ma) constrain the studied interval to the Cenomanian. In southwestern Alaska, the Chignik Formation is a cyclic succession of sedimentary rocks representing shallow marine environments in the lower part and predominantly non-marine conglomerate, sandstone, mudstone and coal in the upper part. Biostratigraphic data constrain this rock unit to the Campanian-Maastrichtian boundary. Both rock units now record an abundance of vertebrate trace fossil sites (Nanushuk Formation, n=72; Chignik Formation, n=54) that include evidence of non-avian and avian theropods, and both quadrupedal and bipedal ornithischians. The relative frequencies of tracks attributable to each of these four clades of dinosaurs for the Nanushuk Formation

are 8%, 14%, 17%, and 61% respectively. In contrast, for the Chignik Formation these relative frequencies are 4%, 2%, 4%, and 90%.
Woody fragments from the Nanushuk Formation and the Chignik Formation were measured for their carbon isotopic composition to relate delta ^{13}C to mean annual precipitation. The samples from the Nanushuk Formation averaged -26.4‰ vs. VPDB, while the single sample analyzed from the Chignik Formation was -24.0‰ vs. VPDB. The Chignik Formation sample suggests a MAP values of 822 mm/year, whereas the Nanushuk Formation averaged 1412 mm/year. The data suggests that precipitation was greater on the Arctic North Slope during the mid-Cretaceous than the Late Cretaceous of southwestern Alaska. Relative rates of precipitation may have had a significant role in broadly structuring each ecosystem. Further, this pattern of increased precipitation in the mid- Cretaceous is regionally consistent with the global pattern associated with the Cretaceous Thermal Maximum.
Grant Information
Funding for this work was provided by the Perot Paleo Club, the Explorers Club and the National Park Service.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

NEW MATERIAL FROM THE POPO AGIE FORMATION OF WYOMING YIELDS INSIGHTS INTO BASAL PHYTOSAURS AND THE LATE CARNIAN FAUNA OF THE WESTERN U.S.A.

FITCH, Adam J., University of Wisconsin-Madison, Madison, WI, United States of America; KUFNER, Aaron M., UW-Madison Geology Museum, Madison, WI, United States of America; STOCKER, Michelle R., Virginia Polytechnic Institute and State University, Blacksburg, VA, United States of America; PRICE, Brandon R., UW-Madison Geology Museum, Madison, WI, United States of America; LOVELACE, David, UW-Madison Geology Museum, Madison, WI, United States of America
The Popo Agie Formation (Chugwater Group) records some of the oldest and northernmost Upper Triassic faunas in the western United States, including early-diverging loricatans, poposaurids, latiscopids, metoposaurids, dicynodonts, and phytosaurs. Understanding the paleoecology of the Popo Agie and its relationships to other Upper Triassic faunas is integral to the study of the Triassic of North America as a whole. We describe two phytosaur crania from the Popo Agie Formation in Fremont County, WY, (UWGM 1978 and FMNH PR 130) in order to shed light on Popo Agie phytosaur diversity and paleoecology. We include these new specimens along with all known Wyoming phytosaur material (*Angistorhinus* and *Parasuchus*) in a phylogenetic analysis of North American phytosaurs. Our preliminary results place UWGM 1978 and FMNH PR 130 basal to *Parasuchus bransoni*, '*Paleorhinus*' *sawini*, and Mystriosuchinae among early-diverging phytosaurs such as *Wannia scurriensis* from the pre-Tecovas strata of the lowest unit of the Dockum Group in Texas. These two specimens share synapomorphies with *Wannia* including: external nares terminating anterior to the antorbital fenestrae, the lateral extent of the basitubera being even with the basipterygoid processes, and an elongated suborbital foramen. The presence of an elongated suborbital foramen, a relatively short, robust rostrum, and large, bluntly-conical teeth are hypothesized to be adaptations for powerful biting, more similar to extant *Crocodylus* species than to *Gavialis*, the traditionally-proposed modern analog of longirostrine phytosaurs like *Angistorhinus*. The co-occurrence of these two morphotypes suggests niche partitioning among the phytosaurs of the Popo Agie. The placement of UWGM 1978 and FMNH PR 130 among non-mystriosuchine phytosaurs such as *Wannia* aligns with the high degree of taxonomic overlap between the Popo Agie Formation and pre-Tecovas strata in supporting a shared or similar fauna between the two units.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

INCREASING COMPLEXITY IN AN EXCEPTIONALLY LARGE POPULATION OF *AZTLANOLAGUS* (MAMMALIA, LEPORIDAE) FROM THE PLEISTOCENE OF COLORADO

FLORA, Geoffrey W., Denver Museum of Nature & Science, Denver, CO, United States of America; MACKENZIE, Kristen, Denver Museum of Nature & Science, Denver, CO, United States of America
Porcupine Cave is an exceptionally rich deposit of high altitude mammals. The cave is located within a montane basin in central Colorado and contains 27 unique localities. Preliminary dating suggests an Irvingtonian, or middle Pleistocene age for the majority of the deposits. The remains of leporids dominate many of the localities within the cave. This assemblage of leporids found within the cave differs significantly from the modern fauna present in the basin today. Excavations from the Denver Museum of Nature & Science have produced multiple localities were at least four extinct taxa are present, including *Aztlanolagus* sp., *Brachylagus coloradensis*, and *Hypolagus* spp., and are all found concurrent with the living genera of *Lepus* spp. and *Sylvilagus* spp. Recent efforts to curate previously unidentified material has yielded an abundance of fossil material attributed to *Aztlanolagus* sp. from the Mark's Sink (DMNH 1349) locality. Mark's Sink is unique in containing a large proportion of Blancan land mammal aged taxa. Remains of the Aztlan rabbit are remarkably abundant within Mark's Sink, but are extremely rare across many of the cave's other localities. *Aztlanolagus* is a diminutive leporid that formerly inhabited the Southwestern United States and Northern Mexico during the Quaternary period. Morphometric analyses from the Mark's Sink material reveals a trend in increasing size and enamel band complexity in the Porcupine Cave population of *Aztlanolagus*. Significant dental variations observed within this large population cautions specific taxonomic identification using currently described characters. While the origins and ecology of *Aztlanolagus* remains obscure, the considerable decrease of leporid diversity, including *Aztlanolagus* from higher stratigraphic levels of Porcupine Cave, supports a climatic shift from a wetter early Pleistocene to a dryer middle Pleistocene within the intermontane basins of Colorado.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

ANTILOCAPRID BEHAVIORAL INFERENCES FROM HEADGEAR MORPHOLOGY

FLORA, Holley M., University of Oregon, Springfield, OR, United States of America; DAVIS, Edward Byrd, University of Oregon, Eugene, OR, United States of America
Artiodactyls are known for their diverse headgear shapes. The shape of their horns, pronghorns, ossicones, and antlers play key roles in how they interact with their environment and each other. In extant families, these shapes can be categorized with body size to predict interspecies behavior and mating systems. For example, larger, recurved horns are typical of gregarious, large-bodied animals that fight for mates. Smaller spike-like horns are more characteristic of small-bodied, paired mates that live in closed environments. This headgear diversity has been traditionally utilized to diagnose extinct representatives of artiodactyls, as exemplified by the antilocaprids. Consequently, for Antilocapridae, evolutionary relationships have primarily been inferred using characters from the cores of their headgear, combined with body size. Here we report a cladistic revision that recovers a hypothesis of Antilocapridae relationships at the genus level, testing prior hypotheses of their evolutionary relationships. Post-cranial, cranial, and headgear characters were utilized, expanding the basis of inferences of evolutionary relationships beyond simple headgear evolution. A phylogenetic analysis not only establishes ancestral headgear morphology, but allows clarification of when behavioral changes took place. Antilocaprids becoming more gregarious and widespread into herds from small more monogamous pairs has been inferred through comparison to other families of artiodactyls, but we are now able to find separate independent evolutions of this evolutionary trajectory within the clade. Preliminary analyses show *Ramoceros* and *Merycodus* diverging from other Merycodontines (*Merriamoceros*, *Paracosoryx*, etc.). *Plioceros* also groups more basally, placing it with previously hypothesized Merycodontines. With larger body size and outward facing complex horns, we suggest that *Ramoceros* and *Merycodus* were early to evolve head to head fighting for limited food sources.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

UNDERSTANDING THE FACTORS UNDERLYING GROWTH VARIATION IN THE THEROPOD DINOSAUR *ALLOSAURUS FRAGILIS*

FLORES, Adrian, Adelphi University, Bethpage, NY, United States of America; D'EMIC, Michael, Adelphi University, Stony Brook, NY, United States of America
Allosaurus is a common large bodied theropod dinosaur from the Late Jurassic Morrison Formation of the western United States. Histologically, it is one of the most extensively sampled dinosaurs. There are two to three species of *Allosaurus* currently recognized by most authors; *A. fragilis*, *A. maximus,* and a third species from Dinosaur National Monument. Histological samples of *A. fragilis* originate from a single locality, the Cleveland-Lloyd Dinosaur Quarry of Utah. Within just this single sample of *A. fragilis,* a nearly eight-fold range in asymptotic body mass and corresponding diversity of maximum annual growth rates has been reported. In contrast, nothing is known about the growth of *A. maximus* or the unnamed species. Several hypotheses exist to explain the dramatic growth variation observed in *A. fragilis*, including hidden taxonomic differences and intraspecific variation related to sex, geography, or time. We test these hypotheses by increasing the histological dataset of *Allosaurus*, sampling several more specimens with a wide spatiotemporal distribution. Our preliminary analysis includes two specimens from the Morrison Formation of northern Wyoming. Both specimens have reached their asymptotic body masses and display a similarly broad range of mass and growth rates as has been observed in the Cleveland-Lloyd sample, suggesting that this disparity characterizes *Allosaurus* in general. Increased sampling will allow us to further differentiate among the hypothesized factors underlying the substantial growth variation observed in *Allosaurus*.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

REASSESSMENT OF THE MORPHOLOGY AND TAXONOMIC STATUS OF THE VARANID LIZARD *SANIWA ORSMAELENSIS* FROM THE EARLY EOCENE OF NORTHWEST EUROPE

FOLIE, Annelise, Royal Belgium Institute of Natural Sciences, Brussels, Belgium; AUGÉ, Marc L., Muséum national d'Histoire naturelle, Paris, France; SMITH, Richard, Royal Belgium Institute of Natural Sciences, Brussels, Belgium; PHÉLIZON, Alain, Reims, France; GIGASE, Paul, Berchem, Belgium; SMITH, Thierry, Royal Belgium Institute of Natural Sciences, Brussels, Belgium
Saniwa is an extinct genus of varanid lizard from the Eocene of North America and Europe. It is the sister taxon to the crown-group *Varanus*. Up to now, only one poorly known species is recognized from Europe, *Saniwa orsmaelensis* from the earliest Eocene of Dormaal, Belgium. This species originally named by Louis Dollo nearly a century ago, is the earliest varanid of Europe. Unfortunately, the material was limited to vertebrae with only preliminary description and no figure provided, except for one dorsal vertebra that later has been designated as the lectotype. Here we describe and illustrate new fossil specimens collected from Dormaal and other early Eocene localities of the Paris Basin, France, including dentary and maxilla fragments as well as skull material, allowing to reassess the validity of the European taxon. These fossils allow further comparisons with the type-species, *Saniwa ensidens*, from the late early Eocene Bridger and Green River formations of Wyoming and to propose a new diagnosis for *S. orsmaelensis*. The occurrence of *S. orsmaelensis* is restricted to the early Eocene of Northwest Europe and its geographic origin is unresolved because the earliest record of *Saniwa* in North America is also from the earliest Eocene. The brief presence of varanid lizards in the European Paleogene could result from two major climatic events. At the Paleocene Eocene Thermal Maximum, large biotic interchanges occurred in the northern hemisphere allowing new dispersals into Europe. However, at the end of the Eocene, thermophilic lizards disappeared due to cooler conditions. Another hypothesis for their disappearance could be the competition that occurred with other anguimorph lizards.
Grant Information
This abstract is a contribution to the Belspo Brain network project BR/121/A3/PalEurAfrica funded by the Belgian Science Policy Office.

Technical Session XIX (Saturday, October 20, 2018, 2:15 PM)

DENTAL HISTOLOGY OF THE DICYNODONT *LYSTROSAURUS*

FONG, Raymond KM, University of Hong Kong, Pokfulam, Hong Kong (CN); LEBLANC, Aaron, University of Alberta, Edmonton, AB, Canada; REISZ, Robert R, University of Toronto at Mississauga, Mississauga, ON, Canada; KAYE, Thomas G, Foundation for Scientific Advancement, Sierra Vista, AZ, United States of America; SIDOR, Christian A, University of Washington, Seattle, WA, United States of America; PITTMAN, Michael, University of Hong Kong, Pokfulam, Hong Kong (CN); LAFLAMME, Marc, University of Toronto at Mississauga, Mississauga, ON, Canada

Dental paleohistological studies are an excellent source of otherwise unobtainable data on the dentition of extinct taxa. These data can be used to enhance our understanding of the function and evolution of teeth and reconstruct their life history.

The tusks from three juvenile to subadult specimens of the dicynodont *Lystrosaurus* are examined here through histological thin sections to analyze their composition, implantation mode, and replacement pattern. Our findings indicate that *Lystrosaurus* possesses dental tissues common to all amniotes, have tusks that are deeply implanted in a soft-tissue-lined tooth socket akin to mammals (including humans), and lack any form of dental replacement. In contrast, an earlier dicynodont, *Diictodon*, has tusks fused to their tooth sockets and shows the signs of at least one replacement cycle. Previous work also established that tusks are sexually dimorphic in *Diictodon* but not *Lystrosaurus*. This hints at functional differentiation in these animals during the Permian that should be investigated further.

In an effort to develop palaeohistological methodology, Laser-Stimulated Fluorescence, an imaging technique that has revealed unseen soft tissue structures in macrofossils, is used here in a paleohistological context for the first time. It was determined to have utility in identifying dental structures, including ones that were otherwise difficult to see.

Grant Information

University of Toronto Faculty of Arts and Science Tuition Fellowship (RKMF); University of Hong Kong Postgraduate Scholarship (RKMF); Jurassic Foundation Award(RKMF)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ASIAN ANCESTRY FOR NORTH AMERICA'S LARGEST ANKYLOSAUR, *ANKYLOSAURUS*?

FORD, Tracy L., Dino Hunter, Poway, CA, United States of America

Ankylosauria consists of three major clades: polocanthids, nodosaurids, and ankylosaurids. Several researchers have shown that the armor/scute/osteoderms of ankylosaurs are morphologically diagnostic. This identification aids in reconstructing ankylosaur taxonomy and evolution. *Sauroplites,* an Early Cretaceous ankylosaur from China, has flat osteoderms with a ridge near its dorsal edge, and tightly packed, octangular, tightly packed pelvic osteoderms. These osteoderms are similar to the Late Cretaceous North American ankylosaurs *Ankylosaurus*, *Glyptodontopelta,* and *Stegopelta*. *Ankylosaurus* cervical osteoderms are diagnostic: flat, hollow, square osteoderms with a ridge on the dorsal edge; *Glyptodontopelta* osteoderms are smaller, with similar morphology. A partial skeleton from the Glenrock Paleontology Museum (Wyoming) has a nearly complete pelvic armor of an old adult *Ankylosaurus*. The specimen is referred to *Ankylosaurus* based on associated large flat osteoderms that is morphologically unique to *Ankylosaurus*. *Aletopelta*, *Stegopelta*, and *Glyptodontopelta* has been referred to the Nodosauridae. *Glyptodontopelta* has flat square osteoderms, similar in morphology to *Ankylosaurus* and *Sauroplites*. The only ankylosaurs with osteoderm morphology of a large, flat, hollow osteoderm are *Ankylosaurus*, *Glyptodontopelta*, *Aletopelta*, *Sauroplites,* and *Stegopelta.* They also have similar pelvic armor with octangular, tightly packed osteoderms. Because osteoderms are diagnostic, similar osteoderms indicate a linage for this clade. *Sauroplites* is the oldest member of this clade and is here considered to be an Asian ancestor for *Glyptodontopelta*, *Aletopelta*, *Stegopelta,* and *Ankylosaurus*. An Asian ancestry for North American ankylosaurs has also been previously suggested for *Nodocephalosaurus*, which is more similar to the Mongolian *Saichania*, than to the North American *Euoplocephalus*. A third group of Asian ankylosaurids in North America is the Shasmosaurinae, with *Cedarpelta* being the North American genus.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PETROGRAPHIC AND ISOTOPIC ANALYSIS OF PHYTOSAUR TOOTH DENTIN REVEALS ARIDIFICATION-RELATED TRENDS IN THE DIAGENETIC ENVIRONMENT OF THE CHINLE FORMATION

FORTNER, John D., Southern Methodist University, Dallas, TX, United States of America

The Upper Triassic (Norian; 228-208 Ma) Chinle Formation of Petrified Forest (PeFo) National Park spans a critical period in Earth's history, during which major tectonic breakup of Pangea coincided with profound changes in atmospheric circulation and faunal compositions. Declining mean annual precipitation estimates and increasing carbonate content from Chinle paleosols suggests a gradual regional aridification resulting from the collapse of the Late Triassic Megamonsoon. While isotopic studies of teeth provide a valuable paleoclimate proxy, studies frequently focus on tooth enamel reliability. Tooth dentin is often ignored in favor of enamel owing to the former's greater susceptibility to chemical alteration, under the presumption that dentin records a mostly diagenetic signal. However, dentin's sensitivity makes it excellent for studying early-stage diagenesis, which may reflect near-surface conditions. Phytosaur tooth dentin provides a means to investigate how diagenetic conditions changed through the Norian in western equatorial Pangea. Teeth from the lowermost Blue Mesa preserve enamel and exhibit primary cements of calcite and secondary cements of goethite and barite, indicating a range of oxidative and alkaline diagenetic conditions during fossilization. Teeth from the topmost Petrified Forest Member are most altered, exhibiting primary and secondary cements of calcite and barite, with large portions of dentin replaced by calcite or recrystallized apatite, suggesting a temporal trend toward more oxic and alkaline conditions by end Norian. Carbonate $d^{13}C_{PDB}$ values of dentin apatite (n=11) and apatite-calcite mixtures (n=18) range from -10.3 to -5.1‰ and -9.7 to -5.3‰ respectively, whereas $d^{18}O_{PDB}$ values range from -14.9 to -8.0‰ and -14.2 to-8.3‰, respectively. Analyses show long-term positive $\delta^{18}O_{PDB}$ and $\delta^{13}C_{PDB}$ trends similar to contemporaneous PeFo paleosol carbonates, suggesting a regional climate trend of Norian aridification. The onset of aridification coincides with a faunal turnover documented stratigraphically near a persistent red stratiform silcrete in the lower Jim Camp Wash Beds of the Chinle's Sonsela Member, a horizon that defines the boundary between the Adamanian and Revueltian biozones of the lower and upper Chinle in PeFo, respectively. A drastic decline in herbivore species' diversity and body size, as well as reorganization in phytosaur taxa, occurs across this boundary, suggesting the onset of water-stressed conditions in association with an aridification trend.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

REVISION OF THE METOPOSAURID TEMNOSPONDYLS FROM THE MIDDLE–LATE TRIASSIC OF MADAGASCAR, AND PALEOBIOGEOGRAPHICAL IMPLICATIONS

FORTUNY, Josep, Institut Català de Paleontologia M. Crusafont, Cerdanyola del Valles, Spain; ARBEZ, Thomas, Muséum national d'Histoire naturelle, Paris, France; MUJAL, Eudald, Institut Català de Paleontologia M. Crusafont, Cerdanyola del Valles, Spain; STEYER, Jean-Sébastien, Muséum national d'Histoire naturelle, Paris, France

Temnospondyls from Madagascar are mainly known from the Lower Triassic of the Ambilobe region (Ankitokazo basin). Younger temnospondyls are extremely scarce in Madagascar. To date, only one previous study described and figured metoposaurid specimens from the Middle–Late Triassic of Folakara (Northwestern Madagascar, Isalo Group, Morondava basin), which served to erect *Metoposaurus hoffmani*. Nonetheless, many other metoposaurid specimens from this locality were cited but not described nor figured. Herein, we describe these unpublished specimens from the MNHN (Paris, France) collections and revised the type material of *Metoposaurus hoffmani*, which actually does not present clear autapomorphies. These Malagasy metoposaurid specimens reveal in contrary interesting affinities with other metoposaurid Gondwanian taxa, notably those from India: this leads to interesting paleobiogeographical implications in term of metoposaurid distribution during the Middle–Late Triassic.

Grant Information

Thanks to CERCA program (ICP) and to the research project (CGL2017-82654-P), financed by AEI/FEDER EU.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

GEOETHICS IN THE FIELD: BEST PRACTICES FOR INTEGRATING ETHICAL PRINCIPLES INTO PALEONTOLOGICAL FIELDWORK

FOSS, Scott E., Bureau of Land Management, Washington, DC, United States of America

As outdoor field professionals paleontologists have a responsibility to not only use appropriate scientific methodology, but also to behave as good stewards of the land upon which they work. As educators paleontologists also have a responsibility to teach others how to conduct themselves professionally. Ethical field study concerns all of the uses and values of the lands, not only their value as a paleontological field laboratory. As a society, land use values shift over time and so perceptions and expectations of what is acceptable practice in the field must also shift. When working in the field paleontologists must continually assess their thinking and behavior both as individuals and as a profession in order to maintain the highest standards of integrity possible. In short, every paleontologist in the field needs to continually evaluate how they are representing themselves and their work.

There are few integral questions to ask when working in the field that fit into three basic topic areas: values, integrity, and perception. Prior to and while working in the field each field professional should recognize the competing values for the land and understand that different land users recognize different uses of the land as important. Second, it is important to maintain the highest levels of professionality while working in the field. This includes using sound field methods, representing one's self and one's institution honestly, and following basic conservation principles, including collecting only what is necessary to address an appropriate research question. Finally, each person in the field must maintain a clear idea of what they are doing, and what their work might look like to others who would either learn by example, or who may not share the same values as the field worker. Always ask, how are you representing the greater paleontological community and what are you teaching others by your example?

This presentation includes case studies of field work gone wrong, including criminal activities perpetrated by geoscience field professionals who were pursuing otherwise sound scientific questions. The purpose is not to shame, but to offer a path to avoid a nightmare scenario and, hopefully, to inspire the greater paleontological community to be leaders in ethical field practices. Paleontological field work is very visible to the public, so it is important to lead by example.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

AN UNUSUAL NORTHERN BIOTA FROM THE MORRISON FORMATION (UPPER JURASSIC) OF THE BLACK HILLS OF WYOMING, U.S.A.

FOSTER, John R., Museum of Moab, Moab, UT, United States of America; PAGNAC, Darrin, South Dakota School of Mines and Technology, Rapid City, SD, United States of America; HUNT-FOSTER, ReBecca K., Bureau of Land Management, Moab, UT, United States of America

The Little Houston Quarry in the Morrison Formation of northeastern Wyoming has been worked since 1991. The site immediately revealed an unusual mix of articulated to disarticulated dinosaur material with pockets of very abundant, mostly disarticulated microvertebrate material in the same layers. It is the most taxonomically diverse vertebrate assemblage in the Morrison Formation north of Como Bluff. In addition to skeletal elements of at least six individuals of the macronarian sauropod *Camarasaurus*, the quarry has yielded elements of an unidentified diplodocine, an adult and juvenile *Allosaurus*, and a single element of a possible camptosaur. The quarry also contains abundant carbonized plant remains (cone scales?), at least one horsetail (*Equisetum*), several charophytes, and a small seed possibly of a type not yet seen in the formation. Invertebrates from the site include gastropods and typical ovoid as well as very elongate, unidentified unionid bivalves. Unusual vertebrate taxa include a theropod tooth that is lingual-labially thin and serrated but symmetrical and unrecurved; this tooth type is larger than but somewhat similar to those from a small jaw reported from the Late Jurassic of Portugal. Another unusual vertebrate taxon is represented by a tooth that is most similar to the anterior teeth

of *Segnosaurus* in having a lingually folded mesial carina unlike any neornithischian or theropod anterior tooth previously reported from the Morrison Formation.
An elongate theropod metatarsal from the site is indistinguishable from those of *Tanycolagreus*, distinct from metatarsals of most other Morrison theropods except *Stokesosaurus* and *Marshosaurus* (which lack preserved metatarsals). The microvertebrate fauna from the site includes at least three types of actinopterygian fish, and the lungfish *Potamoceratodus*. Herpetofauna includes a frog and a relatively large salamander, the turtles *Glyptops* and *Dinochelys*, sphenodontids (*Opisthias*?), a possible paramacellodid lizard, the choristodere *Cteniogenys*, goniopholidid crocodyliforms, and a tooth possibly of an unidentified pterosaur. Mammals include *Psalodon*? *marshi*, *Docodon victor*, and a distinctive dryolestid with only three molars and an alveolus for only one more. At least five types of theropod are recorded, including adult and possible juvenile allosaurs, and two unidentified small taxa. Neornithischian dinosaurs are the small taxon *Drinker* (including "*Othnielosaurus*"), represented by numerous elements from most parts of the skeleton.
Grant Information
South Dakota School of Mines and Technology

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE FINEST FOSSIL OWL
FOWLER, Denver W., Badlands Dinosaur Museum, Dickinson Museum Center, Dickinson, ND, United States of America; FREEDMAN FOWLER, Elizabeth A., Dickinson State University, Dickinson, ND, United States of America; ALEXANDER, John M., Seattle, WA, United States of America
Although ubiquitous in modern environments, the fossil record of owls comprises mostly occasional isolated bones, providing only tantalizing glimpses into their evolution.
Here we report an exceptional fossil owl from the middle Eocene Bridger Formation of Wyoming (~48–46 Ma). The specimen (UWBM 89089, University of Washington, Burke Museum) is finely preserved, partly articulated and mostly undistorted in 3D, comprising a skull and lower jaws (including partial hyoids), atlas-axis and three cervical vertebrae, distal ulna, radius, complete left carpometacarpus and phalanges, both femurs, distal left tibiotarsus, both tarsometatarsi, and the complete left and partial right pes.
Lack of a supratendinal bridge on the distal tibiotarsus permits referral to Strigiformes. Breadth of the trochlea metatarsi IV and presence of a rugose tubercle on the distal tibiotarsus medial condyle permit referral to Protostrigidae.
Comparisons with other North American Eocene Protostrigidae are tenuous because most taxa are known only from fragments of single bones. UWBM 89089 is unlike *Eostrix* because the foramen vasculare distale of the tibiotarsus is located more proximally, trochlea IV of the tarsometatarsus is larger, and trochlea II is wider mediolaterally but less robust. It is most similar to *Minerva lydekkeri*, because it exhibits strong asymmetry between the medial and lateral condyles of the tibiotarsus, but differs in that the groove on the distal articular surface of the lateral condyle is shallower; the diaphysis of *M. lydekkeri* constricts sharply proximal to the distal condyles, whereas the diaphysis only narrows slightly in UWBM 89089, with a small tubercle on the medial surface above the lateral condyle.
Some characteristics suggest that UWBM 89089 may have differed ecologically from extant owls. Uneven ungual sizes between digits, longer proximal phalanges, and orientation of the tarsometatarsal condyles imply the foot had lesser zygodactyl capability than extant owls, with a greater emphasis on digit I and II for grip, more similar to accipitrids and falcons. The otic region of the skull is not strongly developed, suggesting weaker hearing than extant owls. UWBM 89089 exhibits large supraorbital processes, which are weak to absent in extant nocturnal owls, but well developed in diurnal owls and other diurnal raptors. This suggests that strigiforms may have been diurnal basally, relying more on vision than hearing during foraging, and had not yet evolved the specialized pedal adaptations for small prey, as seen in extant owls.

Technical Session XVIII (Saturday, October 20, 2018, 2:30 PM)

SPECIES RECOGNITION AND NICHE CONSERVATISM OF *PEROGNATHUS* (RODENTIA, HETEROMYIDAE) DURING THE LATEST PLEISTOCENE AND HOLOCENE OF THE SOUTHERN GREAT PLAINS, U.S.A.
FOX, David L., University of Minnesota, Minneapolis, MN, United States of America; KORT, Anne, Indiana University, Bloomington, IN, United States of America; MCNULTY, Kieran P., University of Minnesota, Minneapolis, MN, United States of America
Hall's Cave in central Texas, U.S.A. is a stratified site that preserved a rich record of latest Pleistocene and Holocene vertebrate communities. Historical systematic excavations recovered thousands of specimens of ≥110 vertebrate taxa, and recent AMS ^{14}C dates indicate that the excavated layers accumulated over the last 15 kyr with little interruption. Fossils attributed to the genus *Perognathus* (Rodentia, Heteromyidae) are abundant (>750 mandibles catalogued), but modern species of *Perognathus* in the Great Plains are hard to distinguish morphologically, so Hall's Cave specimens, like those at many other sites, are only identified to genus. Only *P. merriami* occurs in central Texas today, and modern range limits of *P. flavus* and *P. flavescens* are to the west and northwest, respectively. Climatic conditions in the modern ranges of these species are statistically distinct, so reliable identification of *Perognathus* species in Hall's Cave and other sites can allow tests of niche conservatism. A 3D landmark analysis of mandible shape for 102 modern specimens assigned to species based on published phylogenetic analyses of mtDNA sequences indicates that *P. merriami*, *P. flavus*, and *P. flavescens* can be distinguished with >90% accuracy. We applied this analysis to *Perognathus* mandibles from Hall's Cave to determine which species occurred in the area in the past. Fossils analyzed so far are from layers corresponding to the Younger Dryas (ca. 12 kyr BP), the mid-Holocene (ca. 6 kyr BP), and the late Holocene (ca. 2 kyr BP). Despite climatic differences between these intervals in proxy records, all fossil specimens analyzed are assigned to *P. merriami* based on discriminant function analysis of Procrustes aligned landmarks. Our results could suggest that climate changes over the sampled interval were not sufficient to drive range shifts of *Perognathus* species in central Texas. However, the fossils have intermediate morphologies in the ordination of aligned landmarks, suggesting either that we have detected morphological evolution in an extant lineage of *P. merriami* or that we have sampled morphologically distinct extinct populations. Larger samples of *Perognathus* from Hall's Cave and other sites are needed to assess past morphological variation and to determine geographic ranges of *Perognathus* species over the latest Pleistocene and Holocene.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

HISTOLOGICAL SAMPLING OF YPM 1831, THE HOLOTYPE OF *TOROSAURUS "GLADIUS"*: FOSTERING PALEONTOLOGICAL DISCOVERIES THROUGH MUSEUM/RESEARCHER COLLABORATIONS
FOX, Marilyn, Yale Peabody Museum, New Haven, CT, United States of America; LAMM, Ellen-Thérèse, Museum of the Rockies, Montana State University, Bozeman, MT, United States of America; SCANNELLA, John, Museum of the Rockies; Montana State University, Bozeman, MT, United States of America
Upon receiving a request for histological sampling of one of the initial specimens of *Torosaurus* described by Marsh, the Yale Peabody Museum (YPM) began collaboration with Museum of the Rockies (MOR) to further this research. MOR, following YPM's Destructive Sampling Guidelines, provided scientific rationale and a description of proposed alterations to the specimen. The request was reviewed and accepted by YPM Vertebrate Paleontology curators and collections staff, and required recording images of the process (extraction, molding, casting, restoration, thin-sectioning), as well as documenting all materials applied.
YPM 1831 was originally prepared in the 19th century, covered with a layer of plaster and paint, and repaired at a later date, making separating the sample to be sectioned an adventure. The segment to be removed was coated with Butvar B-76 @ 10% w/w in acetone. A plaster-bandage cradle was made to ensure accurate replacement of the cast. Attempting to remove the tip of the horn by forcing an existing crack caused an unplanned break. This revealed the bone was not in-filled and that there was hidden plaster reconstruction. PB002 Penetrant Stabilizer (cyanoacrylate) was used to harden the porous bone, as other adhesives would be too soft, would not penetrate as well, and could interfere with histological processing. The sample was finally removed using a Fein Multi-Master tool and a Sawzall with a diamond blade. Molding and casting took place at YPM using Mold Max 20 Silicone and Mold Max Thi-Vex Thixotropic additive (tin cure), with Polytek Liquid Plastic EasyFlo 90 for casting.
Thin-sectioning was done at MOR according to standard procedures, with adaptations for large specimens. Multiple applications of PB002 were used for stabilization throughout the process. Acrylic paint dots were applied while the segment was intact to mark cut locations and anatomical orientation before being further divided. Vacuuming time was increased for the polyester-resin embedding by decreasing the percentage of catalyst (MEKP) from 1% to 0.7%. Embedding was done in layers to improve resin infiltration. Large-format glass slides were cut from 2.2mm thick single-strength glass (SSB) at a size of 75x100 mm. Cut slides were frosted in a micro-blaster using 50 µm aluminum oxide to improve adhesion of the embedded-bone wafer. Thin-sections were ground to 175 µm on a lapidary grinder and were then ready for examination.
This case study illustrates how collaborative efforts between museums can benefit paleontology by fostering new research and discovery.

Podium Symposium (Wednesday, October 17, 2018, 11:15 AM)

PROFOUND LATE QUATERNARY BIOTIC HOMOGENIZATION OF NORTH AMERICAN MAMMAL FAUNAS
FRASER, Danielle L., Canadian Museum of Nature, Ottawa, QC, Canada; VILLASEÑOR, Amelia, University of New Mexico, Albuequerque, NM, Canada; BALK, Meghan A., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; ERONEN, Jussi T., Helsinki Institute of Sustainability Science, Helsinki, Finland; TÓTH, Anikó B., Macquarie University, Sydney, Australia; WORKING GROUP, Evolution of Terrestrial Ecosystems, Smithsonian National Museum of Natural History, Washington, DC, United States of America; BEHRENSMEYER, Anna K., Smithsonian Institution, Washington, DC, United States of America; LYONS, S. Kathleen, Lincoln, NE, United States of America
Anthropogenic climate changes and overexploitation of natural resources, as well as increasing globalization and urbanization, are irreversibly altering landscapes to the degree that almost no untouched ecosystems remain. The acceleration of species range shifts and alien species introductions in the past 200 years are implicated in taxonomic homogenization of biological communities. Biotic homogenization is the increase in the similarity of species composition among sites resulting from the spread of invading species and the extinction of local endemics. We test for homogenization amongst North American mammals during the late Pleistocene through Holocene (~35 ka to modern) using data drawn from the Neotoma Palaeoecology database, thus including records from before and after the arrival of anatomically modern humans between 24 ka and 12 ka. We vetted the data so that communities were comprised of sites with a minimum of 20 species and preserved at least three orders of mammals. The resulting dataset contains 8831 mammal occurrences for 230 species from all modern mammalian orders at 302 localities. We quantify taxonomic differentiation amongst sites using a variety of similarity metrics (e.g., Jaccard) and calculate climate turnover (i.e., mean pairwise climate dissimilarity) using downscaled CCSM3 paleoclimate models for each time interval. North American mammal species assemblages show a ~15–20% increase in similarity after ~20,000 radiocarbon years, coincident with declining climate turnover in North America and the arrival of anatomically modern humans. Homogenization is sustained from ~12,000 radiocarbon years through the Holocene, following the extinction of the megafauna. Range expansions amongst the majority of taxa coincide with intervals of homogenization and are the likely driver. Biotic homogenization is of concern to conservationists because it signals ecological homogenization and, potentially, the loss of resilience to perturbation. Provided current rates of invasion and human landscape modification are sustained, North American faunas are projected to homogenize by ~9% based on current species risk assessment and human population geography. If this happens, mammal assemblages will have become as much as 25% more homogenous since the Last Glacial Maximum. Further ecological homogenization will result in the loss of a variety of ecosystem services without concerted efforts to mediate such homogenization.
Grant Information NSF-DEB
1257625

Technical Session X (Friday, October 19, 2018, 10:15 AM)

ONTOGENETIC DIETARY SHIFTS IN *DEINONYCHUS ANTIRRHOPUS* (THEROPODA; DROMAEOSAURIDAE): INSIGHTS INTO SOCIAL BEHAVIOR IN RAPTORIAL DINOSAURS USING STABLE ISOTOPE ANALYSIS

FREDERICKSON, Joseph A., Norman, OK, United States of America

Arguably one of the most prevalent examples of speculative behavior in dinosaurs is the pack-hunting raptor. First proposed to explain the relatively common co-occurrence of the large-bodied iguanodontian *Tenontosaurus tilletti* and the wolf-sized *Deinonychus antirrhopus* from the Early Cretaceous of North America, a canid-like social hunting structure has become the standard depiction of dromaeosaurs in popular works over t he last three decades. This reconstruction, however, is problematic, largely due to the fact that highly coordinated hunting strategies are rarely observed in modern archosaurs. This debate has led to the alternative hypothesis that *Deinonychus* was more analogous to agonistic reptilian carnivores, like the Komodo dragon (*Varanus komodoensis*). Among the many differences between these two analogs is how social and asocial organisms rear their young, producing a diagnostic apttern based on the presence or absence of ontogenetic dietary changes. In order to test for dietary changes through growth, stable carbon isotope ($\delta^{13}C$, VPDB) analysis was performed on tooth carbonate from small (<5 mm crown height) and large (>10 mm crown height) *Deinonychus* specimens from two microsites from the Early Cretaceous Cloverly and Antlers formations. Further, goniopholidid teeth varying in size from the Cloverly Formation were also tested as a control. The results show that the Cloverly goniopholidids, like their modern counterparts, went through a distinct transition in diet with increased growth, where the smallest teeth were the relatively most enriched (avg. -9.32‰; n=5), the medium-sized teeth were the most-depleted (avg. -10.56‰; n=5), and the largest teeth were in-between (avg. -10.12‰; n=6); characteristic of the dietary shifts seen in modern asocial reptiles. *Deinonychus* showed this same pattern in both formations, with small teeth being the more enriched (avg. -8.99‰; n=10) and the large teeth being more depleted (avg. -10.38‰; n=10). These differences indicate that juvenile and adult *Deinonychus* likely consumed different prey regardless of formation of origin. Hypothetical food sources, such as *Tenontosaurus tilletti*, are close to the ^{13}C isotopic signal of adult *Deinonychus*, consistent with the hypothesized trophic relationship between thesetwo species. Juvenile *Deinonychus* had a more enriched diet, likely composed of smaller, but trophically-higher species. Taken together, these data add to the growing evidence that *Deinonychus* was not a complex social hunter, at least by modern mammalian standards.

Technical Session XVI (Saturday, October 20, 2018, 9:30 AM)

AN ALVAREZSAURID FROM THE LATE MAASTRICHTIAN OF EASTERN MONTANA WITH IMPLICATIONS FOR SYSTEMATICS AND BIOGEOGRAPHY

FREIMUTH, William J., Montana State University, Bozeman, MT, United States of America; VARRICCHIO, David J., Montana State University, Bozeman, MT, United States of America

Alvarezsaurids are an enigmatic group of small-bodied theropod dinosaurs characterized by reduced but robust forelimbs, an enlarged manual digit I, and greatly reduced lateral digits, among other traits. The forelimbs, combined with a long snout and numerous, small, unserrated teeth, suggest an insectivorous diet. Historically, the phylogenetic affinities of Alvarezsauridae have changed considerably, though the basal alvarezsauroid *Haplocheirus sollers* links the group to maniraptoran theropods. Alvarezsaurids are best known from Asia and South America, but poorly represented from North America. *Albertonykus borealis* is the only described taxon, represented by few potentially associated elements from the mid-Maastrichtian Horseshoe Canyon Formation. Alvarezsaurs are only represented by unassociated isolated elements from latest Maastrichtian Hell Creek and Lance formations.

Here we present an associated partial postcranial skeleton of an alvarezsaurid from the Upper Cretaceous Hell Creek Formation of eastern Montana. This new specimen complements fragmentary alvarezsaurid material from the Hell Creek Formation and coeval Lance Formation and represents the most complete alvarezsaur from North America. Its phylogenetic position within Alvarezsauridae has implications for the systematics and evolutionary history of the group. Several diagnostic elements are represented, including articulated procoelous caudal vertebrae, coracoids lacking a bicipital tubercle, articulated parts of the manus, astragalus, and pedal phalanges. This specimen also preserves a phalanx and ungal of one of the reduced digits, elements known only in *Shuvuuia*. Preliminary phylogenetic analyses under a Bayesian framework place this specimen as the sister taxon to the North American *Albertonykus*. These two North American taxa fit within an Asian clade of more derived forms that includes the derived archetypal *Mononykus*, and more broadly within a Laurasian clade distinct from the basal South American alvarezsaurids.

Technical Session V (Thursday, October 18, 2018, 8:45 AM)

DO COUGARS (*PUMA CONCOLOR*) RE-FILL THE MEGAFELID NICHE FOLLOWING THE PLEISTOCENE MEGAFAUNAL EXTINCTION?

FREYMUELLER, Nicholas A., University of New Mexico, Albuquerque, NM, United States of America; PARDI, Melissa I., Vanderbilt University, Nashville, TN, United States of America; SMITH, Felisa A., University of New Mexico, Albuquerque, NM, United States of America

The concept of niche conservatism posits that a species' ecological characteristics remain consistent through time. Following G. E. Hutchinson, niches are defined in multidimensional eco-space by a combination of abiotic tolerances and biotic interactions. Under niche conservatism, these variables remain constant. In reality, biotic interactions can change over ecological time; the Pleistocene megafaunal extinction serves as an example of such changes. During the Pleistocene, meso-carnivores such as the cougar (*Puma concolor*), were likely outcompeted by larger-bodied felids. Following the extinction of these more massive hyper-carnivorous competitors at the terminal Pleistocene (~ 11,500 years), it is unclear if, or how, cougars began to occupy eco-space presumably vacated by the extinctions of the mega-felids (i.e., meso-carnivore release). We employed the maximum entropy method of ecological niche modeling (ENM) analysis using felid occurrences from the Neotoma Paleoecology Database and Community Climate System Model 3 paleoclimate simulations. ENM analysis offers an explicit test of abiotic factors to determine species environmental requirements. We produced species distribution models (SDMs) of North American felids for the late Pleistocene, early Holocene, late Holocene, and historical/modern. Observed SDMs were constructed for a given time bin, and an expected model was constructed for the subsequent time bin under the H_0 of niche conservatism. We compared expected and observed cougar SDMs across the Pleistocene–Holocene boundary to test the H_0 of cougar niche conservatism. We also compared observed cougar SDMs with expected SDMs of extinct felids across the boundary to test the H_a of meso-carnivore release. We find that cougars did not re-fill the empty abiotic niche space vacated by the mega-felids following their extinction. Furthermore, cougars also showed low fidelity to their abiotic niche throughout the Holocene, and they did not track the same abiotic variables through this time. Our findings suggest that biotic interactions, rather than climate, may be the primary influencers that limit cougar distribution.

Grant Information

Work was performed through grants from NSF (DEB #1555525) and the University of New Mexico.

Technical Session XIV (Saturday, October 20, 2018, 8:45 AM)

EXCEPTIONAL PRESERVATION IN A PENNSYLVANIAN FISH AND THE LIMITS OF NEUROANATOMICAL INFERENCE FROM ACTINOPTERYGIAN CRANIAL ENDOCASTS

FRIEDMAN, Matt, University of Michigan, Ann Arbor, MI, United States of America; GILES, Sam, University of Oxford, Oxford, United Kingdom

Ray-finned fishes became major contributors to aquatic vertebrate faunas and diversified morphologically during the Carboniferous, but this interval of the group's history remains poorly understood. Heavily compressed specimens dominate the Carboniferous actinopterygian record, but are limited in terms of the anatomical information they can provide for downstream analyses. A handful of North American and European sites yield three-dimensionally preserved material, and past studies of these fossils—aided by conventional preparation and physical tomography—have provided significant insight into character-rich endocranial structure in early ray-finned fishes. One such horizon is the 'Soapstone Bed' of the Bashkirian (ca. 314 Ma) Lower Coal Measures of Lancashire, U.K., which bears actinopterygian fossils characterized by exceptional preservation, including natural endocasts in material referred to *Mesopoma*. We examined the disarticulated but three-dimensionally preserved holotype of *Coccocephalichthys wildi* using micro-computed tomography as part of a survey of endocranial anatomy in Paleozoic actinopterygians. The specimen comprises some components of the postcranium (e.g., cleithrum) and a partially disarticulated skull including an uncrushed braincase. Although multiple descriptions of this fossil have been made on the basis of external anatomy, buried and internal details remain unknown. Consistent with past phylogenetic interpretations, *Coccocephalichthys* shows derived endocast features widely distributed among Carboniferous actinopterygians but lacking in Devonian taxa: anteriorly directed olfactory tracts, a long common olfactory canal, and widening attributed to expanded optic lobes. More significantly, this specimen shows extensive preservation of soft tissues within the cranial endocavity. Past work has widely assumed a close correspondence between brain and endocast in actinopterygians, despite clear mismatches in other fish groups and only anecdotal evidence for a tight fit in ray-fins. Brain anatomy provides critical evidence for actinopterygian monophyly and internal relationships, and phylogenetic studies often score aspects of brain structure in extinct taxa on the basis of endocast anatomy. While our new data from *Coccocephalichthys* call into question the fidelity with which early actinopterygian endocasts record neuroanatomy more generally, they provide a remarkable snapshot of brain structure in a probable member of the ray-finned fish stem lineage.

Grant Information

U-M College of LSA, Earth and Environmental Sciences; L'Oréal-UNESCO International Rising Talents Fellowship; Royal Society Dorothy Hodgkin Research Fellowship

Technical Session VI (Thursday, October 18, 2018, 9:45 AM)

THE KORBACH FISSURE FILL: COMPOSITION AND BIOGEOGRAPHY OF A LATE PERMIAN PALEOEQUATORIAL FAUNA FROM CENTRAL EUROPE

FRÖBISCH, Jörg, Museum für Naturkunde, Berlin, Germany; KAMMERER, Christian F., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; SUES, Hans-Dieter, National Museum of Natural History, Washington, DC, United States of America; FREY, Eberhard, Staatliches Museum für Naturkunde Karlsruhe, Karlsruhe, Germany; WITZMANN, Florian, Museum für Naturkunde, Berlin, Germany; JANSEN, Maren, Museum für Naturkunde, Berlin, Germany

The Korbach locality in central Germany represents the only tetrapod-bearing fissure fill from the late Permian and one of the few terrestrial tetrapod sites at low latitudes during this time. It formed in a marine carbonate platform of the Zechstein Sea during a stratigraphically constrained, local regression in the Changhsingian. The fissure is highly fossiliferous, but thus far, only the otherwise African and Russian basal cynodont *Procynosuchus* has been definitively reported from this assemblage. Recent preparation of the extensive material recovered from Korbach during the 1990s has allowed recognition of a distinctive, very diverse late Permian continental tetrapod assemblage. In addition to *Procynosuchus*, which represents by far the most abundant taxon at this locality, new fossil identifications include representatives of the major therapsid clades Gorgonopsia, Dicynodontia, and Therocephalia, mostly based on isolated teeth and dentigerous jaw elements. In addition, the fossil assemblage comprises remains of pareiasaurian and lanthanosuchoid parareptiles as well as those of a *Protorosaurus*-like archosauromorph and two captorhinid eureptiles. The latter include a diagnostic maxilla and additional bones referable to the middle-late Permian Chinese genus *Gansurhinus*, as well as a yet unidentified single-tooth-rowed taxon. Finally, new records of late Permian tetrapods from

the Korbach locality include a new taxon of bystrowianid chroniosuchian. This member of the enigmatic Laurasian reptiliomorph clade is documented by an isolated distinct dorsal osteoderm, which is diagnosed by concave lateral margins and subrectangular accessory processes. The discovery of *Gansurhinus* as well as the new chroniosuchian anamniote and lanthanosuchoid parareptile in Korbach provide strong evidence of tetrapod faunal connections between western and eastern Europe and East Asia during the Permian. However, the presence of these Laurasian faunal elements as well as the otherwise mainly Gondwanan *Procynosuchus* in the Korbach locality indicates a complex paleobiogeographic pattern among late Permian tetrapods, not reflected in higher-latitude late Permian faunas.

Grant Information
Funding was provided by the National Geographic Society, a Sofja Kovalevskaja Award of the Alexander von Humboldt Foundation, and the German State of Hesse.

Technical Session XVI (Saturday, October 20, 2018, 11:00 AM)

AN ARTICULATED TITANOSAURIAN (DINOSAURIA, SAUROPODA) POSTCRANIAL SKELETON FROM THE LATE CRETACEOUS OF TEXAS, WITH IMPLICATIONS FOR THE TAXONOMIC STATUS OF *ALAMOSAURUS SANJUANENSIS*

FRONIMOS, John A., Vassar College, Poughkeepsie, NY, United States of America; LAMANNA, Matthew C., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America

The sauropod dinosaur *Alamosaurus sanjuanensis* is the only member of Titanosauria known from North America. Its abrupt appearance in Upper Cretaceous strata of the continent is part of the larger radiation and global dispersal of titanosaurs during that time. Though numerous specimens have been referred to the species, lack of anatomical overlap with the holotypic scapula has made it difficult to determine whether all of these specimens truly represent the same taxon. This, in turn, has left the phylogenetic position and paleobiogeographic origins of *Alamosaurus* unresolved.

To help address these issues, we describe a largely articulated titanosaurian postcranial skeleton (Texas Memorial Museum [TMM] 41541-1) from the uppermost Cretaceous (Maastrichtian) Javelina Formation of Big Bend National Park, Texas. Collected by Wann Langston and colleagues in 1973, most bones of TMM 41541-1 have only recently been prepared for the creation of a composite *Alamosaurus* replica mount at the Perot Museum of Nature and Science in Dallas. The specimen includes three posterior cervical vertebrae, most dorsal vertebrae and ribs, the sacrum (which includes an ossified supraspinal ligament), the first caudal vertebra, the right humerus, the pelvic girdle, and the right femur. The mostly intact trunk region allows the characterization of serial variation in dorsal vertebrae, aiding the identification of other, isolated elements from this part of the titanosaurian skeleton. Moreover, enough of the skeleton is preserved to provide anatomical overlap with most major North American titanosaur specimens. TMM 41541-1 is generally morphologically compatible with these specimens, creating a possible chain of inference supporting its referral to *Alamosaurus sanjuanensis*. However, a survey of first caudal vertebrae from Texas shows consistent differences to that of a more confidently referred exemplar from Utah, calling the referral of TMM 41541-1 to *A. sanjuanensis* into question. TMM 41541-1 shows strong similarities to selected South American titanosaurs, supporting the longstanding hypothesis that these sauropods entered North America from the south during the Late Cretaceous.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

COMPARATIVE OSTEOHISTOLOGY OF EXTANT SMALL-BODIED MAMMALS WITH IMPLICATIONS FOR UNDERSTANDING THE GROWTH DYNAMICS OF MESOZOIC MAMMALS

FULGHUM, Henry Z., University of Washington, Seattle, WA, United States of America; WEAVER, Lucas N., University of Washington, Seattle, WA, United States of America; WHITNEY, Megan, University of Washington, Seattle, WA, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America

The growth dynamics of Mesozoic mammals can reveal relative timings of important life history events that are crucial to our understanding of how mammals survived the Cretaceous–Paleogene mass extinction and reached ecological dominance in its aftermath. As a proxy for life-history information that is otherwise inaccessible from fossils, osteohistology is a critical tool in these paleobiological studies. However, given the lack of comparative studies examining the osteohistology of small-bodied extant mammals, the extent to which bone microstructure accurately reflects life history events in these animals is largely unknown. To establish a basis for inferences about the growth dynamics of Mesozoic mammals from osteohistology, we made thin sections of the femur of adult and juvenile specimens from a phylogenetically diverse sample of 12 extant, small-bodied (< 1 kg) mammal species. The majority of our specimens exhibit two types of bone matrix: a well-organized matrix of lamellar bone, and a disorganized matrix of either parallel-fibered or woven bone. In adult specimens, the inner and outer layers of the cortex are composed of well-organized lamellar bone, whereas the mid-cortex is composed of disorganized bone, and appears frequently as parallel-fibered bone among our smaller taxa. In juvenile specimens, this disorganized bone layer represents a much larger proportion of the cortex. We interpret the disorganized layer as having formed during a period of rapid bone deposition during rapid growth in early ontogeny, whereas the inner and outer lamellar bone layers were likely deposited simultaneously after growth had slowed. The average vascularity of our samples is low (1.12%), and the degree of vascularity appears to be dependent upon an animals adult body size, with our smallest taxa being nearly avascular and our largest taxa possessing primary osteons and some radial vasculature. Future work will aim to quantify these osteohistological features in order to test how they may correlate with life-history characteristics (e.g., body mass, lifespan, age of somatic and sexual maturation, and locomotor mode) of our extant sample. With these data, we hope to build a framework upon which we may make inferences about the growth dynamics (and other life-history variables) of extinct small-bodied mammals and better understand the biological mechanisms underlying patterns of extinction, survival, and diversification.

Technical Session XI (Friday, October 19, 2018, 3:00 PM)

CLIMATE CHANGE AND RATES OF BODY SIZE EVOLUTION IN NORTH AMERICAN EOCENE EUPRIMATES

FULWOOD, Ethan L., Duke University, Durham, NC, United States of America

Living primates are mostly restricted to tropical and paratropical forests. This narrow climatic tolerance appears to characterize the clade throughout its evolutionary history, as fossil euprimate taxonomic diversity on northern continents closely corresponds to periods of warming. Here the effects of climatic amelioration and deterioration on ecological diversity are examined in North American Eocene euprimates, as measured through disparity and rates of evolution in body size.

The length of the first lower molar (lm1) is used as a body size proxy for 39 genera of North American Eocene omomyids and notharctids. Disparity is measured as the mean squared Euclidean distance among all of the taxa present in each NALMA biochron. A supertree of North American primates is then assembled with branch lengths assigned using the stochastic cal3 method. Rates of evolution in lm1 are calculated in Darwins across internal branches of the tree, and mean rates of evolution in body size are recorded for each biochron. Disparity estimates and mean rates of evolution are tested for correlation with reconstructed global temperatures.

Disparity in the total euprimate clade is significantly positively correlated with temperature. As a clade, omomyid disparity shows a significantly negative correlation with temperature. This tentatively suggests decreasing total prosimian disparity due to climate deterioration from the Early Eocene Climactic Optimum, but increasing disparity in omomyids as the clade expands to fill more of total prosimian clade space, perhaps facilitated by the extinction of notharctids after the Bridgerian. Rates of evolution follow a similar pattern through the early and middle Eocene, with high rates early in the Wasatchian and another, sustained increase during the Bridgerian. Rates of evolution gradually increase again from the Uintan, however. This may reflect the expansion of omomyiforms into adapiform ecospace, as omomyiforms also show increasing rates of evolution over this interval.

Together, these results suggest a generally strong relationship between climatically mediated ecospace availability, empirical disparity, and rates of evolution in euprimates. The taxonomic decline of North American euprimates in the late Eocene corresponds with a concomitant decrease in body size disparity, but records a paradoxical increase in the rate of body size evolution. This is consistent with a shift into vacated ecospace by the remaining euprimate taxa, especially late Eocene omomyiforms.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A SMALL CAENAGNATHID TIBIA FROM THE HORSESHOE CANYON FORMATION (MAASTRICHTIAN): IMPLICATIONS FOR GROWTH AND LIFESTYLE IN OVIRAPTOROSAURS

FUNSTON, Gregory F., University of Alberta, Edmonton, AB, Canada; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada

Caenagnathid elements are exceptionally rare in the Horseshoe Canyon Formation, and a small tibia constitutes only the fourth record from the formation. The tibia is elongate and gracile, with a semi-circular cross-section. A representative survey of North American theropod tibiae suggests that cross-sectional shape can be useful for distinguishing theropod superfamilies. Caenagnathid tibiae can be distinguished from those of other theropods by the combination of their elongation, semi-circular cross-sections, and absence of extensive contacts between the fibulae and distal ends of the tibiae. Histological sections reveal that the individual represented by the tibia was likely just over one year old and was increasing its growth rate at the time of death. However, the cyclical growth mark is unusual, consisting of a zone of parallel-fibered bone, rather than a distinct line of arrested growth—similar to annuli of ornithischians. A transition in vasculature orientation and osteocyte lacunae size and density prior to the growth mark may represent a physiological change within the first year of life. It is possible that this represents fledging, ontogenetic niche shift, or an environmental change, but more evidence from other individuals is required to test this. The presence of endosteal lamellae suggests that the tibia already experienced significant mechanical loads, despite the young age of the individual. Together with evidence from other caenagnathids, it suggests that they were active early in life, consistent with a precocial lifestyle.

Grant Information
G.F.F. is funded by Vanier Canada and the Dinosaur Research Institute; PJC is funded by NSERC [Grant # RGPIN 2017-04715].

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PALEONEUROLOGY AND INTERSPECIFIC BRAIN VARIATION WITHIN THE GENUS *SMILODON*

GABAY, Tabatha, University of Kansas, Lawrence, KS, United States of America

Examination of brain variability enhances our understanding of neural development across species and provides deeper insight into how brain morphology corresponds with environment and behavior. Additionally, the brain is a much-overlooked diagnostic tool that can be used to help increase systematic data by examining the gross neural anatomy and unique gyrification patterns across taxa. While *Smilodon* represents one of the most well-known and studied carnivore species, endocranial studies remain limited. Those that do exist focus solely on the Rancho La Brean *Smilodon fatalis*, thus providing a narrow window into the evolutionary development of the brain within the genus. This study (1) provides the first endocranial study of *S. fatalis* outside of Rancho La Brea, (2) proposes a set of temporal neurological changes that occur within this species, (3) compares the gross cerebral morphology of both *S. gracilis and S. populator*, and (4) establishes the interspecific variation of the brain within the genus *Smilodon*, thus expanding the diagnostic characters for the individual species and expounding upon their evolutionary history.

Technical Session V (Thursday, October 18, 2018, 8:00 AM)

AGE-MORTALITY PROFILES IN LA BREA BISON: INSIGHTS INTO POPULATION DYNAMICS AND TAPHONOMY

GALVEZ, Saul U., Cal Poly Pomona, Pomona, CA, United States of America; PROTHERO, Donald R., La Brea Tar Pits, Los Angeles, CA, United States of America In population dynamics, age-mortality profiles (a histogram showing the mortality in each age class) are powerful tools for interpreting ecology. A typical living population has its highest mortality rates among juveniles, and mortality declines among the older age classes. In a fossil assemblage, this is interpreted as a catastrophic death assemblage. Another common pattern is an attritional death assemblage, with high mortality rate among the youngest and oldest age classes, but the healthy adults have a very low mortality rate. Previous authors reconstructed the age-mortality profiles for Ice Age *Bison antiquus* from Rancho La Brea, using the wear stages in lower jaws. They found a unimodal distribution, with a very high number of older juveniles, but few in the other age classes. This seems to suggest taphonomic or presevational distortion of the original biological population sample. For comparison, we measured all the juvenile and adult limb bones (humerus, radius, femur, tibia) using the length of the diaphysis to see what kind of profile they produced. Surprisingly, they gave a bimodal pattern, with a large number of older juveniles (as seen by previous authors), but also a large mode among adults in their prime. This pattern bears no resemblance to the expected patterns for known processes, and must reflect some sort of taphonomic bias in the tar pits. Apparently, individuals of these age classes are more likely to be trapped, or their bones are less likely to be destroyed during the pit wear and churning within the pit.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

UNUSUAL DENTITION IN THE NORTHERNMOST SPECIMEN OF *TYLOSAURUS* (SQUAMATA, MOSASAURIDAE) SUGGESTS ADAPTATION FOR PISCIVORY

GARVEY, Samuel T., University of Cincinnati, Cincinnati, OH, United States of America; KONISHI, Takuya, University of Cincinnati, Cincinnati, OH, United States of America Typically 5 m or more in length, mosasaurs were large aquatic lizards that lived during the Late Cretaceous (c. 100–66 Ma). Of the six subfamilies and more than 70 species recognized today, most are known to have been hydropedal, or flipper-bearing, with a bifurcate vertical tailfin. Mosasaurs were cosmopolitan apex predators, and their remains occur on every continent, including Antarctica. In the Northern Hemisphere, the challenges of paleontological fieldwork in high latitudes have biased mosasaur collections such that a majority of mosasaur fossils are found within 0°–60°N paleolatitude, and plioplatecarpine mosasaurs are the only mosasaurs yet confirmed to have existed in paleolatitudes higher than 60°N. However, this does not mean mosasaur fossils are necessarily lacking at such latitudes. Herein, we report on the northernmost occurrence of a tylosaurine mosasaur from near Grande Prairie in Alberta, Canada (c. 86–79 Ma). Recovered from 65°N paleolatitude, this material (TMP2014.011.0001) is assignable to the subfamily Tylosaurinae by exhibiting a cylindrical rostrum, broadly parallel-sided premaxillo-maxillary sutures, and overall homodonty. We further refer this material to *Tylosaurus* based on the lack of a dorsal midsagittal ridge on the premaxilla. Unexpectedly, TMP2014.011.0001 exhibits widely spaced, high-aspect-ratio teeth, a seemingly juvenile condition, despite its sub-adult or adult age based on an estimated body length of 6 m. In contrast with the juvenile condition, the tooth sockets themselves are widely separated, a highly unusual characteristic for *Tylosaurus*. The specimen also exhibits interdental pitting and anterior maxillary tooth roots covered by downward extensions of the maxillary cortical bone, both features previously unknown in Tylosaurinae. Analogous dental morphologies in other non-mosasaurid taxa, as well as a standard model of tooth function based on tooth morphology, indicate TMP2014.011.0001 may have been adapted exclusively for piscivory. This study suggests the possible presence of a Cretaceous boreal marine community that was distinct from those across the more southern stretches of the Western Interior Seaway, in the western and southern United States.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A NEW SOUTH AMERICAN ORNITHOPOD DINOSAUR FROM THE SANTONIN BAJO DE LA CARPA FORMATION (NEUQUÉN PROVINCE, ARGENTINA)

CRUZADO-CABALLERO, Penélope CONICET – IIPG, General Roca, Argentina; CASCA, José M. CONICET-Museo Olasacher, Zapala, Zapala, Argentina; FILIPPI, Leonardo S. Museo Municipal "Argentino Urquiza", Rincón de los Sauces, Argentina; CERDA, IgnacioCONICET-IIPG, General Roca, Argentina; GARRIDO, Alberto C. CONICET-Museo Olascher, Zapala, Zapala Argentina

In the last decade, the Argentinian ornithopod record—which includes eight described species—has been increased with the discovery of new and diverse bone remains coming from the Late Cretaceous. The area near the village of Rincón de los Sauces (Neuquén Province) presents rich fossiliferous outcrops that have provided new ornithopod remains. These bones come from two units: Plottier and Bajo de la Carpa formations. In the latter, several isolated postcranial bones and a partial articulated skeleton (MAU-Pv-CO-596) have been found. MAU-Pv-CO-596 comes from the Cerro Overo site (Santonian, Late Cretaceous). The skeleton preserves five posterior cervical vertebrae and three of its corresponding ribs, the most anterior six vertebrae and seven left ribs of the dorsal series, the two scapulae, coracoids and sternal plates, four intercostal plates as well as the right forelimb including humerus, radius, ulna and nearly complete manus (excluding some distal phalanges). The skeleton corresponds to a medium-bodied ornithopod with a gracile general appearance. Histological analysis suggests that the specimen was sexually mature but not a fully grown individual. Some distinctive characters present in MAU-Pv-CO-596 such as strongly bowed humeral shaft and weakly developed deltopectoral crest are shared with other South American basal ornithopods. A phylogenetic analysis including MAU-Pv-CO-596 within a large ornithischian dataset has been performed. The results recover an unnamed clade with several South American ornithopods, including MAU-Pv-CO-596 placed as the sister taxon of the clade composed of *Talenkauen* and *Macrogyphosaurus*.

Grant Information

This work was supported by the municipality of Rincón de los Sauces, Neuquén Province (LSF), and the Spanish Ministerio de Ciencia e Innovación (CGL2017-85038-P; PCC, JMG).

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

CONTRASTING INTERPRETATIONS OF THE TEETH TO BALEEN TRANSITION IN MYSTICETE CETACEANS

GATESY, John, American Museum of Natural History, New York, NY, United States of America; BERTA, Annalisa, San Diego State Univ, San Diego, CA, United States of America; DEMÉRÉ, Tom, San Diego Natural History Museum, San Diego, CA, United States of America; EKDALE, Eric G., San Diego State Univ, San Diego, CA, United States of America; EL ADLI, Joseph, Statistical Research Inc., Redlands, CA, United States of America; MCGOWEN, Michael R., Smithsonian Institution, Washington, DC, United States of America

The transition in stem Mysticeti (Cetacea) from tooth-assisted feeding to bulk filtering small prey with baleen ranks among the most dramatic evolutionary transformations in mammalian history. In extant mysticetes, tooth buds are expressed and then resorbed in fetal stages. In the toothless adults, baleen plates are arranged in racks that grow from the margins of the palate and permit efficient batch filter feeding. It is unlikely that this highly derived mode of feeding, which requires coordinated behavioral modifications, emergence of the neomorphic keratinous baleen sieve, and attendant anatomical changes to the skull, evolved rapidly in a single saltatory transition. Paleontologists have used phylogenetic analyses of extinct toothed and toothless mysticetes to make detailed maps of this macroevolutionary transformation in feeding mode. Here, we reassessed phylogenetic studies presented over the past dozen years that have variously reconstructed this complex evolutionary sequence. We compared basic homology assessments, alternative character coding schemes, and contrasting interpretations of function/behavior in the context of several prominent studies. Early work proposed a step-wise transformation in which toothed mysticetes transitioned via 'intermediate' forms with both teeth and baleen to toothless filter feeders. Later studies presented alternative scenarios featuring filtration with teeth instead of baleen, loss of a functional dentition before the evolution of baleen, pure suction feeding, and/or convergent evolution of several key mysticete features. We reanalyzed published cladistic matrices in the context of extensive new molecular data, assessed character support for alternative relationships, and mapped six features related to filter feeding in Mysticeti: presence/absence of 1) teeth, 2) baleen, 3) lateral nutrient foramina on the palate (possible osteological correlates of baleen), 4) a broad rostrum, 5) laterally bowed mandibles, and 6) an unsutured mandibular symphysis. We emphasize the importance of parsimony for interpreting complex evolutionary sequences and stress that coherent evaluation of homology, both anatomical and functional, should be conducted within a robust cladistic parsimony context (or alternative optimality criteria) so that the field can refocus on producing hypotheses that are well-supported by data.

Grant Information

NSF DEB-1457735

Technical Session XV (Saturday, October 20, 2018, 11:15 AM)

A BIPLANAR X-RAY APPROACH FOR STUDYING THE 3-D DYNAMICS OF HUMAN TRACK FORMATION AND FOR INTERPRETING FOSSIL HOMININ TRACKS

GATESY, Stephen M., Brown Univ, Providence, RI, United States of America; PERRY, David, Brown Univ, Providence, RI, United States of America; HATALA, Kevin, Chatham University, Pittsburgh, PA, United States of America

The number of known Plio-Pleistocene hominin track sites has increased dramatically in the past decade. These data have the capacity to inform long-standing debates regarding fossil hominin locomotion, but exactly how pedal anatomy and gait biomechanics should be inferred from tracks remains debated. This lack of consensus stems from our limited understanding of the complex interactions among anatomy, motion, and substrate that generate a track. Insights from track formation in living taxa are elusive because 1) data from stiff-surfaced instruments cannot be extrapolated to deformable substrates, and 2) direct visualization is hindered by foot and substrate opacity.

In this study, we developed new biplanar X-ray methods based on XROMM (X-ray Reconstruction of Moving Morphology) to analyze the foot-substrate interface. Three human subjects were recorded at 50 fps as they walked across radiolucent artificial substrates (three deformable muds and a rigid carbon fiber plank). Using the coordinates of 70 skin markers applied to the sole and toes, we constructed a dynamic mesh of 112 polygons to animate the 3-D shape of the foot during each step. Foot motion was then compared to photogrammetry-derived 3-D models of the final tracks.

We found that foot dynamics were significantly influenced by substrate deformability. Both the heel and medial longitudinal arch deformed to greater extents as substrates became more rigid ($p < 0.01$ via repeated measures ANOVA). In very soft muds, we found that the 3-D topography of resulting tracks did not directly reflect foot motion. Deviations between motion and track depth differed significantly across regions of the foot, and across substrate types ($p < 0.01$ via repeated measures ANOVA). Specifically, deformations from the heel and arch in early stance were reworked as the forefoot and toes were maximally loaded in late stance. These results highlight the complexity and dynamic nature of track formation and offer a path forward for inferring foot anatomy and motion from fossil hominin tracks.

Grant Information

U.S. NSF (SMA-1409612, DBI-126215 6), the Chatham University Research and Sabbatical Committee, and the Brown Undergraduate Teaching and Research Awards program.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW MATERIAL OF THE EXTINCT SLOTH *SIMOMYLODON UCCASAMAMENSIS* (XENARTHRA, MYLODONTIDAE) FROM THE PLIOCENE OF THE BOLIVIAN ALTIPLANO: SYSTEMATIC AND PALEOBIOLOGICAL IMPLICATIONS

GAUDIN, Timothy J., University of Tennessee Chattanooga, Chattanooga, TN, United States of America; BOSCAINI, Alberto, Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales (IANIGLA), CCT-CONICET-Mendoza, Mendoza, Argentina; MAMANI-QUISPE, Bernardino, Museo Nacional de Historia Natural, La Paz, Bolivia; ANTOINE, Pierre-Olivier, University of Montpellier, Montpellier, France; PUJOS, Francois, CONICET, Mendoza, Argentina

Fossil remains of extinct sloths have been discovered in numerous localities throughout the Americas, but knowledge of these animals remains poor in the tropical latitudes in comparison with sloth taxa from more northern and southern regions. Mylodontine ground sloths were widespread during the Pliocene but, in the central regions of South America, well-preserved craniodental remains were extremely rare, impeding reliable assessment of their taxonomy and phylogenetic affinities.

Recent paleontological expeditions to Pliocene deposits of the Bolivian Altiplano (i.e., localities of Choquecota, Pomata-Ayte, Casira, Inchasi, and Ayo Ayo-Viscachani) have provided new well-preserved craniodental remains ascribable to the mylodontid species *Simomylodon uccasamamensis*. Detailed comparison of this material with other moderate-sized Mio-Pliocene mylodontines from North and South America allowed us to reliably differentiate *Simomylodon uccasamamensis* from these taxa on both morphological and morphometric grounds and to revise the taxonomic attributions of several specimens from Bolivia and Argentina. Morphometric analyses show that the species *Simomylodon uccasamamensis*, together with the poorly-known *Glossotheriopsis pascuali*, is the smallest Mio-Pliocene mylodontine, whereas new phylogenetic analyses stress the close relationship between *Simomylodon uccasamamensis* and the late Miocene mylodontine *Pleurolestodon acutidens* from Argentina. Preliminary studies on the enlarged sample of this Andean mylodontid species suggest the presence of moderate sexual dimorphism, recognizable in both shape and size. These observations are in accordance with those made for some Pleistocene sloths (e.g., *Paramylodon* and *Eremotherium*), suggesting that sexually dimorphic sloth taxa were already present in the Pliocene Epoch. *Simomylodon uccasamamensis* also appears to be an endemic taxon of the Andean highlands during the Pliocene, consistently recovered from this area throughout the Montehermosan, Chapdamalalan, and early Marplatan South American Land Mammal Ages. This sloth may have been specifically adapted to the ecological conditions prevailing in the Bolivian Altiplano at this time, a span falling between the South American Mio-Pliocene faunal turnover and the Great American Biotic Interchange.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A PHYTOSAUR MASS DEATH SITE FROM THE UPPER TRIASSIC CHINLE FORMATION IN UTAH: IMPLICATIONS FOR THE ADAMANIAN–REVUELTIAN FAUNAL TURNOVER

GAY, Robert J., Colorado Canyons Association, Grand Junction, CO, United States of America; UGLESICH, Jessica, University of Texas San Antonio, San Antonio, TX, United States of America; JENKINS, Xavier, Arizona State University, Tempe, AZ, United States of America; MILNER, Andrew R., St George Dinosaur Discovery Site at Johnson Farm, St. George, UT, United States of America

In the summer of 2016, field crews from the Museums of Western Colorado (MWC) discovered a laterally extensive bone bed in the Upper Triassic Chinle Formation. Preliminary excavations of the site began in 2017 and continued in 2018. This site, named Portal to NeCrocPolis (P2N), has since yielded new data on the Late Triassic life in southeastern Utah.

Although a stratigraphic section through the site has not yet been completed, P2N is located in approximately the middle of the Chinle Formation as preserved in the White Canyon area. The P2N quarry sits 9 meters above a locally extensive channel sandstone in the middle of the formation that may represent a capping sandy unit of the Moss Back Member recognized from the region. Therefore, the P2N bonebed is in the Petrified Forest Member and above the Adamanian–Revueltian faunal turnover. It would also indicate a ~10 million year ghost lineage for the taxon and represent the only non-pseudopalatine survivor of the extinction.

The site is laterally extensive, covering at least 62 meters of outcrop. All in situ bone has been recovered from a single layer; a vertisol directly beneath a thin (<10 cm) sandstone. All diagnostic material thus far pertains to a single taxon, the phytosaur *Pravusuchus*, of which at least three individuals are present. This is calculated from the number of cranial and limb elements; one looted but recovered by Petrified Forest National Park staff and at least two partially recovered by the MWC crew in 2017. Based on limb elements there are at least two size classes of phytosaur present in the quarry.

The presence of multiple individuals with articulated postcrania (none have been recognized previously from *Pravusuchus*) allow us new insights into the osteology of *Pravusuchus*. Additionally, the mass deposit has the potential to provide new data on Late Triassic paleoecology from southeastern Utah. The stratigraphic uncertainty and the occurrence of *Pravusuchus* (a non-pseudopalatine phytosaur) in Utah raises some interesting questions. We favor the current lithostratigraphic work done by others, and hypothesize that *Pravusuchus* from the P2N quarry may represent a new taxon.

Grant Information

Fieldwork has been supported by multiple grants from Canyonlands Natural History Association and a BLM National Conservation Lands science support grant.

Technical Session VI (Thursday, October 18, 2018, 11:00 AM)

HISTOLOGICAL SKELETOCHRONOLOGY OF THE EARLY PERMIAN STEM LISSAMPHIBIAN *DOLESERPETON*

GEE, Bryan M., University of Toronto at Mississauga, Mississauga, ON, Canada; REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada

The amphibamid temnospondyl *Doleserpeton annectens* from the early Permian karst deposits of Richards Spur, Oklahoma is generally accepted as one of the most closely related taxa to lissamphibians under hypotheses supporting either a batrachian or a lissamphibian origin from the clade. Although the cranial anatomy of the taxon has been extensively studied with respect to morphological features such as the dentition, less attention has been directed toward the postcranial skeleton or to ecological aspects of its paleobiology. In particular, the appendicular skeleton offers great opportunities for advancing our understanding of both small terrestrial temnospondyls and the greater issue of lissamphibian origins.

Here we present histological growth series of femora and humeri that offer new insights into the ontogeny of *Doleserpeton*. The abundance of available material of this small amphibamid at the Richards Spur locality permits broader histological sampling and more detailed ontogenetic studies than have been performed for any other fossil amphibian. By sampling several dozen long bones, we were able to provide qualitative and quantitative constraints on variation in ontogeny. Although the general pattern of correlation between age, indicated by lines of arrested growth (LAG's), and parameters of bone size holds true, some degree of variation is noted in the sample. This could be induced by ecological factors and appears to indicate the presence of developmental plasticity in this stem lissamphibian. Our detailed histological examination of *Doleserpeton* also provides additional information on the inferred paleoenvironment of the locality. Spacing between LAGs remains relatively constant throughout ontogeny, indicating a constant rate of cyclical growth throughout the animal's lifetime that could reflect consistent, repetitive seasonal patterns at the locality. However, closely paired LAGs (double LAGs) are found in some specimens, which is probably indicative of a wide range of seasonal environments that resulted in two cessations of growth within a single temporal cycle. This histological analysis thus contributes new information on the ecology and development of this stem lissamphibian in the context of the unique Richards Spur locality. Planned future work using this large sample will evaluate the sensitivity of growth curve reconstructions of *Doleserpeton* to variable sampling parameters (e.g., sample size).

Grant Information

This work was funded by an NSERC Discovery Grant to RRR and the University of Toronto.

Technical Session III (Wednesday, October 17, 2018, 2:00 PM)

NEW SPECIMENS OF *CORONODON HAVENSTEINI* PROVIDE INSIGHTS INTO THE TRANSITION FROM RAPTORIAL TO FILTER FEEDING IN WHALES

GEISLER, Jonathan, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; BEATTY, Brian L., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; BOESSENECKER, Robert W., College of Charleston, Charleston, SC, United States of America

Coronodon havensteini is an Oligocene toothed mysticete, currently represented by the holotype and only known specimen. Phylogenetic analyses place it as the most basal mysticete, and a synthesis of morphology and dental wear indicate that it engaged in both raptorial and tooth-based, filter feeding. Given its basal position, it likely represents a key transitional stage in the evolution of baleen. Two new specimens of *Coronodon* (CCNHM 164, 166) provide an important opportunity to test the feeding behavior inferred from the holotype. Both new specimens include the braincase, petrosals, numerous teeth, partial mandibles, and various vertebrae. CCNHM 164 also includes a partial scapula, not known in the holotype, and in combination with CCNHM 166, includes the first representatives of the P4, M1, M3, and m3 for this taxon. CCNHM 164, like the holotype, was recovered from the lower Oligocene Ashley Formation (30 Ma), whereas CCNHM 166 was collected from the upper Oligocene Chandler Bridge Formation (25 Ma); a range extension of 5 million years. The m2s in the new specimens and the right m1 in CCNHM 166 exhibit apical wear on the mesial accessory cusps, whereas the distal accessory cusps are essentially unscathed. This includes the basal cusps sheltered by the preceding tooth, supporting the hypothesis that this wear formed when small prey impacted the mesial cusps while water escaped through the narrow slots between teeth. A very different pattern is seen in the right and left p3 and p4 in CCNHM 166. The distal cusps on the p3 and the mesial cusps on p4 have been obliterated, indicating that they impacted hard prey. Similar dental damage occurs on the premolars of *Basilosaurus*, which was likely caused by macrophagy, including feeding on juvenile whales. The incisors/canines in CCNHM 164 are slightly worn, whereas two of these teeth in CCNHM 166 exhibit spalling of the crown, also indicative of macrophagy. Taken together, these specimens support the hypothesis that *Coronodon* engaged in macrophagy and filter feeding, and underscores the challenges for reconstructing the behaviors of extinct species based on the limited sample provided by the fossil record. Finally, all three specimens of *C. havensteini* have a single band of probable enamel hypoplasia, suggesting that the life history of *Coronodon* featured a stressful interval. Future isotopic work may be able to determine whether this formed during weaning, or alternatively, during the transition from pure macrophagy to a mix of macrophagy and filter feeding. Grant Information

This research was supported by grant NSF EAR-1349607.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

CHRONOLOGY OF THE LATE MIOCENE (LATE HEMPHILLIAN) SAN JUAN FAUNA, CHAMITA FORMATION, NEW MEXICO

GENSLER, Philip, U. S. Bureau of Land Management, Santa Fe, NM, United States of America; MORGAN, Gary S., New Mexico Museum of Natural History, Albuquerque, NM, United States of America; ABY, Scott, Muddy Spring Geology, Dixon, NM, United States of America; KONING, Daniel, New Mexico Bureau of Geology and Mineral Resources, Socorro, NM, United States of America

The late Miocene San Juan Fauna is derived from the Chamita Formation in the Española Basin of northern New Mexico. Mammalian biochronology, radioisotopic dates, and magnetic polarity stratigraphy establish an early late Hemphillian (Hh3) North American land mammal age (NALMA) for the San Juan Fauna. Four local faunas or quarries from approximately the same stratigraphic interval in the upper Chamita Formation have produced the mammalian fossils that characterize the San Juan Fauna: Black Mesa Quarry, Lyden Quarry, Rak Camel Quarry, and San Juan Quarry. The last three of these quarries were discovered and excavated by the Frick Laboratory of the American Museum of Natural History in the mid 20th century. The San Juan Fauna contains 24 species of mammals, more than half of which (15 species) are typical of late Hemphillian (Hh3/Hh4)

faunas, including three canids, *Canis ferox*, *Eucyon davisi*, and *Vulpes stenognathus*; two mustelids, *Pleisogulo marshalli* and *Pliotaxidea garberi*; a felid, *Adelphailurus kansensis*; three equids, *Astrohippus ansae*, *Dinohippus interpolatus*, and *Neohipparion gidleyi*; two rhinocerotids, *Aphelops mutilus* and *Teleoceras hicksi*; two camelids, *Megatylopus matthewi* and *Pleiolama vera*; a leporid, *Hypolagus gidleyi*; and a castorid, *Dipoides williamsi*. The San Juan Fauna is found in the 50-m-thick upper tuffaceous zone (UTZ) in the upper Chamita Formation and is bracketed by two $^{40}Ar/^{39}Ar$ dates on tephras (volcanic ash deposits). A tephra at the base of the UTZ, within ~5 m of the primary fossil-bearing horizon, the so-called 'San Juan-Rak Camel Quarries horizon,' has a date of 7.03 ± 0.05 Ma and a second tephra in the upper part of the UTZ, above the main fossil-bearing horizon, has a date of 6.87 ± 0.03 Ma (both dates relative to Fish Canyon Tuff standard of 28.201 Ma). The UTZ is reversely magnetized and correlates with Chron 3Ar, which has an age range of 6.73–7.14 Ma. San Juan is among the best dated Hh3 vertebrate faunas, with an age range of about 0.3 Ma (6.73–7.03 Ma) within the broader time interval of the early late Hemphillian NALMA (~6–7 Ma). The precise dating of the San Juan Fauna helps constrain the age of other correlative Hh3 faunas in western North America that are not as well-dated, including Coffee Ranch, Texas ('type' Hemphillian fauna); Optima (= Guymon), Oklahoma; Edson, Kansas; ZX Bar, Nebraska; and Redington and Wikieup, Arizona.

Grant Information
Funding to conduct the field work and research for this project was provided by the U. S. Bureau of Land Management.

Technical Session XVI (Saturday, October 20, 2018, 8:45 AM)

THE BIOMECHANICS BEHIND EXTREME OSTEOPHAGY IN *TYRANNOSAURUS REX*

GIGNAC, Paul M., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America; ERICKSON, Gregory M., Florida State University, Tallahassee, FL, United States of America

Most carnivorous mammals can pulverize skeletal elements by generating tooth pressures between occluding teeth that exceed cortical bone shear strength, thereby permitting access to marrow and phosphatic salts. Conversely, carnivorous reptiles have non-occluding dentitions that engender negligible bone damage during feeding. As a result, most reptilian predators can only consume bones in their entirety. Nevertheless, North American tyrannosaurids, including the giant (13 meters long) theropod dinosaur *Tyrannosaurus rex*, stand out for habitually biting deeply into bones, pulverizing and digesting them. How this mammal-like capacity was possible, absent dental occlusion, is unknown. Here we analyzed *T. rex* feeding behavior from trace evidence, estimated bite forces and tooth pressures, and studied tooth-bone contacts to provide the answer. We show that bone pulverization was made possible through a combination of: (1) prodigious bite forces (8,526–34,522 newtons) and tooth pressures (718–2,974 megapascals) promoting crack propagation in bones, (2) tooth form and dental arcade configurations that concentrated shear stresses, and (3) repetitive, localized biting. Collectively, these capacities and behaviors allowed *T. rex* to finely fragment bones and more fully exploit large dinosaur carcasses for sustenance relative to competing carnivores.

Grant Information
National Science Foundation (no. 1450850) and the Committee for Research and Exploration of the National Geographic Society (no. 7026–01)

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A NEW DINOSAUR PARK FORMATION (LATE CRETACEOUS, CAMPANIAN) MICROVERTEBRATE LOCALITY FROM SOUTHWEST SASKATCHEWAN: IMPLICATIONS FOR PALEOENVIRONMENTAL CONTROLS ON SPECIES ALPHA DIVERSITY

GILBERT, Meagan M., University of Saskatchewan, Saskatoon, SK, Canada; BAMFORTH, Emily L., Royal Saskatchewan Museum, Eastend, SK, Canada

The Dinosaur Park Formation (DPF) of Alberta and the equivalent upper Judith River Formation in Montana, have been the subject of a wide range of paleontological studies. Outcrops of the Dinosaur Park Formation are far less common and extensive in Saskatchewan when compared to Alberta and Montana but are fossiliferous. Studying the floras and faunas of the DPF throughout the depositional basin allows for studies of spatial beta diversity trends, particularly in relation to proximity to the paleocoastline as a biodiversity driver. Herein, we describe a new DPF locality in Saskatchewan known as Woodpile Coulee.

The site is located in the extreme southwest corner of the province of Saskatchewan 520km north of Billings, Montana. Outcrops occur near the United States/Canada boundary and the Alberta border in Township 27, Range 1. Here, the DPF consists of extensive coal seams, muds, silts, and fine-grained sands highly influenced by small-scale transgressive-regressive cycles. The microsite is situated very near the DPFs contact with the Bearpaw Formation, a transgressive marine shale.

The Woodpile Coulee microsite contains at least 36 different paleospecies. The paleocommunity identified is unique in Saskatchewan, containing several taxa that are rare or unknown elsewhere in the province. Among the dinosaur species present are nodosaurs (*Edmontonia* sp. and *Panoplosaurus* sp.), the pachycephalosaur *Stegoceras* sp., hadrosaurs, ceratopsians, a small hypsolophodont (cf. *Thescelosaurus* sp.), tyrannosaurids, in addition to several small theropods, including *Troodon* sp. Crocodile material (cf. *Leidyosuchus* sp.), champsosaurs, at least two families of turtles (baenids and trionychids), and a broad diversity of cartilaginous and bony fishes from several different orders.

The fauna recovered from Woodpile Coulee was compared with another DPF assemblage found in Saskatchewan (the Lake Diefenbaker site, located 350km to the north). Non-parametric species estimators (i.e. Jackknife-2) imply a higher alpha ('within site') diversity at Woodpile Coulee, but also imply the sample is less complete than Lake Diefenbaker. We suggest this disparity is related to paleoenvironmental conditions that persisted in the extreme southwest of Saskatchewan at the time of deposition. Woodpile Coulee is unique in terms of biodiversity and depositional environment relative to Lake Diefenbaker. This study provides important insights into our current understanding of the DPF in Saskatchewan and diversity across the western interior during the Late Cretaceous.

Technical Session XIV (Saturday, October 20, 2018, 8:15 AM)

ENDOSKELETAL ANATOMY OF PLATYSOMIDS SUPPORTS A CARBONIFEROUS ORIGIN FOR CHONDROSTEI

GILES, Sam, University of Oxford, Oxford, United Kingdom; FRIEDMAN, Matt, University of Michigan, Ann Arbor, MI, United States of America

Chondrostei is one of the four major actinopterygian groups, with around 25 living species. Molecular divergence estimates indicate that chondrosteans diverged from other ray-finned fishes in the Carboniferous, a time period in which actinopterygian fossils are known in abundance. Despite this extensive record, a conspicuous gap remains on the chondrostean stem. Although saurichthyids have traditionally been afiiliated with the group, recent analyses posit a stem neopterygian affinity. As such, the oldest recognised fossil chondrosteans are Early Jurassic (~195 Ma) in age, some 135 million years after the predicted origin of the group, and already display profound anatomical specialisations. Playtsomids have recently been suggested as branching from the chondrostean stem, albeit with limited support. Despite the abundance of platysomids in the fossil record (~15 species known from worldwide deposits), most are known only from two dimensional and largely postcranial remains, with the head skeleton either disarticulated or badly crushed. Here, we use CT scanning to investigate the internal anatomy of a three-dimensionally platysomid cranium preserving the braincase, hyoid arch, gill skeleton, palate and shoulder girdle. The elongate parasphenoid is held almost vertically, articulating with a narrow median vomer anteriorly and bearing a bifurcate posterior stalk. The triangular maxilla is underlain by a fenestrate l-shaped palate, which is mobile with respect to the braincase and cheek. The gill skeleton supports a large basihyal toothplate, contributing to a tongue bite. CT scanning of *Chondrosteus*, an unequivocal chondrostean, reveals a previously misidentified beak-like maxilla, reminiscent of that seen in platysomids. Phylogenetic analyses uphold a chondrostean affinity for platysomids, as well as providing support for a close relationship between bobosatraniids and the broader chondrostean group. Our results extend the chondrostean fossil record back ~130 million years, highlighting unexpected morphological diversity at the roots of Chondrostei, with downstream effects helping to refine palaeontological timescales relating to the origin and divergence of the living actinopterygian radiations.

Grant Information
Junior Research Fellowship, Christ Church; Royal Society Dorothy Hodgkin Research Fellowship; U-M College of LSA, Earth and Environmental Sciences.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

ONTOGENETIC CHANGE IN DISTAL AND PROXIMAL LIMB BONES OF JUVENILE PLEISTOCENE COYOTES (*CANIS LATRANS*) AND DIRE WOLVES (*CANIS DIRUS*) FROM THE RANCHO LA BREA TAR PITS, CALIFORNIA

GILLESPY, Patrick D., Cal Poly Pomona, Pomona, CA, United States of America; PROTHERO, Donald R., Pierce College, Los Angeles, CA, United States of America

Large sample sizes of juvenile animal fossils recording the entire ontogenetic growth series of an organism are rare compared to their adult counterparts. However, the natural asphalt seeps of the Rancho La Brea Tar Pits have yielded spectacular quantities of specimens young and old, allowing for a more complete investigation of ontogenetic trends. We collected long bone length, thickness, and circumference data from three canid species; Pleistocene coyotes (*Canis latrans*) and dire wolves (*Canis dirus*), as well as modern gray wolves (*Canis lupus*). Standardized major axis bivariate regressions were used to determine the ontogenetic change in limb bones and the deviation from the line of isometry. Using regression slopes as a proxy for long bone allometry, we were able to compare the growth patterns of the extinct canids to other cursorial animals and their modern counterparts. We found that long bone growth series are positively allometric, with bones growing longer faster than they do thicker. The degree of allometry is more pronounced in the gracile distal elements than the relatively robust proximal elements. As expected of animals adapted to a running lifestyle, this increasing gracility would allow for a more efficient running locomotion behavior. This would be beneficial while hunting, much like the modern gray wolf when in pursuit of smaller and faster prey. These statistical results show that coyote and dire wolf growth series are typical of other cursorial animals during ontogeny, regardless of climatic influences on body size changes during the glacial and interglacial periods of the Pleistocene.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

INCLUDING ALL AUDIENCES: INTERPRETATION AND EDUCATION OPPORTUNITIES AT JOHN DAY FOSSIL BEDS NATIONAL MONUMENT

GLADISH, Sandra L., National Park Service, John Day Fossil Beds NM, Kimberly, OR, United States of America; FAMOSO, Nicholas A., National Park Service, John Day Fossil Beds NM, Kimberly, OR, United States of America

The mission of the United States National Park Service (NPS) is to preserve unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations. This dual mission can be exemplified by the collaborative nature of the NPS museum and interpretation programs and how they are implemented at each NPS unit. The museum and interpretation programs work jointly to not only preserves the resources on NPS-administered lands, but to provide educational opportunities for the public and answer the "so what" questions when visitors inquire about the resources.

John Day Fossil Beds National Monument (JODA) in central and eastern Oregon uses casts of museum specimens, along with continually updated lesson plans to meet national STEM requirements, in a horse fossil traveling teaching kit that is used by many K–12 educators in their classrooms as well as for outreach programs. JODA's museum gallery displays a variety of original fossils and casts that tell the story of changing climates and evolution and are often used as part of curriculum for elementary through high schools and colleges around the region.

Recently, the museum and interpretation programs at JODA have been collaborating on some new ventures for inclusiveness and accessibility. Utilizing the Artist-in-Residence program, a ceramic artist will be creating tactile, 3-Dimensional exhibits of fossils jaws. The end product will add a much needed touchable element to JODA's exhibits, providing a more in-depth experience for all JODA visitors. The artist will be following NPS guidelines to ensure the exhibit meets standards of accessibility. The exhibit should be

finalized by summer 2019. Facebook Live was also used to provide a behind-the-glass tour of the museum operations at JODA. Presented in the winter, this event was a unique opportunity for visitors to virtually visit JODA and discover the other side of the lab glass to witness fossil operations typically reserved for JODA museum staff and volunteers or researchers. Visitors from all over the United States, including Alaska, visited JODA that day. By expanding programmatic opportunities at JODA and utilizing the practice of universal design, meaningful connections to JODA's fossilresources are enhanced and all visitors benefit.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

SHE FOUND FOSSILS: A CROWDFUNDED, MULTI-LINGUAL, SELF-PUBLISHED, CHILDREN'S BOOK ABOUT WOMEN IN PALEONTOLOGY

GOLD, M. Eugenia L., Suffolk University, Boston, MA, United States of America; WEST, Abagael R., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America

She Found Fossils is a crowdfunded, multi-lingual (English, Spanish, Mandarin) book about women in paleontology. The aim of the project was to highlight the history of women in paleontology, our present diversity and global distribution, and showcase up-and-coming young scientists. Our goal was to create a book that would provide dozens of role models of various ethnicities and career paths in paleontology for children worldwide. To accomplish this project, we used Kickstarter to raise the funds needed for illustration and translation into Spanish. In 1 month of fundraising, we exceeded our goals and were able to fund the translation into Mandarin. Once funding was secured, we reached out to dozens of established paleontologists from across the world to invite them to contribute to the book by answering a list of questions about their educational history, research, day-to-day activities, and challenges they have faced. We researched historical paleontologists by reading their biographies or autobiographies and used social media to identify and engage with students and recent graduates in paleontological fields. For each historical and presently established paleontologist, we wrote a short biography of about 200 words. We became familiar with the reading level of our target audience (as young as age 8), finding that we needed to use a simpler style and structure than we had initially. Some draft biographies were sent to Duke School, North Carolina, for the third grade class to read and review. These children provided excellent feedback and we took many of their suggestions (e.g., a glossary, an additional map, and name pronunciation guides). After writing, we integrated the biographies, photos, and illustrations into a dynamic and colorful layout, using open-source fonts. Finally, we uploaded the whole book to CreateSpace, Amazon's free self-publishing service.

We have partnered with First Book, a non-profit organization that provides books to underserved communities around the US and to 30 nations, to distribute the book for free or at a discount, depending on the needs of the community.

Crowdfunding is an excellent resource for projects that may not be supported by traditional means. Our ongoing challenge is distribution to bookstores. Most stores buy wholesale through established channels, and lack a protocol for self-published work. CreateSpace has several resale discount schemes, but none competitive with standard publishers' rates. This is a particularly serious obstacle for the retailers most interested in our book: independent bookstores.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

BONE HISTOLOGY AND GEOCHEMICAL TAPHONOMY OF ARCTIC CENTROSAURINE CERATOPSIDS FROM THE KIKAK-TEGOSEAK QUARRY (NORTH SLOPE, ALASKA)

GOLDSMITH, Erika R., Temple University, Philadelphia, PA, United States of America; TUMARKIN-DERATZIAN, Allison R., Temple University, Philadelphia, PA, United States of America; PADALKAR, Mughda V., Temple University, Philadelphia, PA, United States of America; GRANDSTAFF, David E., Temple University, Philadelphia, PA, United States of America; FIORILLO, Anthony R., Perot Museum of Nature and Science, Dallas, TX, United States of America; ASH, Richard D., University of Maryland, College Park, MD, United States of America; PLESHKO, Nancy, Temple University, Philadelphia, PA, United States of America; CHEMTOB, Steven M., Temple University, Philadelphia, PA, United States of America

Histological, mineralogical, and geochemical analyses of *Pachyrhinosaurus perotorum* ribs were conducted to investigate growth dynamics of this Arctic taxon, as well as diagenetic and taphonomic characteristics of the Kikak-Tegoseak Quarry (KTQ). Cyclical growth is preserved in six ribs, allowing for the ontogenetic identification of one juvenile (DMNH 23891), 4 sub-adults (DMNH 21574, 24384, 24228, and 23888), and one adult (DMNH 24237). Radial and reticular fibrolamellar bone is prevalent in juvenile and sub-adult individuals, indicating rapid growth during ontogeny. Secondary remodeling is higher than previously reported in dinosaur rib histology, which can be attributed to differences in element-specific growth rate, environmental stresses, or biomechanical stresses. However, more histological studies of *P. perotorum* comparing growth between different post cranial long bones are necessary to constrain the controls on secondary bone formation in this species.

Mineralogical and geochemical data were collected using X-ray diffraction (XRD), Attenuated Total Reflectance-Fourier Transform Infrared (ATR-FTIR) spectroscopy, and Laser-Ablation Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS). Bones display a more crystalline apatite lattice structure based on narrower XRD full width-half maximum (FWHM) values (0.29–0.35°) and higher ATR-FTIR infrared-splitting factor (IR-SF) values (3.3–3.6) in comparison to modern bone. Calculated apatite crystallite sizes are larger than in non-fossil bone. Specimens identified as float material during field excavation show the highest IR-SF values and largest apatite crystallite sizes. ATR-FTIR spectra reveal elevated carbonate due to the addition of B-type carbonate into the apatite lattice. Relative amounts of carbonate correlates with ontogeny, which could reflect a biological signal; however, diagenetic alteration cannot be ruled out. REE data yield variable spider diagrams and diffusion profiles between bones indicating the preservation of different redox conditions and diffusion periods. Previous studies have interpreted variable REE patterns within a single stratigraphic unit as characteristic of taphonomic reworking (spatial and/or temporal). However, this is not supported by physical taphonomic data (e.g., weathering and abrasion) in the KTQ, suggesting a more complex taphonomic history than originally reported.

Grant Information

This work was funded by the Delaware Valley Paleontological Society (DVPS) and Temple University Department of Earth and Environmental Science.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THREE-DIMENSIONALLY PRESERVED DREPANOSAUROMORPH REMAINS FROM THE SONSELA MEMBER (CHINLE FORMATION, NORIAN) OF PETRIFIED FOREST NATIONAL PARK, ARIZONA

GONÇALVES, Gabriel S., University of Washington, Seattle, WA, United States of America; PEECOOK, Brandon R., Field Museum, Seattle, WA, United States of America; SIDOR, Christian A., University of Washington, Seattle, WA, United States of America

Drepanosauromorphs have most recently been placed as an early diverging clade of non-saurian diapsids that includes a total of seven genera and contains *Avicranium, Dolabrosaurus, Drepanosaurus, Hypuronector, Kyrgyzsaurus, Megalancosaurus,* and *Vallesaurus*. The biogeographic distribution of drepanosauromorphs extends across Europe (Italy, U.K.), North America (Arizona, New Mexico, New Jersey) and Asia (Kyrgyzstan). The temporal range of their known fossil record is restricted to the Middle and Late Triassic (Ladinian–Rhaetian), but their early divergence gives the clade a long ghost lineage extending back to at least the middle Permian and thus across the Permo– Triassic boundary. Most drepanosauromorph holotypes are two-dimensionally preserved specimens that are partially to fully complete and articulated skeletons. Here we report on isolated and three-dimensionally preserved cervical vertebrae and mid-dorsal vertebrae of at least one drepanosauromorph taxon from a particularly productive bonebed locality in the Upper Triassic Chinle Formation that has also produced hundreds of elements referable to pseudosuchians, dinosauriforms, stem archosauromorphs, and temnospondyls. The taphonomic conditions that produce isolated, three-dimensionally preserved elements, require the presence of apomorphies for the positive referral of a bone to a particular taxon. Some of the synapomorphies used to diagnose the clade drepanosauromorpha that are present in the Chinle specimens are: (1) centrum of the postaxial cervical vertebrae are heterocoelous; (2) the presence of a single rib facet on the posterior dorsal vertebrae; (3) anterior cervical vertebra contains a hypapophysis on the posteroventral surface of centrum that exhibits massive posteroventrally projecting crest; and (4) the presence of fusion of the centra of the mid-dorsal vertebrae to mid-dorsal ribs. The occurrence of three-dimensionally preserved elements of a drepanosauromorph in the Sonsela Member of the Chinle Formation (220–213 Ma; mid-to-upper Norian) does not extend the biostratigraphic range of the clade, but it does flesh out the biogeographic range of drepanosauromorphs in North America.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

FIDELITY OF "TRADITIONAL" VS "NEW TECH" METHODS OF FOSSIL REPRODUCTION

GONZALEZ, Glen, Boone, NC, United States of America; HECKERT, Andrew B., Appalachian State Univ, Boone, NC, United States of America; ZIMMER, Brian, Appalachian State University, Boone, NC, United States of America

When replicating a fossil for public outreach or research, paleontologists and fossil preparators use different techniques, such as molding and casting, in order to accurately duplicate the specimen. With modern technology, 3D modeling and printing can prove to be an effective alternative to displaying similar detail as the original specimen. However, detailed, quantitative comparisons between these methods are rare in paleontology. We generated a 3D model of a tooth of the giant shark *Carcharocles megalodon* using a Nikon digital camera and the computer program Agisoft Photoscan. After completion of the 3D model, the file was converted into a .stl file to be used for 3D printing. We measured the 3D model, 3D print and a cast made from Smooth-Cast® 320 liquid plastic poured in a Mold Star™ 16 FAST platinum-based silicone rubber mold. All measurements followed protocols established from previous studies. The measurements were compared to those of the original specimen, taking into consideration dimensional changes and percent error. Our research shows that the models were extremely similar to, but did not exactly replicate, the actual specimen. The average percent error was less in the cast (about 2%) and 3D model (also at about 2%), than that of the 3D print, which was significantly higher (30% when printed by a third party). This error may not be acceptable for individuals in research, but would be acceptable for outreach. Qualitatively, the 3D model depicts the original specimen most accurately. Refining and finishing techniques would have to be applied to the other replicas in order to achieve the same level of accuracy. Applications in 3D modeling and printing are diverse and can be employed with professionals working with specimens from long distances, without losing visual quality, and without the risk of damaging a specimen through delivery services. 3D modeling can be especially powerful in research due to its compatibility with virtual reality (VR), where an individual can manipulate the specimen as if they actually had it, provided they have the appropriate equipment. Molding and casting techniques are proven methods that can quickly provide multiple replicas, many of which are used for displays and public outreach events. Further studies into degradation of materials, short- and long-term costs, other logistics, and target audience preference (e.g., cast or 3D print for interactive displays) should be conducted in conjunction with studies such as this one to determine the best method within these practices.

Technical Session XVI (Saturday, October 20, 2018, 11:45 AM)

COMPARATIVE CRANIAL ANATOMY OF NEW, LONG-HORNED, FLAT-HEADED ONTOGIMORPHS OF *PACHYCEPHALOSAURUS* (DINOSAURIA, ORNITHISCHIA) FROM THE HELL CREEK FORMATION, MONTANA REVEALS NOVEL FEATURES IN THE SKULL

GOODWIN, Mark B., University of California Berkeley, Berkeley, CA, United States of America; EVANS, David C., Royal Ontario Museum / University of Toronto, Toronto, ON, Canada; CARROLL, Nathan R., University of Southern California, Los Angeles, CA,

United States of America; WOODRUFF, Cary, Toronto, ON, Canada; WILSON, John, Bozeman, MT, United States of America
Two new partial skulls of the "*Dracorex*" ontogimorph of *Pachycephalosaurus* allow reappraisal of the cranial anatomy of the holotype TCMI 2004.17.1. ROM 53579 comprises a nearly complete, articulated cranium and lower jaws. CCM V2014-1A-1 preserves a right squamosal with an elongated central horn in articulation with the parietal, paired unfused frontals plus a partial braincase and nasal rosette.
We confirm that there is only one postorbital ossification in the skull, not two as previously interpreted in the holotype. Accompanying posterior supraorbital ornamentation is identical in the ROM skull and holotype. Well-defined sutural contacts indicate the frontoparietal suture is more posteriorly positioned than illustrated in the holotype skull. The parietal bisects the squamosal shelf posteriorly in the CCM and ROM skulls. The parietal remains behind the squamosal shelf in the holotype and end-stage juvenile squamosal ROM 53665. Exclusion of the parietal from the squamosal bar appears to persist through early ontogeny until elongation of the distinctive squamosal horns occurs prior to doming of the frontoparietal. This pattern supports the decoupling of horn elongation and frontoparietal doming. In all four partial skulls in this study, short and elongated squamosal horns ornament the squamosals on flat-headed individuals. In the ROM skull, the paired nasals meet along a patent irregular suture. A pair of robust pyramidal nodes sit transversely across the midline (=posterior nasal ring in the holotype). Both nasals preserve a stepped-down slip of bone that contributes to an overlapping sutural contact with a new and previously unreported paired separate "epinasal" ossification (=supernarial or anterior nasal ring in the holotype). This epinasal is ornamented by a central pyramidal node surrounded by a cluster of secondary smaller, rounder nodes. Another unexpected novel feature in the ROM skull is the presence of laterally compressed, serrated anterior dentary teeth with medial vertical ridges. This skull also preserves the predentary for the first time in *Pachycephalosaurus*.
Variation in several traits between specimens appears to be independent of doming, a proxy for maturity, and potential stratigraphic position. Confirmation of the stratigraphic occurrence of dozens of *Pachycephalosaurus* skulls is ongoing. Preliminary results suggest (1) the restriction of known ontogimorphs to specific horizons in the Hell Creek Formation and (2) clarify the evolution and cranial ontogeny of this enigmatic Late Cretaceous dinosaur.
Grant Information
National Science Foundation EAR-1053370 to MBG. Natural Sciences and Engineering Research Council of Canada Discovery Grant (NSERC Grant File Number: RGPIN 355845) to DCE.

Technical Session XVI (Saturday, October 20, 2018, 10:45 AM)

A NEW TITANOSAURIAN SAUROPOD DINOSAUR FROM THE MID-CRETACEOUS MTUKA MEMBER (GALULA FORMATION) OF TANZANIA AND POTENTIAL FAUNAL CONNECTIONS WITH THE EARLY CRETACEOUS DINOSAUR BEDS OF MALAWI
GORSCAK, Eric, Field Museum of Natural History, Chicago, IL, United States of America; O'CONNOR, Patrick M., Ohio Univ, Athens, OH, United States of America
The past two decades of field exploration of the African continent has augmented the patchy Cretaceous fossil record and advanced our understanding of the land-living vertebrates during the last period of the Mesozoic. For example, efforts in the Cretaceous Galula Formation exposed in southwestern Tanzania have unearthed significant fossil discoveries in concert with revised geology and stratigraphic ages for its two recognized members, the mid-Cretaceous Mtuka (MM) and the Late Cretaceous Namba Members (NM). Currently, the NM is the best known unit of the two and has yielded mesoeucrocodyliform and titanosaurian sauropod dinosaur fossils. The revised age of the NM together with the recently described titanosaurians further support it as a distinct unit from the neighboring Aptian Dinosaur Beds (DB) of Malawi. However, the relative paucity of vertebrate materials from the lesser-known MM remain to be fully assessed for any faunal associations with either the NM and DB faunas.
A new titanosaur from the MM is one of the most complete titanosaurian individuals recovered from mainland Africa, preserving teeth, portions from all major regions of the axial skeleton, and both sets of appendicular girdles and limbs, including a complete metatarsus. Several characters diagnosis the new titanosaur, including: absence of the interpostzygapophyseal lamina in posterior dorsal vertebrae and prominent posterolateral expansions of middle–distal caudal vertebral bodies. Phylogenetic analyses place the Mtuka titanosaurian and *Malawisaurus* from the DB either within a paraphyletic grade (parsimony and uncalibrated Bayesian analyses) or as sister taxa (Bayesian tip-dating analyses). Several characters support a close relationship with *Malawisaurus*, including tooth morphology and posterolateral expansion of the middle-distal caudal centrum (a trait less developed in *Malawisaurus*).
Given this new information based on recently described African titanosaurians, the Galula Formation presents two different temporal perspectives on the Cretaceous of mainland Africa. First, the mid-Cretaceous MM suggests potentially close faunal linkages with the adjacent DB of Malawi. Second, the Late Cretaceous NM exhibits a general Gondwanan signal with titanosaurians *Rukwatitan* representing an older African lineage and *Shingopana* more closely related South American forms. By contrast, northern African faunas differ with the Late Cretaceous *Mansourasaurus* from Egypt being more closely related to Eurasian titanosaurs.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

OUT OF GONDWANA: A RECORD OF THE CRETACEOUS COELACANTH *AXELRODICHTHYS* (ACTINISTIA, MAWSONIIDAE) FROM NIGER
GOTTFRIED, Michael D., Michigan State University, East Lansing, MI, United States of America; MCKEEBY, Ryan, Michigan State University, East Lansing, MI, United States of America
The Cretaceous mawsoniid coelacanth *Axelrodichthys* is well-known from the Cretaceous (Aptian–Albian) of Brazil, and in recent years has also been described from Cretaceous sites in Madagascar, Morocco, and southern France. This report focuses on a partial *Axelrodichthys* sp. skull roof collected at the Cretaceous (Aptian) 'Fish Mountain' site near Ingal (or In-Gall), Niger, by the 1988 Natural History Museum (London) Niger Expedition
The specimen (catalogued in the NHM as P.66196) consists of a portion of the posterior skull roof that preserves a median extrascapular, and surrounding dermal elements from the right side of the skull roof including a lateral extrascapular, partial postparietal, and supratemporal. The surface ornamentation on these bones is well-preserved and consists of divergent subparallel raised ridges, some of which bifurcate distally, separated by linear grooves and pits. The linear ridges are primarily arranged in orientation with the long axis of the skull roof. The nearly symmetrical and leaf-like shape of the median extrascapular on the Niger specimen is similar to (but notably larger than) that described from the Malagasy occurrence of *Axelrodichthys* sp., which was collected from the Santonian–Coniacian? Ankazomihaboka beds of northwestern Madagascar. The presence of a median extrascapular is integral to assigning the skull roof from Niger to *Axelrodichthys*, and not to the related mawsoniid genus *Mawsonia*, which has an extrascapular series but not a median element. We interpret the specimen from Niger as representing a new species within *Axelrodichthys* based on the overall arrangement and proportions of the posterior skull roof elements.
The record of *Axelrodichthys* to date suggests a late Early Cretaceous origin and middle to early Late Cretaceous diversification in western Gondwana. This was followed by apparent dispersal eastward to Madagascar, and also northward into southern Europe closer to the end of the Cretaceous, culminating with the geologically youngest occurrence of *Axelrodichthys* to date in the form of *A. megadromos* from the Campanian of southern France.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

TAPHONOMY AND PALEOECOLOGICAL IMPLICATIONS OF THREE PIT CAVE DEPOSITS IN THE BLACK HILLS OF SOUTH DAKOTA
GRAHAM, Russell W., Pennsylvania State University, University Park, PA, United States of America; PARDI, Melissa I., Vanderbilt University, Nashville, TN, United States of America; CHRISTINE, Joel A., Clarion University, Clarion., PA, United States of America
Three different pit cave deposits from two caves, Don's Gooseberry Pit (DGP) and Parker's Pit (PP), illustrate different taphonomic pathways that have implications for paleoecological interpretations. All three deposits were derived from small entrances that selected for fossils of small body size. DGP was filled to 1 meter of its surface opening. Excavations extended downward about 3 meters to the bedrock floor. Vertebrate fossils from near the top of the cave were mainly from animals such as toads, young rabbits, and small mice that could not escape from the shallow pit. Body size of animals increased with greater depth. This illustrates selection by 'trap effectiveness.' Until a depth that prohibits the escape of most animals is achieved, the species composition of the paleoecological sample is further biased by small body size. Deposits and fossils in DGP are also time averaged as revealed by radiocarbon dating. The mixing is incompletely understood but dating individual specimens of various species documents ecological replacement. PP's main entrance is a 12 m vertical drop to a large debris cone (MC1). Another plugged entrance (RC) provides an inclined ramp that allowed species to enter and exit the cave freely. Comparison of the age structures of populations of *Peromyscus* from the two deposits reveals that individuals from MC1 are significantly older than those from RC. We believe this results from survival of mice that fall into MC1 and unable to escape live in the predator-free cave, dying of 'old age.' In contrast, the younger sample from RC represents a predator-prey accumulation. This hypothesis is bolstered by the abundanceof weasel and field mouse remains as well as weasel bite marks on *Peromyscus* bones. In conclusion, all three deposits are biased by small body size that limits community and diversity analyses to micro-vertebrates. RC offers an opportunity for predator-prey analyses but prey selection restricts paleoevironmental studies. Upper levels of DGP are extremely biased for any type of paleoecological study but all deposits in MC1 and all levels, except for the upper most, of DGP yield the least biased micromammal records establishing a good foundation for paleoenvironmental studies.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A DIVERSE ASSEMBLAGE OF WHITE RIVER INSECTIVORES INDICATING A RESPONSE TO THE EOCENE–OLIGOCENE CLIMATE TRANSITION
GRANQUIST, Anna, University of New Mexico, Albuquerque, NM, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America
There is abundant evidence of a global cooling event spanning the Eocene–Oligocene boundary, but its impact on mid-latitude terrestrial faunas is relatively unknown. Here we examine the influence of this cooling on the insectivore fauna of the White River Group, using four assemblages from Toadstool Geologic Park, Nebraska and the surrounding area. The assemblages occur between 34.5 and 33.4 Ma, and two occur during the Eocene and two during the Oligocene, capturing any response to the Eocene–Oligocene Climate Transition (EOCT). More than 3000 total identifiable specimens were recovered from anthills at each of the four localities, of which more than 200 were insectivores; primarily preserved as dental elements. The studied assemblages preserve an unusually diverse assemblage of insectivores, rivalling that seen at the nearby but presently inaccessible Raben Ranch locality. Based on studies of the reaction of modern insectivores to climate change, we hypothesized that the relative abundances of the insectivore taxa preserved in the studied section should respond to EOCT-driven environmental change.
All four localities show a paucity of larger taxa, including limited numbers of some notable taxa such as Leptictis, which are abundant in other reported White River assemblages. Even accounting for sample size and taphonomic differences (by normalising to other well-preserved parts of the microfauna), there are considerably fewer insectivore specimens from the late Eocene, and that assemblage is considerably less diverse than the Oligocene assemblages. This suggests that, unlike the large mammal fauna of the White River Group, the insectivore fauna does show a response to the EOCT. The drivers of this response are less clear, although recent environmental shifts have caused changes in insectivore populations due to their direct impact on the arthropods on which they feed.
Grant Information
The work was funded by UNM Honors Research Institute Grant 18-01 and the Honors Senior Research Scholarship.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

CT IMAGING OF THE INTERNAL ANATOMY OF SLOTH CLAWS

GRASS, Andy, NYITCOM-AR, Jonesboro, AR, United States of America

One of the most immediately noticeable peculiarities about sloths, among many, are their large, curved claws. Indeed, the name *Megalonyx*, a giant ground sloth from North America named by Thomas Jefferson, means "great claw." Sloths have used their claws for a variety of purposes, including suspension from tree branches in modern sloths, hooking branches to pull food closer while eating, and digging gigantic burrows, which have been attributed to some genera of ground sloths. Large claws may also have contributed to the evolution of the pedolateral foot orientation in some ground sloths, where the fifth metatarsal is the primary weight bearing bone, and the dorsal surface of the foot faces laterally. As such, a sloth's claws are and were integral to their existence.

For this study, sloth claws were scanned in a Micro CT at the American Museum of Natural History, and these scans were segmented to view their internal anatomy. Both manus and pes claws from both genera of modern sloths, *Bradypus* and *Choloepus*, were scanned, as well as manus and pes unguals from the ground sloths *Megalonyx jeffersonii* and *Paramylodon harlani*, including specimens from the Tarkio Valley *M. jeffersonii* from the University of Iowa. Two of the ground sloth claws were broken on the ends, which revealed holes on the distal surface. It was unclear if these holes were natural, or the result of taphonomy or tools. The CT scan revealed that these holes are in fact passages for blood vessels and lead to discrete canals in the interior of the claw. These canals originate from external foramina on the lateral sides of the claws, which are next to very clear external vessel impressions. These two lateral canals come together to form one central canal, which then branches again more distally. *Bradypus* is considered to be basal to all other sloths, including the other modern sloth, *Choloepus*. Despite this phylogenetic distance, all of the sloths showed similar patterns of vascular canal branching. There tended to be more vessels on the volar side of the claws, perhaps to supply areas that are more used for touch and pressure sensation. It will be interesting to see if anteaters and armadillos, which also have large claws but use them for more strenuous digging activities than modern sloths, also show similar vasculature patterns and structure.

Technical Session XII (Friday, October 19, 2018, 2:15 PM)

OSTEOHISTOLOGY AND SKELETOCHRONOLOGY IN AN ONTOGENETIC SERIES OF *CLIDASTES* (SQUAMATA, MOSASAURIDAE): GROWTH AND METABOLIC RATES IN BASAL MOSASAURIDS

GREEN, Cyrus C., Fort Hays State University, Hays, KS, United States of America; WILSON, Laura E., Fort Hays State University, Hays, KS, United States of America

Previous histological studies of *Clidastes* have hypothesized higher growth rates in basal mosasaurids than varanids due to higher vascularity. These studies focused on adult specimens and did not look at ontogenetic changes in growth rates. Isotopic studies of *Clidastes* indicate high metabolic temperatures, leading to speculation these animals had either gigantothermic or endothermic metabolisms. Whether the growth rates in *Clidastes* are comparable to endothermic or ectothermic animals has not been studied. This study used osteohistology and skeletochronology to investigate ontogenetic changes in internal microstructure, determine age at the time of death, and estimate growth rates in *Clidastes* ontogeny.

Four humeri representing a size gradient in *Clidastes* were histologically analyzed. Skeletochronological ages of the four specimens are yearling (>1 year), juvenile (3–4 years), sub-adult (6–7 years), and possible adult (13–14 years). All humeri showed parallel-fibered bone as the main tissue type. Vascularity and growth rates decrease as size and age increase through *Clidastes* ontogeny. Primary osteons and radial canals seen in early ontogeny decrease until only longitudinal simple canals remain in late ontogeny. No growth marks are visible in the yearling, but previously published measurements of a smaller humerus were used to estimate yearling growth rates of 3–7µm/day. In the juvenile, growth rates in the second year of life are 1.7 µm/day. In the sub-adult, growth rates in years four and five are 1.6 and 1.75 µm/day respectively. In the largest humerus, growth rates in years eight through eleven are variable, but all are less than 0.80 µm/day. No humeri show evidence of skeletal maturity, though the slowing of growth in the largest humerus could represent sexual maturity.

Clidastes grew much faster during the first year of life. Growth slowed during the second year but continued at this same rate until after the sixth or seventh year where it slowed again. Except for the first year, growth rates in *Clidastes* are less than 2.0 µm/day. While this study did find that vascularity in *Clidastes* is greater than modern varanids, growth rates are more comparable to varanids than endothermic animals. Growth rates from this study support the gigantothermic rather than endothermic metabolic hypothesis for *Clidastes*.

Grant Information

This project was made possible by grants from the Western Interior Paleontological Society and Fort Hays State University.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

TESTING THE UTILITY OF CASSOWARIES AS LIVING MODELS FOR NON-AVIAN DINOSAUR CRANIAL ORNAMENTS

GREEN, Todd L., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America; GIGNAC, Paul M., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America

Complexly constructed cranial ornaments, consisting of multiple bony partitions (e.g., horns, domes, ridges, rugosities, crests, casques) are common among living and extinct dinosaurs; yet, the developmental processes and selective regimes that bring about these metabolically expensive and seemingly bizarre structures remains a mystery. Such features have independently evolved numerous times and are varied in their anatomical composition. Those of ornithischian dinosaurs (e.g., ceratopsians, hadrosaurids, pachycephalosaurs) are limited to premaxillary, nasal, prefrontal, frontal, parietal, and squamosal elements (plus epi-ossifications), whereas non-avian saurischians (e.g., *Dilophosaurus*, oviraptors) can include premaxillary, nasal, lacrimal, frontal, parietal, or postorbital bones—all of which are dermatocranial or metaplastic in origin. The casques of modern cassowaries (i.e., *Casuarius*) are commonly used as exemplars for cranial ornaments in extinct archosaurs. However, contradictory interpretations of their cranial osteology have rendered the utility of cassowary casques as cranial analogs somewhat ambiguous. Here, we formally document the configuration of casques in southern cassowaries and outgroup neognaths (e.g., *Bycanistes*, *Numida*, *Macrocephalon*) using µCT imaging to test the hypothesis that cassowaries are a suitable osteo-developmental model for non-avian dinosaur ornaments. Casque bones of modern Aves can grow rapidly and are often obscured by sutural fusion in adulthood, rendering them difficult to study. Sampling neonates and juveniles with incipient casques allowed us to track telescoping elements and measure growth. Our results point towards at least two modes of casque ontogeny among modern birds: (1) disunited, in which a midline chondrocranial element grows relatively slowly and posteriad to buttresses lateral dermatocranial bones (i.e., cassowaries), and (2) geminal, in which a rapidly growing casque is built from anteriad right/left dermatocranial constituents only (i.e., Neognathae). These findings suggest that cassowaries are an outlier among dinosaurs, making them poor models for cranial developmental and evolution studies outside of Palaeognathae. Instead, modern neognaths have ornaments constructed more like those of many non-avian dinosaurs. We, therefore, propose avoiding cassowaries as developmental models for elucidating the composition and growth of dinosaur headgear and focusing instead on the diversity of non-paleognathous avifauna for comparative analysis.

Grant Information

Funding for this project was provided by the National Science Foundation and the Western Interior Paleontological Society Karl Hirsch Memorial Grant.

Technical Session I (Wednesday, October 17, 2018, 8:45 AM)

AN EXCEPTIONAL NEW LATE TRIASSIC (CARNIAN) FOSSIL ASSEMBLAGE FROM ZIMBABWE AND THE BIOGEOGRAPHY OF THE EARLY DINOSAURS ACROSS PANGEA

GRIFFIN, Christopher T., Virgina Tech, Blacksburg, VA, United States of America; MUNYIKWA, Darlington, National Museums and Monuments of Zimbabwe, Harare, Zimbabwe; BRODERICK, Timothy J., Broderick Geological Consulting, Harare, Zimbabwe; TOLAN, Stephen, Mfuwe, Zambia; ZONDO, Michel, Natural History Museum of Zimbabwe, Bulawayo, Zimbabwe; NESBITT, Sterling J., Virginia Tech, Seattle, WA, United States of America; TARUVINGA, Hazel, Natural History Museum of Zimbabwe, Bulawayo, Zimbabwe

Biogeographic endemism was drastically reduced following the end-Permian mass extinction until the Carnian stage of the Late Triassic, when endemism reached pre-extinction levels. This endemism has been hypothesized to have been driven primarily by strong latitudinal gradients across Pangea, with environmental, not geographic, barriers preventing worldwide dispersal of terrestrial taxa. Because the oldest dinosaur material is known exclusively from a few Carnian-aged deposits of eastern and western Gondwana (Brazil, Argentina, India), the origin and early evolution of dinosaurs may be tied to the broader biogeographic trend created by this confluence of endemism and paleoclimate across Pangea. Here, we report an exceptional new vertebrate assemblage from the Pebbly Arkose Formation of northern Zimbabwe, with hundreds of skeletal elements collected from a single locality. We preliminarily date the new locality as ?late Carnian by the presence of hyperodapedontid rhynchosaurs, an important "index taxon" for the Carnian. In addition to the abundant rhynchosaur material, we collected cynodont and pseudosuchian archosaur remains and recovered a nearly (~90%) complete individual and other associated remains of a small (2-3 m length) sauropodomorph dinosaur, the oldest definitive dinosaur known from Africa and roughly equivalent in age to the oldest known globally. This individual possesses apomorphic sauropodomorph character states (e.g., hatchet-like deltopectoral crest of the humerus) and the postcranial skeleton is strikingly similar to that of *Saturnalia* from the late Carnian of Brazil. The cranium appears to possess more derived character states shared with taxa like *Plateosaurus* (e.g., angle of the posterior end of the maxilla) rather than the earliest diverging sauropodomorphs with cranial material. Because this assemblage is at roughly the same paleolatitude (~45°) as coeval rhynchosaur-dominated, cynodont- and dinosaur-bearing sediments from India and South America, this formation geographically links these previously known assemblages, allowing sampling across a latitudinal band spanning Pangea. The similarities of these assemblages, and the dissimilarity of assemblages further north and south, supports the influence of climatic bands on the paleobiogeography of post-extinction Pangea. These conditions played a major role in the early evolution and spread of dinosaurs across the world by restricting the geographic availability of suitable environments to a portion of southern Pangea.

Grant Information

National Geographic Early Career Grant, GSA Student Research Grant, Virginia Tech Graduate Student Assembly Graduate Research Development Program, NSF GRFP

Technical Session XVII (Saturday, October 20, 2018, 2:15 PM)

THE EVOLUTION AND ASSOCIATED TRAITS OF FACULTATIVE BIPEDALITY IN DIAPSIDS: IMPLICATIONS FOR IDENTIFYING ARCHOSAUROMORPH LOCOMOTOR TRANSITIONS

GRINHAM, Luke, University of Cambridge, Cambridge, United Kingdom; VANBUREN, Collin, University of Cambridge, Cambridge, United Kingdom; NORMAN, David B., University of Cambridge, Cambridge, United Kingdom

The evolutionary transition from quadrupedal to bipedal locomotion requires anatomical and biomechanical changes. Most modern bipeds are ricochetal mammals and birds, but bipedality evolved multiple times in fossil diapsid clades. However, how bipedality evolved in these clades is uncertain, particularly in large-bodied taxa. Between the end-states of obligate bipedality (OB) and obligate quadrupedality (OQ) is facultative bipedality (FB) in which both quadrupedal and bipedal locomotion are used. FB is assumed to be a necessary transitionary locomotor mode during the evolution of OB, but the traits associated with this locomotor mode are unknown. Here, locomotor evolution is reconstructed across Archosauromorpha and extant taxa are used to test for traits associated with this transition for the first time.

A published archosauromorph phylogeny was pruned and dated based on first and last fossil occurrence using equal share dating. Locomotor mode was treated as an ordered categorial variable, with OQ, FB, and OB used as character states based on the most recent classification of a taxon. Taxa that have not been attributed a locomotor mode were pruned. Ancestral states at each node were then estimated using a maximum likelihood approach.

Facultative bipedality is estimated to have evolved around five times from quadrupedal taxa, and a further four times from bipedal taxa. In this study, OB is not found to evolve from FB, contrary to logical assumption of the locomotor transition.
Methods to assign locomotor mode to fossil taxa were inconsistent across studies. It was hypothesised that using a consistent method based on morphological traits to determine locomotor mode would allow for more accurate estimation of OQ and FB in fossil taxa and improve the ancestral state estimation. Linear morphometric analyses were performed on axial and appendicular skeletal elements of 29 recent OQ and FB lepidosaur specimens (14 species). To test for trait differences between groups, linear discriminant analysis and backward stepwise elimination of standardised major axis regressions were performed. Facultative bipeds share features with arboreal taxa including a long tail relative to trunk length and low intermembral index. Forelimb to hindlimb ratio did not differ between OQ and FB taxa, despite its common use in locomotor studies. These results highlight the use of non-mammalian extant systems for diagnosing locomotor mode in extinct taxa and the uncertainty of bipedal evolution in the fossil record.
Grant Information
Funded by a NERC DTP awarded to Luke Grinham.

Technical Session XVII (Saturday, October 20, 2018, 3:30 PM)

NEW APPROACHES TO NEOSUCHIAN (ARCHOSAURIA, CROCODYLOMORPHA) PHYLOGENETIC RELATIONSHIPS AND IMPLICATIONS FOR LONGIROSTRINE SNOUT EVOLUTION

GROH, Selina, University College London, London, United Kingdom

Since their emergence in the Late Triassic, crocodylomorphs have undergone a long history of evolutionary change, resulting in a wide array of body types, diets, and environmental preferences. One of this clade's most striking adaptations is a strongly elongated snout, usually inferred as an adaptation to piscivory. As such, longirostry is likely to have arisen convergently on many occasions, and the morphological characters associated with this condition can cause erroneous clustering of these groups in phylogenetic analyses, potentially obscuring 'true' relationships. Here we employed a supermatrix approach, coupled with new data to capture as much evidence on their relationships as possible and synthesize previous work on their systematics. We focused on the crocodylomorph clade Neosuchia and analyzing the largest dataset for this clade assembled to date (569 morphological characters for 19 extant and 87 extinct taxa), based on a comprehensive review of previous studies and personal observations of original specimens. In addition to 487 discrete characters our data set contains 82 continuous characters to capture the quantitative nature of several evolutionary traits more accurately. These data were analyzed using both maximum parsimony (with and without extended implied weighting [EIW]) and Bayesian inference. Maximum parsimony coupled with EIW performed better than both equal weights parsimony and Bayesian analyses, based on the achievement of higher stratigraphic congruence and no homoplasy-driven clustering of longirostrine clades. Our resulting topologies resolved all major neosuchian clades and confirmed the placement of Tethysuchia as non-eusuchian neosuchians. Our trees suggest that the longirostrine condition evolved independently in three major clades within Neosuchia (Tethysuchia, Gavialoidea, and Tomistominae) and on at least three further occasions within isolated longirostrine species in brevirostrine clades (e.g., *Mecistops cataphractus*, *Euthecodon arambourgi*). Character optimizations reveal that all longirostrine snouts were assembled similarly, with modifications mainly in the maxilla and premaxilla. In all longirostrine groups, changes to the anterior skull regions are accompanied by modifications of the posterior skull, which are often unique to each clade and might represent adaptations to their different habitats. EIW and continuous characters prove valuable tools in resolving relationships in morphological datasets in the presence of strong homoplasy.
Grant Information
London NERC DTP grant (Ref NE/L002485/1), University College London Bogue Fellowship 2016

Romer Prize Session (Thursday, October 18, 2018, 12:00 PM)

JAW CORRELATES OF DIET PROVIDE NOVEL INSIGHT ON THE ADAPTIVE RADIATION OF EARLY MAMMALS

GROSSNICKLE, David, University of Washington, Seattle, WA, United States of America

Therian mammals underwent an immense adaptive radiation that involved ecological, morphological, and taxonomic diversification. However, there remains considerable debate over the timing and dynamics of the radiation, particularly as it relates to the Cretaceous Paleogene (K–Pg) mass extinction event 66 Ma. This is due in part to difficulties in examining patterns of ecological diversity in deep time, which requires ecological inferences from fossil morphologies. Dental and mandibular elements are the most commonly preserved fossils of early mammals, and molar morphologies often provide ecological evidence via dietary correlates. In contrast, the link between jaw shape and diet in mammals has been explored to a lesser degree. Thus, to identify jaw correlates of diet that can be readily applied to fossil mammals, I first examine the association between jaw shape and diet in modern mammals. To this end, I apply phylogenetic comparative methods to linear jaw measurements and quantitative dietary data for a taxonomically diverse sample of mammals. Results indicate that the distance between the jaw joint and angular process (JAPr distance) is an especially powerful predictor of diet, increasing with greater herbivory. This distance reflects the attachment area sizes of jaw muscles that are particularly important for mastication of plant materials. Further, I compare the fit of evolutionary models to the JAPr distances and find strong evidence for the presence of unique selective regimes associated with herbivory and faunivory. Finally, I apply these findings to the fossil record by measuring the JAPr distance in therian jaws from the Cretaceous and early Paleogene (i.e., 145–34 Ma). Fossil patterns suggest that therians were small insectivores for much of the Cretaceous and experienced a rapid increase in dietary diversity prior to the K–Pg boundary, starting at approximately 80 Ma and coinciding with the ecological diversification of flowering plants. In addition, the diversification of herbivorous mammals accelerated after both the K–Pg mass extinction event and the Paleocene–Eocene Thermal Maximum (56 Ma), and these patterns may also be linked to evolutionary expansions in angiosperms (e.g., larger seeds and fruits) that provided novel ecological opportunities. Thus, this study demonstrates the strong correlation between jaw morphology and diet, and it offers new insight on early mammal evolution by suggesting a multi-step radiation that is linked to evolutionary advances in flowering plants.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

SCALING OF STATICALLY DERIVED OSTEOCYTE LACUNAE: IMPLICATIONS FOR PALEOPHYSIOLOGICAL RECONSTRUCTION

GRUNMEIER, Orvil D., Adelphi University, Abington, PA, United States of America; D'EMIC, Michael, Adelphi University, Stony Brook, NY, United States of America

Osteocytes are mature versions of bone-forming cells that develop in two ways, statically or dynamically. Osteocytes derived from static osteogenesis ('static osteocytes') differentiate in situ from mesenchyme, form early in bone growth, and act as the scaffolding for subsequent bone formation by those derived from dynamic osteogenesis ('dynamic osteocytes'). Static osteocytes are large, form equant lacunae, and are clustered in cords, whereas dynamic osteocytes are dispersed and form elongate lacunae with three very different axes. Osteocyte lacunae conform to their dimensions during osteogenesis and are usually well preserved in fossil bone, offering a rich dataset for addressing paleobiological questions about extinct animals. A previous study regressed lacunar volume from dynamically formed osteocyte lacunae of a broad sample of extant bird species against body mass, whole-body maximum growth rate, mass-specific metabolic rate, genome size, and erythrocyte size. There were significant relationships with body mass, growth rate, metabolic rate, and genome size, with the latter being the strongest. We measured over 3,800 statically formed osteocyte lacunar axes from the same dataset and regressed lacunar volume against these same parameters. The relationship between osteocyte lacunar volume and body mass was stronger when measuring statically derived osteocyte lacunae, whereas relationships between osteocyte lacunar volume and growth rate or basal metabolic rate disappeared. The relationship between osteocyte lacuna volume and genome size remained significant and moderately strong, while osteocyte lacuna volume was still unrelated to erythrocyte size. Our results suggest that growth and metabolic rate signals are contained in dynamic but not static osteocytes, indicating that the former should be used in estimating these parameters in extinct animals.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE INFLUENCE OF HETEROCHRONY ON THE EVOLUTION OF THE HADROSAUROID DENTARY

GUENTHER, Merrilee F., Elmhurst College, Elmhurst, IL, United States of America; MACMILLAN, Austin, Elmhurst College, Elmhurst, IL, United States of America; BANK, Nicholas, Elmhurst College, Elmhurst, IL, United States of America

Hadrosaurids are characterized, in part, by a derived dental battery and specialized jaw mechanics that enable novel approaches to herbivory. The complexity of the dentary may arise due to the influence of heterochrony. Multiple hadrosauroid taxa have ontogenetic series preserved, allowing for an examination of ontogenetic changes within the group and the identification of heterochrony. Specimens of the dentaries of *Eolambia caroljonesa* and *Maiasaura peeblesorum* were examined, because both are well represented by perinatal through adult growth stages. This allowed for a comparison of the development of the dentary between basal hadrosauroids and derived hadrosaurids.
A qualitative analysis of the ontogenetic series shows that the perinatal and juvenile dentaries of *Eolambia* closely resemble those of *Maiasaura*, with minor differences. The alveoli of *Eolambia* extend more deeply into the dentary than those of *Maiasaura*, but there is a similar density of alveoli and similar alveolar width in both *Maiasaura* and *Eolambia* in the earliest stages.
Later in ontogeny, a divergence in the pattern of growth of the dentary occurs between *Eolambia* and *Maiasaura*. The density of alveoli increases at a faster rate in *Maiasaura* compared to *Eolambia*. A quantitative analysis of the linear measurements also indicates that the dentary of *Eolambia* grows isometrically, but the dentary of *Maiasaura* grows allometrically. Geometric morphometric analyses further support the morphological similarities between *Eolambia* and *Maiasaura* juveniles while illustrating the morphological disparities that accumulate as the two taxa grow along different trajectories.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A NEW GENUS OF DESMOGNATHAN SALAMANDER (PLETHODONTIDAE) FROM THE EARLY PLIOCENE GRAY FOSSIL SITE OF NORTHEAST TENNESSEE

GUNNIN, Davis R., East Tennessee State University, Johnson City, TN, United States of America; SCHUBERT, Blaine W., East Tennessee State University, Johnson City, TN, United States of America; BREDEHOEFT, Keila E., East Tennessee State University, Johnson City, TN, United States of America; SAMUELS, Joshua X., East Tennessee State University, Johnson City, TN, United States of America

Plethodontids are the most speciose and ecologically diverse of the extant salamanders, consisting of around 460 species that display a range of terrestrial, aquatic, arboreal, and fossorial habits. The distribution of the family is confined almost entirely to the western hemisphere, with primary areas of diversity in the southern Appalachian Mountains and Mesoamerica. One North American group, the desmognathans, are ecomorphologically diverse, with all plethodontid life-modes represented save arboreality. Extant taxa are well-studied, but historical biogeography and deep evolutionary relationships within this clade are poorly understood due to a lack of fossils dating prior to the Quaternary. The early Pliocene Gray Fossil Site (GFS) of northeast Tennessee records the oldest desmognathan fossils and the only record of this clade prior to the Pleistocene, with a previous study recognizing one GFS desmognathan based on trunk vertebrae. A new maxilla and atlas recovered from the GFS represent a new genus of very large desmognathan salamander displaying a mosaic of desmognathan features. The GFS maxilla shares many morphological similarities with *Phaeognathus hubrichti*, particularly a unique process projecting from the posterior tip of the pars dentalis in the direction of the jugal ligament, a feature that appears to support fossorial habits in the extant taxon. However, due to the basal placement of *P. hubrichti* within desmognathans and the possibility of unrecognized plesiomorphies, the GFS fossils could not be assigned to *Phaeognathus* based on overall similarity. Instead, we chose to quantitatively compare the morphology of the GFS atlas to

modern desmognathine taxa by performing a landmark-based geometric morphometric analysis, which yielded unexpected results. Including the GFS form as an unknown, a discriminant analysis using partial warp scores found the GFS atlas to be most similar in shape to the large and robust *Desmognathus quadramaculatus*, which may reflect an increased bite force in the GFS salamander as the morphology of the atlas is closely tied to bite mechanics in desmognathans. No ecological analogues to the GFS form are known from the southern Appalachians today; the inferred most ecologically similar salamander (*P. hubrichti*) resides ~640 kilometers away in southern Alabama and is still much smaller in total size. As such, discovery of a large, potentially fossorial desmognathan in the Appalachians of northeastern Tennessee forces us to reconsider the Neogene evolutionary dynamics of Appalachian plethodontids.

Technical Session V (Thursday, October 18, 2018, 8:15 AM)

TAR PITS IN PERSPECTIVE: LATE PLEISTOCENE NON-ASPHALTIC MAMMALIAN FAUNAS FROM THE LA BREA PLAIN INDICATE FAUNAL BIAS AT RANCHO LA BREA, CALIFORNIA

GUST, Sherri, Cogstone Resource Management Inc, Orange, CA, United States of America; MCLEOD, Samuel A., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; LEGER, Ashley, Cogstone Resource Management, Inc., Orange, CA, United States of America; SCOTT, Kim, Cogstone Resource Management, Inc., Riverside, CA, United States of America; SCOTT, Eric, Cogstone Resource Management, Inc., Riverside, CA, United States of America; HARRIS, John M., La Brea Tar Pits & Museum, Los Angeles, CA, United States of America

The Rancho La Brea (RLB) asphalt deposits in Los Angeles, California have dominated the late Pleistocene paleontological record of the region for well over a century. Although the 'tar pits' are among the world's richest localities for Pleistocene terrestrial vertebrates, the mammalian record at the site is heavily weighted in favor of carnivorans—especially dire wolves, sabertooths, and coyotes. This bias reflects the accumulatory mechanism of the site, whereby one animal trapped in asphalt might lure many potential predators and scavengers. If accurate, this scenario may also indicate the potential for other biases in faunal representation at the site. Large herbivores at RLB are dominated by, in descending order, bison, horse, ground sloth, camel, and proboscideans. Here we assess if the relative abundance of large herbivores at RLB may be influenced by the site's method of accumulation.

We examined fossils from late Pleistocene localities in the La Brea Plain (westernmost Los Angeles basin) that lacked an asphaltic context, including new discoveries from subway excavations geographically proximate to RLB. Our results confirm that carnivorans are poorly represented in non-asphaltic localities, reflecting their scarcity in a normally-distributed community. In contrast, a strong preponderance of fossils of extinct *Bison*, which constitute over 40% of the non-asphaltic herbivore fossils, reflects their local abundance and widespread regional distribution in the late Pleistocene. Remains of *Mammut americanum* and *Mammuthus columbi* are surprisingly well represented in non-asphaltic deposits, constituting 25% of the sample and indicating that proboscideans were much more common in the region than the RLB record suggests. Other large herbivores include, in descending order, horse, camel, ground sloth, and deer—of which horses, sloths, and deer are less well represented in non-asphaltic contexts than at RLB. Late Pleistocene large mammal communities in the La Brea Plain were dominated by bison and proboscideans. Conceivably, the large size, strength, and social structure of proboscideans may have helped them avoid entrapment in the RLB asphalt seeps.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

PROBLEMS AND POSSIBLE SOLUTIONS TO THE PHYLOGENY WITHIN PANDELPHINA, ESPECIALLY INIOIDEA (CETACEA, ODONTOCETI)

GUTSTEIN, Carolina S., Universidad de Chile, Macul, Chile; COZZUOL, Mario A., Universidade Federal de Minas Gerais, Belo Horizonte, Brazil; MPODOZIS, Jorge M., Universidad de Chile, Santiago, Chile

The Pandelphina were defined based on molecular phylogeny studies and include the most recent common ancestor between *Platanista* and *Delphinus* plus all its descendants. However, the relationships within the group are not resolved.

The morphological characters included in the most commonly used phylogenetic matrix were reviewed (based on the last reviewed matrix of *Isthminia*): their descriptions and coding were compared and new characters were defined based on variation studies whenever possible. We reviewed the coding of seven taxa of Inioidea, two taxa of Platanistoidea, one of Lipotoidea, and five taxa of Delphinoidea. Twenty-one character codings were modified, three characters were redefined, and two new characters were proposed. For all these reviews and definitions, we used at least five specimens for each species whenever possible.

With respect to the phylogenetic analyses available in the literature, we observed that in the last few years, a number of new genera of iniids have been proposed as the sister group of *Inia* (living species): *Meherrinia*, *Isthminia*, *Brujadelphis*, and *Skaldiporia*. Meanwhile, a new species of Inioid, *Awadelphis hirayamai*, from Japan was also proposed, but with the use of another phylogenetic matrix, resulting in a sister group with *Brachydelphis* (from Peru and Chile). With the exception of the analysis within the *Isthminia* publication, all phylogenetic analyses used nearly one-third ordered characters and user-defined weight, and excluded the revised matrix proposed for *Isthminia* in which was provided a complete revision for the coding of *Ischyrorhynchus* (fossil South American riverine species). These analyses recovered *Ischyrorhynchus* as a Platanistoid, creating more steps to explain paleobiogeographic patterns in both groups.

We ran an analysis of the same matrices separately but with unordered characters and implied weighting in TNT, recovering very confusing results that did not confirm the known topologies for the main groups (i.e., Ziphiidae, Physeteriidae, Delphina). We then ran a consolidated analysis with the reviewed matrix of *Isthminia* (without the external clades that are not the purpose of the present study), plus the other taxa recently described with the same settings. This last analysis also showed some inconsistencies when we vary the k parameter of the implied weighting setting, nevertheless the taxa traditionally and consistently accepted as Inioidea were grouped in a clade. Similarly, Delphinoidea was recovered as a monophyletic clade with some variation on the position of some "kentriodontids" (i.e., *Atocetus*).

Grant Information
Proyecto Anillo ACT172099, FONDECYT N° 3160710

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

***HESPEROTESTUDO* (TESTUDINES, TESTUDINIDAE) SHELL REMAINS FROM ZACATECAS, MÉXICO**

GUZMAN, Ana F., INAH e IPN, Ciudad de México, Mexico; HERNÁNDEZ-LUNA, Carlos A., INAH, Ciudad de México, Mexico

Hesperotestudo is a clade of giant tortoises which inhabited North and Central America during the Oligocene–Pleistocene. It is a very common fossil in U. S. Cenozoic deposits and the most abundant reptilian component in some localities. In Mexico, however, it has a poor Pliocene–Pleistocene record made of very fragmentary and usually isolated remains not useful enough to recognize a species-pattern or to describe. In this paper we add a new Neogene locality for *Hesperotestudo* in northern Mexico and describe the shell remains. The shell was excavated using archaeological techniques in Pliocene sediments on a hillside drained by seasonal streams that feed Río Juchipila, in SW Zacatecas; fallen fragments collected by local people were also recovered. Materials were cleaned, consolidated, measured and compared with modern *Gopherus* shells and descriptions of fossil and modern North American tortoises. The remains belongs possibly to one individual and include an articulated partial shell, with right 4th, 5th, and anterior part of 6th peripheral plates; ventral edge of right 2th, 3th and partial 4th costal plates; and epiplastron, entoplastron, and anterior edge of hyoplastron plates. Fallen elements include articulated nuchal and left 1st peripheral plate; articulated right 1st, 2nd, and partial 3th peripheral plates; dorsal portions of both 1st costal plates, left articulated to 1st neural plate; and fragmentary costal and another indeterminate plates. The shell size (730 mm from epiplastron to 4th costal plate) and the narrow pectoral scute in the midline (58 mm) support its allocation to *Hesperotestudo*. Pliocene species that reach such size are *H. hayi* and *H. campester*; however, the absence of diagnostic bones (for example, 2nd neural, suprapygal, and pygal plates) does not allow to make a more specific identification; also, *H. campester* has a bigger pectoral scute. The presence of *Hesperotestudo* in south U.S. and north México suggest a relative climatic stability in a broad region at the end of the Neogene that contributed the dispersion of the giant tortoises. The specimen from Zacatecas is also the first state record and let us to connect the NW and the central Mexican fossil populations.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

STANDING TALL: NEW TITANOSAUR MATERIAL FROM NEW MEXICO PROVIDES INSIGHTS INTO THE POSTURE AND GAIT OF GIANT LATE CRETACEOUS SAUROPODS

HABIB, Michael, University of Southern California, Los Angeles, CA, United States of America

The ecology of North American titanosaurs (represented, to date, by *Alamosaurus*) has unique implications for understanding the ecosystems in North America at the end of the Mesozoic. A recently discovered titanosaur specimen from New Mexico (LACM 157550) provides a wealth of new information regarding the morphology of North American titanosaurs. LACM 157550 includes an articulated series of undistorted cervical vertebrae, along with well preserved ossified tendons. LACM 157550 is similar in many respects, including overall vertebral proportions, to the articulated *Alamosaurus* neck from Big Bend National Park (BIBE 45854), and LACM 157550 likely belongs to that taxon. LACM 157550 is remarkably well preserved and was an exceptionally large sauropod: the smallest cervical vertebra in the series, thought to be C6, has a centrum length of over 600 mm.

The outer cortical thickness of the bones is quite thin (ranging from about 1.5 to 3.5 mm), but the combination of large vertebral diameter and highly optimized internal lattice (within 5% of estimated optimal lattice thickness) would have given the cervical vertebrae very high ratios of stiffness to weight. The ratio of bending to compressive strength suggests that the neck in LACM 157550 was habitually elevated. While the angle of neck elevation was likely not extremely steep, even a modest angle of elevation (35 degrees) could have placed the head at a height of over 25 feet. New material from LACM 157550 suggests that the neck was more robust than previously realized, and likely carried expanded dorsal ligaments and musculature.

New material from LACM 157550 also provides the opportunity to take on a novel biomechanical challenge: to reconstruct basic gait patterns using mechanics of the cervical skeleton. This novel approach is only possible because of the unique morphology of sauropod dinosaurs. The ossified hypaxial tendons likely acted as leaf springs and reduced damped oscillatory neck motions during walking. The optimal dampening range of the ossified tendons should therefore be related to a combination of the neck proportions, stride length, and stride speed. The particularly long, elastic, ossified tendons of LACM 157550 suggest a large waveform oscillation tendency, with relatively low stride rates and long stride lengths (compared to other sauropods). This implies that LACM 157550 (and therefore *Alamosaurus*) was a comparatively long-limbed sauropod.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

REMAINS OF AN ENIGMATIC CRETACEOUS BONY FISH, *PALAEONOTOPTERUS GREENWOODI* (TELEOSTEI, OSTEOGLOSSOMORPHA), FROM ALABAMA, U.S.A., AND THEIR STRATIGRAPHIC AND PALEOBIOGEOGRAPHIC SIGNIFICANCE

HACKER, Riley J., Green Bay, WI, United States of America; LONDON, Maxwell G., Chicago, IL, United States of America; SHIMADA, Kenshu, DePaul Univ, Chicago, IL, United States of America

Palaeonotopterus greenwoodi is an enigmatic Cretaceous bony fish (Teleostei, Osteoglossomorpha) currently known only from the Albian–Cenomanian Kem Kem Beds of Morocco. In the paleontology collections of the Alabama Museum of Natural History (ALMNH) in Tuscaloosa and the McWane Science Center (MSC) in Birmingham, Alabama, U.S.A., are nine tooth plate specimens from Alabama that can be referred to as *P. greenwoodi*: ALMNH 3344, ALMNH 4351, MSC 1637, MSC 2263, MSC 34813, MSC 35047, MSC 36617, MSC 36755, and MSC 38707. Their occurrences range from

the Tombigbee Sand Member of the Eutaw Formation in Hale, Dallas, and Montgomery counties to the Mooreville Chalk Formation in Dallas, Greene, and Montgomery counties. Most of these specimens represent one or more fragments of an isolated tooth plate, but one specimen in particular, MSC 38707, consists of both the upper and lower tooth plates. Although both tooth plates are incomplete, one of them (lower?) is reasonably well preserved suggesting that the oval tooth plate measured approximately 13 cm in length and 11.5 cm in width. Whereas these specimens do not add any substantial new anatomical information to what is known about this fossil species or to elucidate its exact phylogenetic affinity, they are significant stratigraphically and paleobiogeographically. Notably, these specimens not only represent the geologically youngest material ranging from late Santonian to early Campanian in age, but also constitute the first record of the species outside of Morocco. Therefore, the present fossil record suggests that *P. greenwoodi* first evolved in northwestern Africa by the mid-Cretaceous (Albian/Cenomanian) and dispersed to North America by the late Santonian by crossing the expanding AtlanticOcean.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE USE OF GIS SOFTWARE FOR BONEBED MAPPING TO IMPROVE RESEARCH OUTCOMES

HAIAR, Brooke, University of Lynchburg, Lynchburg, VA, United States of America; PERAULT, David, University of Lynchburg, Lynchburg, VA, United States of America; ROMINE, Natalie, University of Lynchburg, Lynchburg, VA, United States of America

The systematic mapping of dinosaur bonebeds has been a long-standing field practice since Barnum Brown started in the Morrison Formation in the late 1800s. There have been numerous techniques used since those hand-sketched beginnings, though most dinosaur bonebeds still rely heavily on hand-drawn diagrams made in the field supplemented by digital images. More recent work has focused on using photogrammetry to identify the real-world placement of fossil localities, though these are often at too gross a scale to be useful in identifying the interrelationships between the elements in the bonebed. GIS has presented a novel way of mapping bonebeds, an excellent example being the work done at Dinosaur National Monument.

The bonebed used for this mapping project is from the Morrison Formation, not far from Barnum Brown's original work. Combining field sketches and digital images with the GIS software, we have been able to create a vector map containing multiple years of bonebed data in the same digital image. This is extremely useful, as several different researchers have led expeditions to the quarry over the years. Mapping all of the elements recovered has led to new insights on the deposit that weren't possible with field notes alone. Patterns of skeletal deposition, potential locations of desired elements, and providing guidance for future excavations are some of the benefits of this technique. The fluid state of the GIS map also allows us to update and change the data parameters of any element once more information is recovered from preparation. We believe the combination of traditional field mapping and modern GIS software is a powerful research tool and well worth the time and expertise required.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

A NEW METHOD OF INCREASING THE EFFICIENCY OF MICRO JACKS IN THE REMOVAL OF MATRIX SURROUNDING A FOSSIL SPECIMEN.

HAJI-SHEIKH, Misty, Northern Illinois University, DeKalb, IL, United States of America; NAPLES, Virginia L., Northern Illinois University, DeKalb, IL, United States of America

Regardless of the characteristics of the matrix in which they are found, fossils nearly always require extensive preparation prior to being placed in storage, on exhibit or studied for research. This time honored process has changed only to a small degree in the last hundred or more years. Initially, collectors used picks, hammers or chisels, and for smaller specimens, dental tools to remove unwanted materials adhering to specimens. More recently, mini jack hammers and other power tools have been employed at excavation sites where generators are available. Such tools increase the efficiency of matrix removal, by probing the substrate while simultaneously vibrating it and blowing away the fragments. However, in the frequent cases where the matrix in which a fossil is embedded is concrete-like in consistency, the process remains painfully slow. While working at the Hanksville-Burpee quarry during the 2017 field season, using ME 9100s that operate at 15,000 cpm and 100-120 psi, we discovered that the simultaneous use of two micro jacks dramatically increased the efficacy of the matrix removal process. In cases such as those where the Hanksville-Burpee quarry is located, a single micro jack is able only to dig a shallow furrow in the dense, fine grained rocky matrix or to spall off small chunks of rock. In contrast, juxtaposition of two stylus points a short distance apart generated a harmonic pattern that sufficiently jarred the matrix so that it fragmented the rocky material between their tips, thus greatly shortening the time to extricate the specimen as well as allowing easier substrate removal. Experiments that varied the angles between the two micro jack styluses were conducted, as well as the distances between them. The goal was to determine the combination of distance range and stylus orientation that achieved maximum effectiveness using this dual matrix removal technique. This technique can be accomplished by moving each tool relative to the other, or by holding one micro jack steady and moving the second. Instead, the angle and distance between the styluses determines how well the two tips can interact to amplify the results each can achieve individually.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

AUTOMATIC BONE MEASUREMENT FROM X-RAY COMPUTED TOMOGRAPHY

HALL, Alexander S., Thermo Fisher Scientific, Houston, TX, United States of America; JACOBS, Justin L., The University of Texas at Arlington, Arlington, TX, United States of America; SMITH, Eric N., The University of Texas at Arlington, Arlington, TX, United States of America

Analyzing three-dimensional data often requires slow and tedious manual decision making by a trained user. Traditionally, decisions about what belongs to a material are made layer-by-layer for every single image in a z-stack of hundreds or thousands of images. For example, digitally extracting one single bone from a complete skeleton is often the most time consuming portion of comparative morphology projects. Using X-ray computed tomography (CT) data with sufficient information about biologically real boundaries (sutures, joints, etc.), one can use professional CT segmentation software to automatically segment skeletons. In this project, we report a new workflow using an object separation process within professional CT analysis software. After optimizing the object separation parameters, individual bones were isolated and measured with only a fraction of the work required by manually selecting bones layer by layer. We will present a use case where examined CT data from a snake skeleton at the single-bone level leading to the discovery of a bone cancer (i.e,. osteosarcoma). The workflow should assist with achieving a semi-automated way to analyze anatomical CT data for use in comparative morphology.

Grant Information
A Beta Phi chapter Phi Sigma research grant to ASH funded the CT reconstruction computer used for this work.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

DIETARY ECOLOGY OF COYOTES AND DIRE WOLVES AT MARICOPA BREA DURING THE LATE PLEISTOCENE AS INFERRED FROM DENTAL MICROWEAR TEXTURE ANALYSIS

HALL, Elizabeth, Vanderbilt University, Nashville, TN, United States of America; DESANTIS, Larisa, Vanderbilt University, Nashville, TN, United States of America

Dire wolves (*Canis dirus*) were abundant carnivorans in North America during the Pleistocene, with coyotes (*Canis latrans*) both co-occurring with dire wolves and persisting today. Modern coyotes are known to be opportunistic with a varied diet that includes carcass utilization and even garbage and vegetation due to their residence in human areas. Pleistocene coyotes were generally larger and more robust than modern coyotes, and had wider teeth that may have allowed them to hunt larger prey and generally have more carnivorous diets. Recent research at Rancho La Brea in southern California using dental microwear texture analysis suggests that they did not scavenge for food or heavily utilize carcasses during the late Pleistocene in southern California, while dire wolves instead had a more catholic diet of flesh and bones. Here, we test if this finding holds true for specimens found at Maricopa Brea, another late Pleistocene fossil site located in southern California that contains well preserved canids (in addition to other carnivorans). We found that coyotes and dire wolves have indistinguishable dietary behavior as inferred from dental microwear texture analysis, with no significant differences (all p-values $\geq$ 0.35) in anisotropy, complexity, and textural fill volume. Interestingly, coyotes from Maricopa Brea have higher complexity values than Pleistocene and Holocene coyotes from La Brea ($p < 0.0001$, $p = 0.017$, respectively), yet are indistinguishable from modern coyotes ($p = 0.154$). These findings suggest that coyotes were more opportunistic at Maricopa Brea during the late Pleistocene, in contrast with Rancho La Brea. Further, there may be inherent trade-offs with body size (especially as Maricopa coyotes are smaller than other Pleistocene coyotes), suggesting that reduced body size in coyotes may be correlated with increased scavenging behavior.

Grant Information
NSF 1757545 and Vanderbilt University

Preparators' Session (Thursday, October 18, 2018, 2:00 PM)

FISHING WITH SILICON CARBIDE: PREPARING DIVERSE MARINE VERTEBRATES FROM THE LATE DEVONIAN (FAMENNIAN) CLEVELAND MEMBER OF THE OHIO SHALE, OHIO, U.S.A.

HALL, Lee, Cleveland Museum of Natural History, Cleveland, OH, United States of America; ZELINSKI, Dale, Cleveland Museum of Natural History, Cleveland, OH, United States of America; MCGEE, Amanda R., Cleveland Museum of Natural History, Cleveland, OH, United States of America; RYAN, Michael, Cleveland Museum of Natural History, Cleveland, OH, United States of America

Since its incorporation in 1920, the Cleveland Museum of Natural History's (CMNH) Department of Vertebrate Paleontology has amassed a substantial collection (~8,000) of Late Devonian (Famennian) marine vertebrates from the Cleveland Member of the Ohio Shale. The collection consists largely of arthrodire placoderms, including numerous specimens of the iconic apex predator *Dunkleosteus terrelli*, paleoniscoid fish (e.g., *Kentuckia hlavini*), and among the oldest complete chondrichthyans in the world (e.g., *Cladoselache fyleri*).

Arthrodire skulls (cartilaginous postcrania are rarely preserved) are found in blocky shale, cone-in-cone limestone or shale concretions, and may often contain mushroom-like pyrite nodules growing from the cancellous bone tissue and across the bone surface. Chondrichthyans are almost exclusively found as complete specimens within shale concretions (likely a reflection of historical collecting bias), and preserve three-dimensional soft tissue structures (e.g., ceratotrichia, gill arches, stomach contents). These varying preservational circumstances necessitate the utilization of specific preparation techniques and tools to properly extract the massive, bony placoderm skulls and the delicate features of shark soft tissues.

Experimentation by CMNH staff and volunteers has established protocols for the preparation challenges of each unique Cleveland Member taxon. Shale overburden is worked down in layers using a flex-shaft hand grinder fit with a silicon carbide abrasion disk in a ventilated blasting cabinet with the aid of a microscope. For placoderm bone, once the first sign of black bone appears in the dark gray matrix, air abrasion using dolomite abrasive media is used to remove the remaining fine layer of shale. Masses of pyrite or barite can be removed down to the bone surface using an air scribe with a dull carbide steel tip. Grinding is not recommended on pyrite due to excess heating and wheel wear. For sharks, layered matrix removal is done exclusively with grinding wheels and air scribes. Air abrasion is not recommended as it tends to easily obliterate or mar soft tissue and tooth enamel.

Employing these basic methods, delicate/fragile fossils can be safely extracted from their hard shale matrix. In addition to revealing the Konservat-Lagerstätten preservation of soft tissue and gut contents in sharks, this procedure has recently led to the discovery and description of the first definitive cartilaginous postcrania from the Late Devonian apex predator *Dunkleosteus terrelli*.

Technical Session IV (Wednesday, October 17, 2018, 3:15 PM)

DELAYED INCREASE IN MORPHOLOGICAL RATES OF EVOLUTION AFTER THE ORIGIN OF THE PLACENTAL MAMMAL CROWN GROUP

HALLIDAY, Thomas J., University of Birmingham, Birmingham, United Kingdom; DOS REIS, Mario, Queen Mary University London, London, United Kingdom; TAMURI, Asif U., University College London, London, United Kingdom; FERGUSON-GOW, Henry, University College London, London, United Kingdom; YANG, Ziheng, University College London, London, United Kingdom; GOSWAMI, Anjali, Natural History Museum, London, United Kingdom

Differing divergence date estimates derived from interpretation of the fossil record and from molecular-clock studies have confounded attempts to resolve the timing and pattern of early placental mammal evolution. Despite results from diverse dating analyses favouring a Cretaceous origin of Placentalia, no unambiguous Cretaceous placental mammal has yet been discovered. Here we investigate the differing patterns of evolution of morphological and molecular data to explore possible explanations for this conflict. Using a dataset incorporating skeleto-dental anatomy of a broad spread of extant and extinct genera, as well as genomes for 43 extant genera, we quantify the relationship between morphological and molecular rates of evolution across the placental mammal phylogeny. We show that, independent of estimated divergence dates, morphological rates were slow relative to molecular evolution during the initial divergence of Placentalia, but substantially increased relative to molecular evolution during the origination of the majority of the extant orders. The rapid radiation of placentals into the highly morphologically disparate forms that are observed throughout Cenozoic faunas is therefore not associated with the origin of Placentalia, but rather post-dates the origin of the placental superorders. These findings predict that early members of major placental groups (Atlantogenata, Laurasiatheria, and Euarchontoglires) should therefore be present in Cretaceous sediments. However, extremely low relative rates of morphological evolution on those branches delimiting the superorders cause us to predict that these taxa may not be easily distinguishable from one another or from stem eutherians solely on the basis of skeleto-dental morphology. When combined with the most recent date estimates derived from both fossil and molecular data, those placental lineages inferred to have crossed the Cretaceous–Palaeogene boundary are those with increased relative rates of morphological evolution. Our results support the hypothesis of a Late Cretaceous origination of crown placentals with limited initial morphological divergence, with the subsequent adaptive radiation occurring at ordinal level in the earliest Paleocene. The lack of definitive Cretaceous placental mammals may therefore be explained by high predicted morphological similarity among stem and basal crown eutherians, providing an avenue for partially reconciling the fossil record and molecular divergence estimates in Placentalia. Grant Information

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A MONSTERSAURIAN LIZARD FRONTAL FROM THE CAMPANIAN WAPITI FORMATION OF ALBERTA, CANADA.

HAMILTON, Samantha M., University of Alberta, Edmonton, AB, Canada; PAPARELLA, Ilaria, University of Alberta, Edmonton, AB, Canada; BELL, Phil, University of New England, Armidale, Australia; CAMPIONE, Nicolas E., University of New England, Armidale, Australia; FANTI, Federico, Alma Mater Studiorum - Università di Bologna, Bologna, Italy; LARSON, Derek W., Philip J. Currie Dinosaur Museum, Grande Prairie, AB, Canada; SISSONS, Robin, Edmonton, AB, Canada; VAVREK, Matthew, Grande Prairie, AB, Canada; SULLIVAN, Corwin, University of Alberta, Edmonton, AB, Canada

The DC Bonebed is a newly reported channel deposit from the Wapiti Formation of central-western Alberta, Canada. It lies in a stratigraphic interval that is likely equivalent in age to the Bearpaw Formation of southern Alberta and contains a diverse assemblage of isolated skeletal elements from many small to medium-sized vertebrates such as fish, turtles and lizards. Lizard material previously collected from the Wapiti Formation have included very well preserved cranial elements from several representatives of the infraorder Scincomorpha (Squamata), including *Chamops segnis, Kleskunsaurus grandeprairiensis*, and *Socognathus unicuspis*. Among recently recovered material from the DC bonebed is an isolated right frontal of a lizard referable to the anguimorph clade Monstersauria. Monstersaurians are known from a diversity of Mesozoic and Cenozoic fossil taxa and are represented today by the extant Gila monster and beaded lizards (*Heloderma* spp.). The frontal is extremely well preserved, and its finished margins clearly indicate it was not fused to its left counterpart. This is the most complete monstersaur frontal to have been reported from the Cretaceous of Alberta, and it represents one of the largest monstersaurs known from the Upper Cretaceous of North America, being of comparable size (estimated skull length about 130 mm) to the Late Cretaceous monstersaur *Estesia mongoliensis* from Mongolia (skull length = 150 mm in the holotype). Synapomorphies of Monstersauria that are present in the Wapiti specimen include lack of fusion between the frontals, and large, mound-like, pitted osteoderms on the dorsal surface of the frontal. Some other Cretaceous North American monstersaurs, such as *Paraderma*, *Labrodioctes* and *Primaderma,* possess similar pitted, polygonal osteoderms. The Wapiti specimen remains taxonomically indeterminate at the species level due to lack of adequate comparative material and could belong to any of the previously mentioned North American Cretaceous genera or to *Palaeosaniwa,* for which sufficient frontal material has not yet been recovered. A micro-CT scan of the specimen reveals no clear planes of separation between the osteoderms and the underlying bone forming the dorsal surface of the frontal proper, and such fusion suggests that the individual was not a developing juvenile. This specimen significantly increases the known latitudinal range of monstersaurian lizards during the Late Cretaceous, and increases the known diversity of the Campanian fauna of the Wapiti Formation.

Grant Information

This research was funded by an NSERC Discovery Grant (RGPIN-2017-06246) and an endowment associated with the Philip J. Currie Professorship at the University of Alberta.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

CONTEXTUALIZING THE MOSAIC EVOLUTIONARY ASSEMBLY OF THE MODERN BIRD SKULL

HANSON, Michael, Yale University, New Haven, CT, United States of America; BHULLAR, Bhart-Anjan S., Yale University, New Haven, CT, United States of America

The avian bill and its associated cranial kinetic system is an incredibly variable structure adapted for feeding and prehension in a wide array of dietary and ecological niches, and insight into the origin of the modern dexterous bird bill is as important to understanding the history of birds as is the origin of flight. Key characteristics of this structure in its anatomically modern form include tooth loss and the reduction of the bony temporal arches. Toothless jaws appear among Avialae (the clade containing *Archaeopteryx*, modern birds, and their relatives) at least three times: in confuciusornithids, *Gobipteryx* (a member of Enantiornithes), and crown Aves. Although the toothless beaks outside the crown superficially bear a strong resemblance to those of extant birds, only the tooth loss sequence in Ornithurae occurs in conjunction with a mobile quadrate bone. Confuciusornithids and many Enantiornithes retained a highly ossified, immobile temporal region. Bone reduction in the temporal arches occurs independently in some lineages of the relatively abundant Enantiornithes and among the scarcer Mesozoic ornithurans. The former retain highly consolidated, toothed, and plesiomorphically dinosaurian snouts likely incapable of the fine cranial kinesis necessary for the dexterity seen in extant birds. The sequence from *Yanornis* to *Ichthyornis* shows that the premaxillary teeth were lost first in ornithurans in conjunction with the emergence of a toothless premaxillary bone. We show, using new data derived from μCT scans and firsthand observations of fossils, that the most complete and three-dimensionally preserved Mesozoic ornithurans, *Ichthyornis* and *Hesperornis*, exhibit a mosaic of ancestral and highly derived characters. These include avialan plesiomorphies such as deeply-embayed jaw adductor muscle chambers, teeth in the maxillae and dentaries, and occlusal pits in the upper jaw. More derived characters ancestral to extant birds include the mobile quadrate, expanded palatal shelves of the maxillae, and toothless jaw tips. Highly homoplastic characters that otherwise appear convergently in deeply nested semiaquatic crown-avian taxa are also seen in these non- crown birds and include pronounced postorbital processes, fossae for salt glands, and enlarged cranial muscle attachment sites. These taxa indicate that cranial kinesis and use of the bill as a dexterous substitute for a hand likely preceded the loss of teeth, and that the suite of characters associated with modern bill function occurred only within ornithuran birds.

Grant Information

Supported by a Yale Institute for Biospheric Studies Doctoral Pilot Grant

Technical Session VI (Thursday, October 18, 2018, 8:30 AM)

RETENTION OF FISH-LIKE TOOTH REPLACEMENT IN THE PALATAL DENTITION OF PERMIAN TETRAPODS

HARIDY, Yara, Museum für Naturkunde, Berlin, Germany; GEE, Bryan, University of Toronto at Mississauga, Mississauga, ON, Canada; REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada

Non-marginal dentition is present in most Paleozoic tetrapods as coronoid teeth in the lower jaw and teeth on oral surface of palatal bones. Despite its prevalence, non-marginal dentition in early tetrapods has received little attention, especially from a histological and developmental perspective. Our histological examination of several terrestrial tetrapods revealed that their palatal dentition had an unexpected pattern of development and replacement, different from that in the marginal dentition, and a pattern previously known only to be present in fish. This is consistent with the generally accepted hypothesis that the marginal and non-marginal dentition of Paleozoic tetrapods was inherited from their sarcopterygian and stem tetrapod ancestry. The normal pattern of marginal tooth replacement shows new teeth developing lingual, or directly under the older teeth, gradually replacing the old teeth while maintaining a positional pattern with in the jaw. In contrast, the palatal teeth, as seen in the terrestrial dissorophoids and captorhinid examined here, develop on the surface of the bone and are replaced through successive burial of one tooth generation by a new bone layer to which the next generation of teeth is attached. This is a replacement pattern is referred to as ‘over growth’ when documented in the odontodes and scales in fish. Therefore, it is surprising to find that this overgrowth pattern persists in the palatal dentition of at least two clades of terrestrial Paleozoic tetrapods, bridging the aquatic–terrestrial transition. We propose a sequential developmental mechanism in which the decoupling of tooth development and appositional growth of the underlying bone lead to the embedding patterns seen in early fish, and now Paleozoic tetrapods.

Technical Session VIII (Thursday, October 18, 2018, 2:15 PM)

CRETACEOUS STEM-THERIAN PETROSALS FROM MONGOLIA PROVIDE EARLIEST EVIDENCE FOR MODERN COCHLEAR PHYSIOLOGY

HARPER, Tony, Johns Hopkins University, Palm Desert, CA, United States of America; ROUGIER, Guillermo W., University of Louisville, Louisville, KY, United States of America

The mid-Cretaceous Höövör locality in southern Mongolia has produced a variety of triconodont, symmetrodont, and tribosphenic teeth and isolated mammalian cranial elements. Petrosal bones from Höövör represent the most plesiomorphic mammals to show the presence of several derived inner ear features such as the cochlear aqueduct/round window and an osseous bony lamina for the attachment of the basilar membrane. Prior studies have supported the basal trechnothere affinities of the first Höövör petrosal (Höövör 1); however, the undescribed second (Höövör 2) petrosal shows several more therian-like internal and external features, but it is currently not referable to any known taxon from this locality.

High resolution micro-CT images taken from both Höövör petrosals allow for visualization of the cochlear canal and several supporting neurovascular structures associated with the unique form of macromechanical tuning of the cochlear apparatus seen only in therian mammals today. In particular, virtual endocasts of the bony labyrinth show a neomorphic venous canal impinging the recessus scala tympani, while simultaneously showing a generalized reduction of venous sinuses relative to the condition seen in stem mammaliaformes. We hypothesize that this localized hypertrophy is associated with the increased metabolic demands of the stria vascularis, the sole organ responsible for

producing endolymph in extant therians. This pattern of venous drainage, visible with high resolution imaging, provides indirect evidence for the initiation of the therian type of cochlear physiology, above and beyond the transitional state seen in monotremes today. The Höövör petrosals, therefore, demonstrate that loss of the more ancient types of cochlear tuning (as seen in other amniotes), and probable loss of the lagenar macula, occurred in stem therians with short and uncoiled cochleae. Ostensibly, at the time of their first appearance these morphological features are not associated with the capacity for ultrasonic hearing in the stem therian lineage.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

LOWER CRETACEOUS CROCODYLIFORMS FROM LIGHTNING RIDGE, NEW SOUTH WALES, AUSTRALIA: NEW EVIDENCE OF THE BASAL EUSUCHIAN *ISISFORDIA*

HART, Lachlan J., University of New England, Armidale, Australia; BELL, Phil, University of New England, Armidale, Australia; SALISBURY, Steven W., University of Queensland, Brisbane, Australia

The Australian record of Mesozoic crocodyliforms is sparse in comparison with most other Gondwanan continents. To date, only two taxa have been formally named: *Isisfordia duncani* from the upper Albian portion of the Winton Formation of central-western Queensland, and '*Crocodylus*' *(Bottosaurus) selaslophensis* from the Cenomanian Griman Creek Formation of Lightning Ridge, north-western NSW. The latter taxon, based solely on an isolated jaw fragment, is enigmatic and has historically been considered a *nomen dubium*.

Reanalysis of the '*Crocodylus*' *(Bottosaurus) selaslophensis* holotype shows that it displays sufficient similarity with *I. duncani* to warrant referral to *Isisfordia*. Central to this argument is the re-identification of the jaw fragment as part of the maxilla rather than the dentary as was previously supposed, combined with the presence of characteristic labiolingually flattened teeth. The identification of remains that can potentially be assigned to an indeterminate species of *Isisfordia* from Lightning Ridge is bolstered by the discovery of an opalised partial braincase, also from the Griman Creek Formation, which displays at least one unambiguous autapomorphy of the former and adds new information about the braincase anatomy of *Isisfordia* species. Furthermore, postcranial remains from the Griman Creek Formation, including a series of associated vertebrae, also show features consistent with *I. duncani* or a closely related species.

The confirmed occurrence of *Isisfordia*, combined with a previously described (unnamed) taxon, indicates that the Griman Creek Formation is likely to be the only Cretaceous unit in Australia to have yielded more than one crocodyliform taxon. These discoveries are also significant as they extend the geographical and temporal range of *Isisfordia,* which is currently considered the most basal taxon within Eusuchia, the clade that contains extant crocodylians.

Grant Information
Australian Research Council Discovery Early Career Researcher Award (project ID: DE170101325)

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

MANUS MORPHOLOGY OF AN EXTRAORDINARILY LARGE PROBOSCIDEAN FROM THE GRAY FOSSIL SITE OF EASTERN TENNESSEE, WITH COMPARISON TO SAUROPOD MODIFICATIONS BASED ON GIGANTISM

HART-FARRAR, Brenna J., East Tennessee State University, Johnson City, TN, United States of America

Beginning in the fall of 2015, excavations at the Mio-Pliocene aged Gray Fossil Site (eastern, TN, U.S.A.) yielded a nearly complete skeleton of an unknown mastodon-like proboscidean. Morphology and initial mass estimates suggested that the specimen could not be easily classified within pre-existing taxa; hence, a detailed description was warranted for alpha taxonomy. Among the elements recovered thus far is a complete left manus, described here and compared to other large proboscidean taxa (both extinct and extant), and other non-mammalian giants (i.e., sauropods). With additional recovered elements and different allometric equations, body mass was calculated to approximately 16.5 tons, making it one of the largest land mammals ever. Descriptions and measurements of the manus were compared to the proboscideans: *Mammut americana*, *Mammuthus columbi*, *Amebelodon britti*, and *Loxodonta africana*. Observations show variability of the carpals and metacarpals of the Gray specimen compared to those of *Mammut americana* and *Loxodonta africana*. Articular facets show a mosaic of areas that have less mobility whereas others have more mobility than in other proboscideans. Compared to the two recently aforementioned proboscideans, the trapezoid is more angular; the trapezium has two medial facets instead of four; and the first metacarpal has the phalangeal and sesamoid facets oriented obliquely to the dorsal facet. Such differences may correspond to size, aiding in stability and support of large body masses. No terrestrial vertebrate taxa, especially within Mammalia, are close in size, but the superficial size similarity of sauropods with large proboscideans, along with their similar fat pad and foot structure make them ideal for comparisons. If large proboscideans exhibit manus modifications, it is suspected that giant sauropods like *Brachiosaurus* and *Argentinosaurus* would have similar structural modifications resulting in convergence in these unrelated taxa. Though proboscideans do not reach the body masses of the largest sauropods, it is possible that there are modifications unique to the lineages, such as proboscideans exhibiting locking sesamoids and sauropods displaying splayed metacarpals.

Grant Information
I would like to thank the Don Sundquist Center of Excellence in Paleontology for funding and the Florida Museum of Natural History for granting me access to their collections.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

DISTRIBUTION OF THE AMERICAN MASTODON (*MAMMUT AMERICANUM*) IN THE AMERICAN SOUTHWEST THROUGH THE PLEISTOCENE

HARTLEY, James C., Benson, AZ, United States of America

The American mastodon (*Mammut americanum*) is a browsing proboscidean that lived in spruce woodland environments throughout much of North America. It was among the megafauna that went extinct at the end of the Pleistocene. This study reviews previous studies by others on American mastodon sites in the American Southwest (much of which is currently plateau and lowland desert). Mastodon sites are evaluated based on their geological age and elevation above sea level, to determine if mastodon distributions shifted with shifting climates through the Pleistocene. American mastodon fossils are infrequent in the Southwest compared to mammoths and other megafauna. Based on previous research by others, American mastodons lived at lower elevations above sea level (usually below 4,000 meters) during glacial stages and at higher elevations during interglacial stages. This is consistent with the established ecology of mastodons as browsers living in cooler wooded environments.

Technical Session VII (Thursday, October 18, 2018, 2:00 PM)

A TESTABLE MACROEVOLUTIONARY FRAMEWORK FOR CHARACTER ACQUISITION IN THE ORIGIN OF AVIAN FLIGHT

HARTMAN, Scott, University of Wisconsin-Madison, Madison, WI, United States of America; MORTIMER, Mickey, Maple Valley, WA, United States of America; LOVELACE, David M., University of Wisconsin-Madison, Madison, WI, United States of America

Attempts to reconstruct the origins of avian flight have traditionally embraced "trees-down" or "ground-up" models. More recently, these dueling ecomorph interpretations have been interpreted as a false dichotomy, but no explicit framework as been put forward to test which characters evolved within what context. Utilizing a phylogenetic analysis with expanded taxon sampling we propose a framework for breaking the process into four stages.

Stage I: Acquisition of theropod characters unrelated to avian flight, including bipedalism, three fingered hands, a furcula, and filamentous epidermal structures. Stage II: Acquisition of characters directly exapted for flight such as enlarged forelimbs, pennaceous feathers on the forelimbs and tail, increased angle between scapula and distal coracoid, and laterally facing glenoid fossae. Stage III: Characters acquired due to aerial locomotion, including tertial feathers, expansion of the flight stroke and associated muscles, and in more derived taxa an alula and reduction of the distal caudal series to a pygostyle. Stage IV: Characters associated with higher endurance crown avian-style flight including enlarged keeled sterna, hinged sternal ribs, loss of gastralia, and well-developed caudal air sacs.

There is a broad consensus that characters in Stage I were acquired in terrestrial settings, while those in stage IV were acquired after avialans had radiated into arboreal habitats. Our phylogenetic analysis recovers short-armed, non-volant members at the base of all maniraptoran clades, including Avialae. We interpret this as strong support that Stage II characters were also acquired within terrestrial settings. Thus, explanations for the origin of pennaceous proto-wings and the incipient avian flight-stroke must be decoupled from aboreality, and their eventual exaptation for flight. Stage II taxa with small body size and enlarged forelimbs may have utilized wing assisted incline running (WAIR) to access trees despite lacking unambiguously arboreal characters, breaking the ground-up/trees-down dichotomy.

Several Stage II taxa independently approached Stage III conditions, including some microraptorians, *Rahonavis*, *Archaeopteryx* and scansoriopterygids; this suggests that WAIR enabled several parallel experiments with aerial locomotion. Unambiguous Stage III avialans *Sapeornis*, jeholornithids and confuciusornithids show clear adaptations for living in trees, suggesting arboreality was important in the final transition to avian flight.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

DINOSAURS IN COMIC BOOKS AS A MEANS OF STEAM ENGAGEMENT WITH MIDDLE SCHOOL STUDENTS IN UNDER-SERVED DISTRICTS IN VIRGINIA, U.S.A.

HASTINGS, Alexander K., Virginia Museum of Natural History, Martinsville, VA, United States of America; STONEMAN, Lisa, Roanoke College, Salem, VA, United States of America; HASTINGS, Kathryne A., Virginia Museum of Natural History, Martinsville, VA, United States of America; DEATHERAGE, Christy, Virginia Museum of Natural History, Martinsville, VA, United States of America

Engagement in STEAM education initiatives (Science Technology Engineering Art and Math) is often difficult, particularly for middle school in under-served populations. Given the rising popularity of comic book-based properties and a common interest in dinosaurs, we developed an eight-session series for an After School program titled "Comic Books & Dinosaurs." This was implemented in four schools in two under-served districts of Virginia, focused on middle school students (Martinsville and Henry County).

The program included discussions of scientific representation of paleontology in the comic book art form, as well as basics of paleontology and comic book development. Students also visited the Virginia Museum of Natural History (VMNH) and were given tours of the lab and fossil collections. The aim of the museum visit was to help students generate concepts and gain basic visuals in order to create their own content. The goal was then for students to create their own, short comic books, with some assistance from VMNH staff. For each of the seven sessions not held at VMNH, a different dinosaur fossil was brought to help encourage discussion on a range of topics (e.g., inferring predation from tooth marks on a sauropod rib).

Surveys of 10 questions were given during the first and final sessions. Questions were primarily to assess baseline understanding about paleontology, and efficacy for retention. Given the highly variable attendance at the after school program, this resulted in a limited number of students with both pre- and post-surveys (n=22). As per guidelines of the Internal Review Board, informed consent forms were distributed to the students' guardians. Because students had the option of not answering questions, this also resulted in a variable number of responses across the two surveys. Of the students that completed both surveys, there was marked improvement in their ability to answer basic paleontological questions. As an example, correct identification of a pterosaur as not a dinosaur increased from 11% (n=18) to 67% (n=21) and identification of a pigeon as a dinosaur increased from 5% (n=19) to 67% (n=21). Especially considering the surveys were separated by about three weeks, the results imply meaningful retention.

On the whole, some students seemed to really value the experience, while others clearly did not care for it. In terms of student enjoyment, such a program would likely work better if students (rather than teachers) were selecting to partake in the sessions.
Grant Information
Funds provided by the 'Martinsville-Henry County After Three' after school program.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

NEWLY COLLECTED MATERIAL FROM STARR CHAPEL CAVE REVEALS FURTHER PRESENCE OF PLEISTOCENE FAUNA IN NORTHWESTERN VIRGINIA, U.S.A.

HASTINGS, Alexander, Virginia Museum of Natural History, Martinsville, VA, United States of America; HUBBARD, David A., Virginia Speleological Survey, Charlottesville, VA, United States of America; GRADY, Fred, US National Museum of Natural History, Fredonia, NY, United States of America; VODDEN, Raymond G., Virginia Museum of Natural History, Martinsville, VA, United States of America; KHAMEISS, Belkasim, Ball State University, Muncie, IN, United States of America

Bone deposits are fairly common within Virginia caves, typically consisting of local species of bats and pack rats. While these small mammals have existed in Virginia since the Pleistocene, without extensive radiocarbon dating, it is difficult to illustrate the antiquity of these bone deposits. Much rarer are bone collections with identifiable remains of extinct and extirpated fauna. The Starr Chapel Cave in northwestern Virginia was recognized as having extinct taxa in 1999; however, permitted fieldwork was not granted until 2017. Two fossil-collecting excursions resulted in a sizable collection of 368 cataloged specimens of bones and teeth.

A total of 485 bones and teeth could be identified beyond simply Vertebrata. Mammals outnumbered all other vertebrate groups combined (84.5%, n = 410). Of these, rodents constituted the largest portion of identified mammals at 23.7% (n = 97) followed by bats 11% (n = 45). The lower percentage of bat material was surprising given the current occupation of the cave by bats. The collection includes four bat genera (*Eptesicus*, *Lasionycteris*, *Lasiurus*, and *Myotis*) and the pack rat *Neotoma*, which are all known to occupy Virginia caves today. However, the fauna also included several non-cave-dwelling species such as rabbit (*Sylvilagus* and *Lepus*), white-tailed deer (*Odocoileus*), and gopher (*Marmota*) that are still extant in Virginia but were also present during the Pleistocene. A partial molar matches very well with juvenile teeth of the American Mastodon (*Mammut americanum*), and a second partial molar matches very well with tapir (*Tapirus* sp.), known from other sites in Virginia; Both represent extinct Pleistocene taxa. Additional extirpated taxa are represented by partial teeth that match well with elk (*Cervus* sp.), caribou (cf. *Rangifer*), and three rodent genera that currently only live in other regions: *Neofiber*, *Geomys*, and *Sigmodon*. Additionally, the cave fauna includes Ordovician invertebrate fossils that eroded out from the limestone walls, the most common of which are crinoids and the brachiopod *Orthorhynchula linneyi*.

The cave has high potential to yield further Ice Age fauna as well as potential for direct-bone radiocarbon dating to help improve the resolution of the age of the cave fauna as well as the overall timing of Pleistocene fauna in Virginia.

Preparators' Session (Thursday, October 18, 2018, 2:45 PM)

ULTRA-THIN SMALL MAMMAL CRANIAL RECONSTRUCTION IN THE 0.5–0.7 MILLIMETER RANGE USING BUTVAR B-76

HAUGRUD, Shawn J., East Tennessee State University, Gray, TN, United States of America

The Gray Fossil Site in east Tennessee represents a diverse assemblage of earliest Pliocene fossils, including many new species. Preservation at the site is often exquisite, but due to the small size of many animals and the enormous weight of the overlying clay small articulated specimens are often crushed flat. Bone directly adjacent to the folded breaks can sometimes be irreparably damaged by the taphonomic processes. Specimens can be fully prepared but the missing bone left from crushing does create zones of weakness. Curators desired the specimens to be stabilized by replacing the missing bone with filler. Candidates for filler were required to be archival, reversible, strong, and lightweight. It was also required that the filler be thinner than a millimeter, readily distinguishable from the actual bone, and not interfere with MRI and CT scanning. To meet all these requirements we developed a new technique that used Butvar B-76 as filler.

We first used this technique in 2008 on a nearly complete skeleton of a fossil red panda, *Pristinailurus bristoli*, particularly in reconstructing the crania. Once the majority of preparation had been completed, the exposed broken margin left by missing bone was coated in a fine bead of Butvar B-76. We then attached beads to points projecting into the void and pulled them into extremely fine threads, attaching to points across the void on a corresponding surface. This created a structure similar in appearance and curvature to a wire-frame. The threads where then stretched and contoured with a dental explorer while still in a semi-plastic state to match the curvature of the missing bone and allowed to set. Once the frame was hardened, a new higher volume bead was started and with a side to side motion of the glue tube pulled into a very thin sheet over the threads. The original threads were partially dissolved and incorporated into the freshly applied Butvar B-76, forming a 0.5 millimeter thick transparent sheet that matched the thickness and contour of the original missing bone. The final product is quite stable and allows the specimen to be handled with confidence. No degradation or changes have been observed over the last 10 years. The specimen has been scanned and the Butvar B-76 does not show up in scans due to its low density. We have successfully prepared a number of small specimens over the last 10 years using this technique, including eggshell.

Technical Session XV (Saturday, October 20, 2018, 8:30 AM)

BONE CARBONATE–COLLAGEN SPACING OF STABLE CARBON ISOTOPE VALUES IN EXTANT TREE SLOTHS AND IMPLICATIONS FOR THE INTERPRETATION OF GROUND SLOTH DIET

HAUPT, Ryan J., Smithsonian Institution's National Museum of Natural History, Washington, DC, United States of America; CLEMENTZ, Mark, University of Wyoming, Laramie, WY, United States of America

There is continued debate about the degree to which extinct ground sloths were strict herbivores versus performing some level of omnivory/carnivory. One way to estimate protein percent in diet is by examining the bioapatite carbonate to collagen spacing between stable carbon isotope values ($\delta^{13}C_{carbonate–collagen}$), which has shown promise at distinguishing different dietary guilds (e.g., terrestrial vs. marine consumers, carnivores vs. herbivores, etc.). This technique has been applied to ground sloths, but isotopic studies of xenarthrans have long been hampered by lack of modern comparative data. Wild tree sloths are thought to consume little to no animal protein, but when in captivity, their leafy diets are often supplemented with dry dog food (~10% of their intake by weight, but ~45–70% of dietary protein by weight). This dietary discrepancy provides an opportunity to answer the following question: does a small amount of high-protein food in a sloth's diet yield a measurable difference in their $\delta^{13}C_{carbonate–collagen}$ values? Here we analyzed bones from deceased modern captive (n = 3) and wild (n = 3) two- and three-fingered sloths from the Sloth Sanctuary of Costa Rica and included values from one previously published wild *Choloepus*. Our results show that captive sloths have significantly higher $\delta^{15}N$ values (i.e., higher trophic level) than wild sloths (p = 0.049), consistent with the higher $\delta^{15}N$ values of dog food (3.4‰) relative to local leaves (2.7‰), and consistently lower but not significant $\delta^{13}C$ spacing (p = 0.07). Wild sloths show tight $\delta^{13}C$ spacing of ~1‰ (5.9 to 6.8‰), whereas captive sloths show lower mean spacing (4.8‰) and greater range (3.1 to 5.9‰). The range and distribution of values for the two groups are consistent with our expectations based on differences in dietary protein percentages. When compared to values from the literature, including Pleistocene ground sloths, we found that both captive and wild tree sloths have lower $\delta^{13}C$ values than ground sloths (p = 0.017 and 0.003), and both wild and captive groups were statistically indistinguishable from small-bodied herbivores (p = 0.18 and 0.17) and low-meat omnivores from Costa Rica (p = 0.09 and 0.43). These results suggest that the $\delta^{13}C_{carbonate–collagen}$ spacing in modern sloths is sensitive to subtle shifts of protein intake in sloths, consistent with previously observed shifts in other mammalian taxa and ultimately supporting the interpretation of ground sloths as large-bodied herbivores.
Grant Information
Funding was provided by an Experiment crowd-funding campaign. More information and a list of backers can be found at http://experiment.com/sloths.

Technical Session IV (Wednesday, October 17, 2018, 2:00 PM)

QUANTITATIVE ANALYSIS OF THE ADAMANIAN–REVUELTIAN TERRESTRIAL VERTEBRATE EXTINCTION AND REPLACEMENT; LATE TRIASSIC, PETRIFIED FOREST NATIONAL PARK, AZ, U.S.A.

HAYES, Reilly, University of Rhode Island Geosciences, Kingston, RI, United States of America; PUGGIONI, Gavino, University of Rhode Island, Kingston, RI, United States of America; BEDNARICK, Amanda, University of Rhode Island, Kingston, RI, United States of America; FASTOVSKY, David E., University of Rhode Island, Kingston, RI, United States of America

Whether an extinction was "abrupt" or "gradual" is the most fundamental question one might ask about it, but sparse data and poor temporal control make answering even that difficult, particularly when working with fossil vertebrates in terrestrial settings. Sparse data ensure that the last appearance does not signify the actual moment of the taxon's complete extinction, an event that would likely occur somewhat later. But how much later? In the Late Triassic Chinle Formation of Petrified Forest National Park (PEFO), AZ, the uncommon coincidence of high-precision geochronology and robust lithostratigraphy allows us to apply the Bayesian statistical approach of J. Alroy to quantify the dynamics of a Late Triassic vertebrate extinction and replacement, the Adamanian–Revueltian (A–R) faunal turnover, and develop temporal credible intervals for when the extinction actually occurred.

The Alroy method constructs the most likely timing of extinction iteratively: it first defines as a "prior" a taxon's per-interval chance of extinction, assuming that the probability of extinction can be modeled as an exponential process, and that the chance of extinction by the time of the last fossil occurrence is 50%. Then, using a modified form of Bayes' Theorem, it incorporates successive, conditional probabilities of extinction (the "posteriors"), given a taxon's stratigraphic record of appearances. The posteriors successively become the priors for each sequential interval, and the process repeats until we may define a 95% credible interval constraining the time of extinction.

We have applied these credible intervals to evaluate the relative timing of taxon extinctions and originations in the Chinle at PEFO. With this approach, we can quantitatively test the synchronicity of the Adamanian extinction, as well as the Revueltian origination. An asynchronous extinction falsifies the hypothesis that the Adamanian–Revueltian turnover is a single event representing a biostratigraphic datum. Additionally, we test the coincidence of these events with the Manicouagan impact (215.5 Ma; Quebec, Canada), widely implicated as the cause of the A–R turnover.
Grant Information
Sigma Xi, URI Geosciences, URI Graduate School, URI Coastal Fellows Program, NASA RI Space Grant Consortium, Paleontological Society

Technical Session XII (Friday, October 19, 2018, 3:45 PM)

POSTCRANIAL ANATOMY OF THE GIANT SNAKE *TITANOBOA CERREJONENSIS*: IMPLICATIONS FOR ESTIMATING ECOLOGY AND BODY SIZE

HEAD, Jason J., University of Cambridge, Cambridge, United Kingdom; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; RINCÓN, Aldo F., Universidad Del Norte, Barranquilla, Colombia; MORENO-BERNAL, Jorge, Universidad Del Norte, Barranquilla, Colombia; BOURQUE, Jason, Florida Museum of Natural History, Gainesville, FL, United States of America; JARAMILLO, Carlos, Smithsonian Tropical Research Institute, Balboa, Panama

Titanoboa cerrejonensis was originally described from the Paleocene Cerrejón Formation of Colombia on the basis of isolated precloacal vertebrae. Initial body size estimates, phylogenetic relationships, and ecology were inferred from a limited sample of vertebral morphology, however, and axial skeletal morphology, including intracolumnar variation and overall body form for the taxon, was unknown. Subsequent collection of three partial skeletons of *Titanoboa* that sample all regions of the axial skeleton allow for robust estimation of axial skeletal anatomy and inferences of ecology and behavior in the taxon. Vertebral morphology is consistent with a phylogenetic position within non-caenophidian macrostomatans. The atlantal neural arch possesses a single, elongate posterodorsal spine. Anterior precloacal elements are transversely narrow and possess pronounced, ventrally oriented hypapophyses. Vertebrae from the approximate middle region of the precloacal trunk are laterally expanded with wide central haemal keels. Posterior precloacal vertebrae are dorsoventrally short and possess wide, well-developed subcentral paralymphatic fossae, consistent with enlargement of the paralymphatic system just anterior to the cloaca. Caudal elements are poorly preserved but appear to possess paired haemapophyses. Rib morphology grades from elongate, strongly shouldered, and recurved elements anteriorly to gracile, short, and approximately straight elements posteriorly.

Vertebral size changes along the precloacal column are consistent with visceral positioning, and potentially with prey acquisition strategies, in extant booids. Centrum length does not change substantially along most of the body, whereas width changes strongly with a maximum between 25–40% along the body length. Revised body size measurements indicate maximum transcostal widths of approximately 60 cm and a snout– vent length of approximately 12–13 m. Combined with cranial osteology and osteohistology, postcranial anatomy of *Titanoboa* indicates obligately aquatic habits with a likely piscivorous feeding ecology.

Technical Session XVI (Saturday, October 20, 2018, 11:30 AM)

USING BONE MICROSTRUCTURE TO INFER INTRASKELETAL GROWTH AND POSTURAL SHIFTS IN THE HADROSAURID DINOSAUR *MAIASAURA PEEBLESORUM*

HECK, Christian T., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America; WOODWARD, Holly N., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America

Hundreds of fossils of the Campanian hadrosaurid dinosaur *Maiasaura peeblesorum* have been collected from a 2 km^2 laterally expansive monodominant bonebed of disarticulated individuals. A recent osteohistological analysis of *Maiasaura* utilized this unique assemblage to infer growth dynamics and survivorship using a sample of 50 tibiae. A subsequent study suggested that, based on appendicular myological and biomechanical evidence, *Maiasaura* underwent an ontogenetic postural change from bipedal when young to quadrupedal when older. Because bone growth responds to stress, we hypothesize that evidence of such a postural transition may be recorded as changes in bone tissue or vascular organization within the humerus. To test this, and as a pilot study to ascertain ontogenetic intraskeletal trends in *Maiasaura* growth, we examined the diaphyseal bone microstructure of seven humeri ranging in length from 19.8 cm to 61.6 cm. Based on LAG counts, the sample consists of three individuals less than a year old, one yearling, one 6 year old, and one 7 years of age. Histology revealed that none of the humeri were skeletally mature. Similar to tibiae, *Maiasaura* humeri are composed of fibrolamellar tissue with reticular, laminar, and plexiform vascularity. Contrary to tibiae, there is no observable alternation from reticular to plexiform tissue within cortical zones beginning after the second LAG. Instead, vascularity is primarily reticular in yearlings. and shifts to plexiform to laminar after the second LAG. Our study also permits tentative intraskeletal, ontogenetic limb proportion relationships: the 40 cm humerus with one LAG corresponds to tibia lengths between 45 cm and 57 cm; the 46 cm humerus with six LAGs, to tibiae between 85 cm and 88 cm; the 62 cm humerus with seven LAGs, to tibiae 88 cm in length. Despite similarities in fibrolamellar bone tissue organization, averaged daily cortical apposition rate in the humerus was 45% lower than the tibia in the first year, 20% lower during the second year, and 69% lower by the seventh year. Although vascular organization changed from reticular to plexiform after year one, we were unable to confidently identify histological features related to postural change within our sample of seven humeri. However, differences in averaged annual apposition rates between the tibia and humerus suggest that with increased sampling, ontogenetic trends in limb scaling will manifest, improving our understanding of *Maiasaura* intraskeletal growth and providing another method for addressing the postural change hypothesis.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

FINDING FOSSILS ON FRIDAYS (FFF)—USING AN APPRENTICESHIP MODEL TO BUILD A GUILD OF UNDERGRADUATE RESEARCHERS AND EXPAND PALEONTOLOGICAL OUTREACH AT APPALACHIAN STATE UNIVERSITY

HECKERT, Andrew B., Appalachian State University, Boone, NC, United States of America

Successful undergraduate research programs require invested faculty, focused, short-term projects, and opportunities for students to develop skills outside of class. Microvertebrate projects are ideal because the required infrastructure is minimal, but fossils and research potential are plentiful. “Finding Fossils on Friday” (FFF) is a weekly afternoon session where students pick screenwash concentrate for these kinds of research projects. FFF operates on a “guild” philosophy—students begin as “apprentices,” first examining coarser matrix with the naked eye before progressing to picking finer concentrate under the microscope. Those with aptitude, interest, and maturity (i.e., have “paid their dues” picking) are offered oversight of a project, which is then the focus of FFF until another project rises to the top of the list. Advanced guild members learn, then train others in, fossil identification, measurement, image acquisition, cataloguing, and other skills. The best students can earn student research assistantships and/or course or thesis credit. Most present results on campus, many at SVP or other meetings, and some even co-author publications. The synergy of the group is significant—FFF’s critical mass means that almost any technique we use can be peer-taught, and most projects are from field areas visited on course trips, providing an additional sense of ownership.

Because FFF is mobile, we take it to regional outreach events, where our exhibits feature undergraduates performing actual research (data collection), effectively bridging the gap between academia and citizen science. Having students interface with the public improves their communications skills as they train each other on our exhibits and then interact with hundreds of visitors. This frees me to network on their behalf while exposing them to diverse opportunities in paleontology. FFF translates well to social media, and we are prominently featured on multiple university web pages as a charismatic example of student research. We also use FFF as a recruiting tool, and promising high school students routinely visit and interact with the FFF crew on campus.

With the ongoing success of FFF we have increased our intramural funding and added a new class (GLY 3264: Paleontological Techniques), which focuses on preparation, allowing FFF to expand to FFFFF by adding “fixing” (preparing) and “forging” (molding/casting) fossils, further fueling our outreach activities by providing low-cost casts of common vertebrate fossils for classrooms on campus and beyond.

Grant Information

FFF has enjoyed support from the Department of Geological & Environmental Sciences, the Office of Student Research, and the University Research Council

Podium Symposium (Friday, October 19, 2018, 12:00 PM)

SKELETONS IN MOTION: ONTOGENY AND EVOLUTION OF AVIAN LOCOMOTION

HEERS, Ashley M., California State University, Los Angeles, TULARE, CA, United States of America; RANKIN, Jeffery, Rancho Los Amigos National Rehabilitation Hospital, Downey, CA, United States of America; HUTCHINSON, John R., Royal Veterinary College, Hatfield, United Kingdom

Locomotion plays a central role in the lives of most vertebrates, and reconstructing locomotor behaviors of extinct taxa is key to understanding many major evolutionary transitions, such as the origin of walking tetrapods, flying birds, and swimming whales. How can we rigorously investigate locomotor capacity among these extinct forms? One of the best documented transformations in locomotion is the evolution of bird flight, which has been intensely examined from a static, two-dimensional perspective through studies focusing on subsets of anatomical characters (e.g., feathers, particular joints, or particular flight muscles). However, locomotion is a highly dynamic, three-dimensional, and whole-body movement. Recent advances in imaging techniques and biomechanical analysis facilitate more dynamic, holistic, and three-dimensional investigations and can greatly enhance our understanding of locomotor evolution. Here, we illustrate how empirical data on muscle morphology, skeletal kinematics, and aerodynamic force production are combined with advancedbiomechanical modeling and simulation techniques to explore the ontogeny and evolution of avian locomotion. Simulations of wing-assisted incline running suggest that developing birds with dinosaur-like anatomies have excess muscle capacity and are limited more by feather morphology, possibly because feathers grow more rapidly and differently than bone and muscle. Elastic contributions from tendons and dynamic events such as wing clapping appear to play an important role in high frequency flapping and highlight the necessity of modeling extant organisms to validate models of extinct organisms. These findings provide insight into the development and evolution of avian locomotion by (1) establishing how muscular and aerodynamic forces interface with the skeletal system to generate dynamic, three-dimensional wing movement, and (2) providing a benchmark to inform biomechanical modeling and simulation of other locomotor behaviors, both across extant birds and among extinct theropod dinosaurs.

Technical Session VIII (Thursday, October 18, 2018, 2:30 PM)

THE DENTITION IN GOMPHODONTIA (CYNODONTIA, CYNOGNATHIA): DISPARITY, RATE OF EVOLUTION, AND DENTAL COMPLEXITY THROUGH TIME

HENDRICKX, Christophe, University of the Witwatersrand, Johannesburg, South Africa; ABDALA, Fernando, Unidad Ejecutora Lillo, San Miguel de Tucumán, Argentina; CHOINIERE, Jonah, University of the Witwatersrand, Johannesburg, South Africa; BENSON, Roger, University of Oxford, Oxford, United Kingdom

Gomphodonts were close relatives of mammals and one of the Mesozoic cynodont lineages that became extinct at the end of the Triassic. Members of this clade were small to medium-sized (0.3 to 2 m in body length), quadrupedal animals characterized by labiolingual expansion of the postcanines (gomphodont morphology) allowing crown-to-crown occlusion. This suggests that gomphodonts were omnivorous or possibly exclusively herbivorous animals, feeding on hard plant material. Three clades, mainly differentiated by their postcanine morphologies, are currently recognized among Gomphodontia: the Diademodontidae, Trirachodontidae, and Traversodontidae. This project investigates morphological diversity and rates of anatomical innovation in the dentition of gomphodont cynodonts based on a data matrix of 109 dental characters coded in 36 gomphodont taxa. The phylogeny of Gomphodontia was examined based on a cladistic analysis performed on a combined data matrix of our dentition-based matrix and the most recent dataset of the gomphodont skeleton. Postcanine complexity through time was quantified, using the orientation patch count (OPC) of three-dimensional crown surfaces reconstructed from photogrammetry in 32 taxa. Results of these analyses revealed: (1) a pectinate organization of several subclades within Traversodontidae; (2) fast rates of dental evolution associated with the emergence of gomphodonts and Trirachodontidae + Traversodontidae in the Early Triassic, traversodontids in the Olenekian, and Gomphodontosuchia in the early Ladinian; (3) slow rates of dental evolution in derived gomphodontosuchians in the late Ladinian; (4) a limited morphospace occupation of the dentition of trirachodontids in the Olenekian and

Anisian, and a widespread morphospace occupation of the dentition of traversodontids, which increases up to the early Carnian then decreases throughout the rest of the Late Triassic; (5) no structured evolution of dental complexity on the gomphodont tree; and (6) a slight increase in dental complexity from the late Anisian to the early Norian, and a drop in dental complexity at the end of the Triassic. This shift in dental disparity, evolutionary rate, and postcanine complexity in gomphodont cynodonts, all decreasing in the Late Triassic, might be due to increasing competition with other clades of emerging terrestrial herbivorous tetrapods (e.g., tritylodontids, dinosaurs), possibly leading to the extinction of gomphodonts at the end of the Triassic.

Grant Information
DST-NRF Centre of Excellence, Palaeosciences grant PPD2015/17CH and CoE2017-038, and Postdoctoral Fellowship from the University of the Witwatersrand

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

REVISITING THE ALLISON MEMBER OF THE MENEFEE FORMATION (UPPER CRETACEOUS, EARLY CAMPANIAN), SAN JUAN BASIN, NEW MEXICO

HENDRIX, Amanda L., Appalachian State University, Boone, NC, United States of America; DEANS, Austin M., Appalachian State University, Boone, NC, United States of America; HARRISON, A. Alex, Appalachian State University, Boone, NC, United States of America; LEWIS, Caleb, Centennial High School, Pueblo, CO, United States of America; LUCAS, Spencer G., New Mexico Museum of Natural History, Albuquerque, NM, United States of America; HECKERT, Andrew B., Appalachian State University, Boone, NC, United States of America

The sandstones and mudstones of the Allison Member of the Menefee Formation locally preserve a rich collection of vertebrate body fossils of early Campanian (Aquilan) age. Here we provide additional data on the microvertebrates from two localities: NMMNH L-5636 and L-5635. Chondrichthyans include both batoid and non-batoid taxa. Batoid taxa recovered include members of the families Rhinobatidae (*Cristomylus*, *Myledaphus*, *Protoplatyrhina*, *Pseudohypolophus*, and *Pseudomyledaphus*), Rhombodontidae (*Rhombodus*), Sclerohynchidae (*Ischyrhiza*), and Dasyatidae (*Dasyatis*). Non-batoid chondrichthyans include the hybodont *Lonchidion*, the odontaspidid *Carcharias*, the mitsukurinid *Scapanorhynchus*, and the cretoxyrhinid *Cretodus*. Of the chondrichthyans, *Cristomylus*, *Lonchidion*, *Myledaphus*, *Pseudohypolophus*, and *Psueudomyledaphus* are most abundant. Osteichthyans are represented by teeth and scales. We assign bulbous, crushing teeth to the phyllodontid *Paralbula*. Additional ziphodont osteichthyan teeth can be assigned to Lepisosteidae, Pycnodontidae, and Amiidae. Tetrapod fossils show wear, suggesting some distance of transport. An albanerpetonid-like batrachian dentary, along with an abundance of turtle shell fragments, reinforce past hypotheses of a relatively humid deltaic floodplain. Osteoderms and teeth belonging to a *Brachychampsa*-like alligatoroid are the most abundant tetrapod fossils collected. Two recently discovered unusual crocodilian teeth differ morphologically, suggesting two or more genera of crocodilians occupying multiple niches within the ecosystem. One tooth appears more slender and lingually curved, suggesting a feeding habit closer to piscivory. The second tooth discovered is the most robust, lacking curvature or strong carinae. This tooth appears designed to withstand stress of feeding on larger active prey and likely belonged to a hypercarnivorous taxon. Ornithischian teeth include fragments belonging to Hadrosauridae indet., and previously recorded indeterminate centrosaurine skeletal elements suggest greater diversity. Several theropod teeth, representing a dromaeosaurid and two species of troodontids, further increase the known diversity. Mammals are represented by several multituberculate teeth, two marsupial teeth, and two metatherian mammal premolars. These discoveries represent the oldest mammalian fossils known from New Mexico. This data provides a more thorough understanding of a Menefee ecosystem during a poorly documented interval in the Late Cretaceous.

Preparators' Session (Thursday, October 18, 2018, 1:45 PM)

THE LATE PENNSYLVANIAN BIRTHDAY BONEBED FROM THE HALGAITO FORMATION OF VALLEY OF THE GODS, SOUTHEASTERN UTAH: COLLECTION, PREPARATION, AND PHOTO DOCUMENTATION.

HENRICI, Amy C., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; BERMAN, David S., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; SUMIDA, Stuart S., California State University San Bernardino, San Bernardino, CA, United States of America; HUTTENLOCKER, Adam K., University of Southern California, Los Angeles, CA, United States of America; SCHLOTTERBECK, Tyler, South Dakota School of Mines and Technology, Rapid City, SD, United States of America

Field crews led by David S Berman collected 20 blocks from the Upper Pennsylvanian Halgaito Formation, southeastern Utah, intermittently from 1989 to 2015. The blocks contain a diverse fauna represented by chondrichthyan teeth; dipnoan tooth plates and skull bones; partial skeletons of a temnospondyl amphibian and three genera of synapsids; and scattered skeletons of a new araeoscelidian reptile. The blocks, the largest of which measures 137 x 94 cm, were collected using the standard technique of encasing them in a plaster-burlap jacket. A north arrow was marked on the top surface of each block for bone orientation analysis.

The fossils are mostly preserved on a horizontal bedding plane in a friable-to-blocky siltstone penetrated by modern plant roots. A very dilute white glue was used to consolidate the bones and matrix before jacketing. Acetone or alcohol-based glues were not used, because they react with moisture in the rock and turn white. In the lab, Butvar-98 diluted in isopropyl alcohol was used frequently to further consolidate the blocks. Because the matrix is very friable, air scribes could not be used for preparation, so the bones were exposed using pin vices with several sizes of carbide bits and tips modified for different tasks. A microscope was necessary for preparation of the smaller bones. It was mounted on an articulated boom arm held by a post attached by a clamp to the preparationtable.

Several methods were tried for photo documenting the specimens for curation and research. A DSLR camera was initially mounted on a standard tripod positioned adjacent to a block with poor results. Then the tripod was taped in a horizontal position onto a rolling step ladder so that the camera could be positioned over a block. It proved difficult to reach the camera to focus and shoot images. A larger tripod and better DSLR camera were obtained so that the tripod with mounted camera could be positioned over the block, and the camera operated via a laptop. This worked well for the blocks and larger specimens. In order to obtain publication quality photographs of the small araeoscelid bones, the camera with a 100 mm macro lens was mounted on a tripod with the center column oriented horizontally and positioned over the block, which sat on a table whose base was derived from a dental chair, allowing the table with block to be moved up or down relative to the camera to obtain appropriate shooting distance. A ring-light flash mounted on the camera lens proved to be the best light source. The images were subsequently processed using photo stacking and blending techniques in Adobe Photoshop.

Grant Information
Funding Source: National Geographic Society; M. Graham Netting Fund and Carnegie Discovers (Carnegie Museum of Natural History).

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

TESTING THE VARIABILITY SELECTION HYPOTHESIS: PALEOCLIMATE, PALEOENVIRONMENT, AND SUBSISTENCE OF *HOMO ERECTUS* ACROSS AFRICA AND EURASIA

HENSLEY-MARSCHAND, Blaire, Southern Connecticut State University, New Haven, CT, United States of America; POLLY, P. David, Indiana University, Bloomington, IN, United States of America

Until the appearance of *Homo erectus*, early hominins were geographically restricted to the continent of Africa. Members of this species, with their more human-like body proportions and increased brain size, were the first to expand their range to new areas across Eurasia. It has been suggested that this was possible as a result of their ability to survive in a variety of different climates and environments; this Variability Selection Hypothesis is based on data that indicate diverse and unstable climates and environments in East Africa prior to the expansion of *H. erectus* out of Africa. This hypothesis is tested and evaluated here by comparing climates, prey composition, prey utilization, and predator composition/competition at nine *H. erectus* sites across Africa and Eurasia. Paleoprecipitation estimates, based on ecometric analyses of the large, herbivorous mammals at each site, show the virtual loss of a wet season at northeastern Asian sites and high degree of variability in precipitation among all sites across annual, driest quarter, and wettest quarter estimates. Prey composition is also found to be variable among sites as there are fewer total potential prey species, notably Bovidae and Suidae, at Eurasian sites. Hominins at African and Eurasian sites are found to have been utilizing prey differently based on stone tool damage with larger taxa more commonly processed at African sites, and cervids, though absent at African sites, were processed at Asian sites. Lastly, predator competition was similarly inconsistent among *H. erectus* sites. Eurasian sites are found to have a higher number and proportion of total carnivore species in addition to a higher number and proportion of large carnivore species. These results, highlighting a high degree of variation in climate, prey availability, prey utilization, and predator competition at *H. erectus* sites, are consistent with the Variability Selection Hypothesis and identify the challenges that our ancestors adapted to and survived in for hundreds of thousands of years.

Grant Information
Stone Age Institute Dissertation Research Funding

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

PROJECT OREODONT: TRAINING VOLUNTEERS TO PREPARE AN HISTORIC BACKLOG

HERBEL, Carrie L., University of Nebraska-Lincoln, Lincoln, NE, United States of America; SKOLNICK, Robert, University of Nebraska State Museum, Lincoln, NE, United States of America; MCMULLIN, Jeremy D., University of Nebraska State Museum, Lincoln, NE, United States of America

Nebraska is famously known, or more accurately, infamously known, for the Schultz and Falkenbach Oreodont Volumes. Before data analysis of this study took place, many oreodont specimens were collected by the Works Project Administration (WPA) in the 1930s and early 1940s. Later, primarily in the 1950s, University of Nebraska State Museum (UNSM) Director C.B. Schultz tasked field crews to 'head hunt' oreodonts. A small portion of these collections led to the Oreodont Volumes, while the majority languished for decades in the vertebrate fossil collections (250+) and in field jackets (647) unprepared. In 2017, a project began where these specimens were prepared and stabilized using the growing UNSM volunteer preparator program.

The volunteer oreodont project starts with study of labeled skull and jaw images along with previously prepared specimens to allow volunteers to become familiar with oreodont anatomy. The project's primary goal is to expose the dentition and other diagnostic features typically used by researchers during analysis. Initially, simple, often poor quality, skulls or jaws are given to the volunteer. The first specimen is prepared using only hand tools such as carbide needles. Close supervision along with reminders on methods and comparison to images or prepared specimens help develop volunteer confidence with the oreodonts. Simple introduction of consolidants is injected throughout the process. Once finished, specimens are reviewed then rehoused in archival boxes with simple support. As volunteer experience grows, they begin using airscribes to remove mudstones and siltstones surrounding the majority of unprepared oreodonts. Some volunteers are fearless and often over-prepare specimens, while others are nervous and hesitant throughout the preparation effort. Trying to find a balance between these two extremes can be challenging.

As of May 2018, a total of 99 specimens were completed and available for study. At this rate, the White River Collection Room's oreodonts will be in sound shape by 2019. Tackling the 647 oreodont jackets housed in fossil storage can then begin.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

PALEOPATHOLOGIES IN CARBONIFEROUS TETRAPODS AND THE EVOLUTION OF BONE HEALING

HERBST, Eva C., Royal Veterinary College, Hatfield, United Kingdom; DOUBE, Michael, Royal Veterinary College, London, United Kingdom; SMITHSON, Timothy R., University Museum of Zoology Cambridge, Cambridge, United Kingdom; CLACK, Jennifer, University Museum of Zoology Cambridge, Cambridge, United Kingdom; HUTCHINSON, John R., Royal Veterinary College, Hatfield, United Kingdom

Here we describe new paleopathologies in the early tetrapods *Crassigyrinus scoticus* and *Eoherpeton watsoni* from the Carboniferous of Cowdenbeath, Scotland. X-ray microtomography imaging revealed abnormal bone formation in the hindlimb bones of specimens from both species, characterized by formation of trabecular bone external to the normal cortical bone of the shaft. The etiology of these abnormal osseous growths cannot be determined, because several diseases and injuries can result in bony lesions similar to those we observed. However, these pathologies are evidence of bone's ability to respond to insult, be it disease or trauma, hundreds of millions of years ago. We conducted a literature review of paleopathologies in tetrapods, rhizodontids, and lungfish to compare cases of abnormal bone modelling and mapped out occurrences on a phylogeny. We combined this fossil evidence with extant phylogenetic bracketing, comparing healing pathways among and between extant sarcopterygians and actinopterygians, to investigate the evolution of bone healing. We infer that, based on phylogenetic optimization, bone healing is ancestral for sarcopterygians. It is possible that bone healing is an intrinsic property of osseous tissue, which emerges from the growth and remodelling capacities of healthy bone.

Grant Information
Natural Environment Research Council

Technical Session XV (Saturday, October 20, 2018, 9:45 AM)

PRONGHORN, PRONGHORN, WHY DOST THOU RUN SO SWIFT?

HIGGINS, Pennilyn, University of Rochester, Rochester, NY, United States of America; MEACHEN, Julie, Des Moines University, Des Moines, IA, United States of America The pronghorn 'antelope' (*Antilocapra*), endemic to the Rocky Mountain region of North America, is notorious as a swift-footed and agile ungulate. The only living member of the family Antilocapridae (Artiodactyla), pronghorns are capable of outrunning extant North American carnivores, raising the question of the origins of their intense speed. Prior to the end of the last glaciation, several large, now extinct, carnivores roamed North America, including the North American cheetah, *Miracinonyx*. It has been hypothesized that pronghorns were common prey of *Miracinonyx*, having evolved their great speed as a defense mechanism. While this seems reasonable, there is little in the way of empirical evidence of *Miracinonyx* preying upon *Antilocapra*.

The exquisite preservation of vertebrate fossils in Natural Trap Cave (northern Wyoming, U.S.A.) has permitted the study of DNA from ancient and extinct carnivores and herbivores during the last glacial episode. Other organic molecules are also preserved in the fossilized bones, including collagen. Isotopic analysis of carbon and nitrogen from bone collagen provides a direct means of distinguishing predator-prey relationships. Nitrogen isotopes, in particular, can illuminate these relationships as predators tend to have $\delta^{15}N$ values between 2.4 and 4.6‰ more positive than those of their prey. Collagen was extracted from bones and tooth dentine of representative carnivores (*Miracinonyx* and *Canis*) and from their potential prey species (*Antilocapra*, horses, *Bison*, and *Ovis*). Isotopic values from nitrogen show that *Antilocapra* is in fact the preferred prey of *Miracinonyx*. Data also suggest that wolves (*Canis*) may have preferred horses (either *Equus* or *Harringtonhippus*) as a prey animal. These data do not provide a clear common predator for *Bison*, which could include the other large carnivore present at Natural Trap Cave, *Panthera atrox*.

Grant Information
NSF EAR 1425059 (Natural Trap Cave Revisited: Ancient DNA, Climate and the Megafaunal Extinction) Julie Meachen, PI

Technical Session VI (Thursday, October 18, 2018, 12:00 PM)

THE TETRAPOD FAUNA OF THE TRANS-SAHARAN SEAWAY IN THE LATE CRETACEOUS AND EARLY PALEOGENE OF MALI

HILL, Robert V., Zucker School of Medicine at Hofstra/Northwell, Hempstead, NY, United States of America; MCCARTNEY, Jacob, State University of New York College at Geneseo, Geneseo, NY, United States of America; ROBERTS, Eric M., James Cook University, Townsville, Australia; TAPANILA, Leif, Idaho State University, Pocatello, ID, United States of America; CLAESON, Kerin M., Philadelphia College of Osteopathic Medicine, Philadelphia, PA, United States of America; HEILBRONN, Kelly, James Cook University, Townsville, Australia; BOUARÉ, Mohamed, École Nationale des Ingénieurs, Bamako, Mali; O'LEARY, Maureen, Stony Brook Univ, Stony Brook, NY, United States of America

During the Cretaceous and Early Paleogene, the Trans-Saharan Seaway (TSS) extended intermittently from the Tethys Ocean onto the West African craton, at times inundating the region now dominated by the Sahara Desert. Multiple transgressions of this epicontinental sea resulted in sedimentary structures and fossil deposits that collectively document a picture of a dynamic tropical paleoecosystem. Importantly, this record illustrates ecological changes across two biologically important planetary events: the Cretaceous–Paleogene (K–Pg) extinction and the Paleocene-Eocene (PE) Thermal Maximum.

Worldwide, and especially in Africa, high-resolution stratigraphic sections across the K–Pg boundary that also preserve abundant vertebrate fossils are rare. Additionally, faunal changes at the PE boundary are less studied for the neritic zone than for deeper oceanic realms. Our work over the past two decades greatly clarifies the global picture of these major faunal horizons by integrating fieldwork, alpha taxonomy, stratigraphy, and phylogenetics. In the context of a forthcoming synthesis, we present an analysis of the fossil remains of tetrapods that lived in and around the TSS.

Tetrapod fossils collected from TSS deposits include abundant skeletal remains of bothremydid turtles, palaeophiid and nigerophiid snakes, and dyrosaurid crocodyliforms. Each of these clades exhibits a different pattern of survivorship across the K–Pg event. Malian bothremydid turtles belong to the tribe Taphrosphini and occur exclusively in marine strata on either the Cretaceous or Paleogene side of the boundary. Nigerophiid and probably also palaeophiid snakes survived the event, diversifying and exploiting marine habitats in the Paleogene. In contrast, dyrosaurids seem to exhibit a more wholesale survivorship, with levels of diversity comparatively unchanged by the K–Pg event. The influence of fresh water in the TSS may have provided refuge that allowed differential survivorship relative to closely related terrestrial or fully marine lineages. Prior collection efforts in the Malian TSS recovered a few fossils of hyracoid and proboscidean mammals, all from Paleogene rocks.

During periods of regression, remote portions of the TSS may have been cut off from the open ocean, essentially converting these areas into local centers of endemism. Many tetrapods in our sample are among the largest members of their clades. This phenomenon may represent aquatic instances of insular gigantism, precipitated by geographic isolation in stranded embayments of the TSS.

Technical Session II (Wednesday, October 17, 2018, 10:15 AM)

DEVELOPMENTAL BIOLOGICAL INFERENCE ON THE EVOLUTION FROM THE RIBCAGE TO THE TURTLE SHELL

HIRASAWA, Tatsuya, RIKEN BDR, Kobe, Japan; KURATANI, Shigeru, RIKEN BDR and CPR, Kobe, Japan

The turtles' body plan differs from that of the other tetrapods in the solid dorsal and ventral shells (carapace and plastron), and represents a good example of morphological evolvability of the tetrapods. It has been widely accepted that the carapace and plastron evolved from the ribs and clavicular girdle plus gastralia, respectively, but the evolutionary transition was poorly preserved in the fossil record. To infer the evolutionary process of the turtles' body plan, we have analyzed the embryonic development of the Chinese soft-shell turtle, *Pelodiscus sinensis,* and compared with those of the other amniotes. In the turtle embryo, the rib primordia are not extended to the lateral body wall unlike those of the other amniotes, and only the deep layer of the body wall muscle develops in the lateral body wall. Concomitantly, the sternum, which develops adjacent to the ventral ends of the ribs in the other amniotes, does not develop in the turtle embryo. This axially-arrested development of rib primordia is responsible for the formation of the carapace consisting of laterally-extended ribs, thus likely evolved prior to the acquirement of the carapace. Among fossil taxa, sauropterygians have repeatedly been placed in the closest position to turtles by phylogenetic analyses in previous studies. In all the sauropterygian fossils, the evidence for the presence of the sternum is lacking, and the gastralia occupy the ventral aspect of the ribcage in exchange for the sternum, thereby suggesting absence of the sternum in life. Therefore, it is inferred that the axially-arrested development of rib primordia had evolved in the common ancestor of turtles and sauropterygians.

Grant Information
This work was supported by JSPS KAKENHI grant numbers JP15K21628, JP17K18354 and JP17H06384.

Technical Session IX (Friday, October 19, 2018, 11:15 AM)

A TAXON-FREE, MULTI-PROXY MODEL FOR MIOCENE NORTH AMERICAN PALEOECOLOGICAL INTERPRETATIONS

HOCK, Devra, University of Nebraska-Lincoln, Lincoln, NE, United States of America; SECORD, Ross, University of Nebraska-Lincoln, Lincoln, NE, United States of America

Paleoecological proxies for vertebrate communities are usually based on modern ecosystems. Many proxies are developed from Old World ecosystems and may not be appropriate for North American interpretations. Also, most proxies exclude small-bodied mammals. Here we explore a taxon-free, multi-proxy model based on three ecomorphological traits in extant North American mammals: locomotion, diet, and size. The assumption that extinct taxa occupied the same niche as extant relatives becomes increasingly tenuous further back in time, requiring taxon-free approaches. The aim of this study is to develop a comprehensive model for interpreting Miocene ecosystems in North America. We used pre-existing primary datasets of historical geographic mammal occurrences. The datasets were augmented with locomotion, diet, and body mass information. Mammalian geographic occurrences were assigned to digital maps of Bailey's Ecoregions of North America in ESRI ArcMap and then re-assigned to broader biomes based on preliminary Principal Component Analysis (PCA). Taxa were sorted by biome and two datasets were created, an occurrence dataset where the number of occurrences was used to weight traits, and one with duplicates removed, not weighted by occurrence. PCA was conducted on proportions of trait classifications per biome for both datasets. Occurrence data with small-bodied mammals provided the strongest separation of biomes. PC1 consists of 48.2% of variance, PC2 with 26.7%. On PC1, grassland and woodland corresponds to size classes B (50–500 g) and G (>10500 g), cursorial, and mixed feeder, with loadings of 0.5, -0.5, -0.46, and -0.28 respectively. On PC2, forest and desert correspond to size class A (0–50 g) with 0.37, arboreal/scansorial (-0.57), semi-fossorial (0.41), and carnivore (-0.38). Without small sizes, woodland corresponds with different traits on PC1 and PC2. Unweighted data had similar results with and without small-body sizes. On PC1, forest and woodland correspond to separate traits, with semi-arid on PC2. With small-body sizes, forest also corresponds to different traits on PC2. Our results show that datasets weighted by the number of occurrences of a specific trait are most effective in separating biomes, as compared with unweighted. Results also show that including small-bodied mammals (<50 g) provides stronger biome separation. We preliminarily conclude that weighted occurrence coupled with small-body data should provide the best separation of biomes and be most appropriate for paleoecological applications in North America.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

DINOSAUR PARK: AN HISTORIC FOSSIL SITE AND CITIZEN SCIENTIST EXPERIENCE IN THE GREATER WASHINGTON, D.C. AREA

HODNETT, John-Paul M., Maryland-National Capital Parks and Planning Commission, Upper Marlboro, MD, United States of America; MONTAPERTO, Kristin M., Maryland National Capital Park and Planning Commission, Upper Marlboro, MD, United States of America

The Maryland-National Capital Park and Planning Commission's (M-NCPPC) Dinosaur Park, is located in Laurel, Maryland, and offers a unique scientific experience for the citizens and visitors of the greater Washington, D.C. area. Formally called the Muirkirk Fossil Site, fossils were first discovered as a byproduct of iron ore and clay mining that began in the late 1600s. Fossils from the site date to the Early Cretaceous (Aptian/Albian) Potomac Group and represent some of the oldest Cretaceous fossils in the Mid-Atlantic region—including at least twenty-five vertebrate taxa. The Muirkirk site remained in

private hands and was commercially quarried until 2005. In 2009, campaigning efforts by the local paleontological community, resulted in the land owner donating a 47 acre undeveloped section of the site to the M-NCPPC for preservation and public development. This 47 acre parcel was named Dinosaur Park and through collaborative efforts currently contains a "fossil garden", dinosaur themed playground, outdoor classroom, interpretive signage, picnic seating, and comfort station which enhance the visitor experience and educational resources.
Since 2009, Dinosaur Park maintains site preservation by limiting visitor access to the fenced fossil resource through yearly bi-monthly open house events, or scheduled education programs. Visitor collection is restricted to surface collecting without the use of tools. This method has been successful in protecting the site's longevity and allowing it to "breath" between public events and programs. Nearly two thousand plant and animal fossils have been recorded since the park opened, including the recent discovery of a possible pterosaur, making it the first body fossil recorded from the Potomac Group. New public research initiatives include a screen washing program that not only offers visitors insight into paleontological methods, but has increased the yield of smaller vertebrate fossils. Future plans for Dinosaur Park include surveying new sections and developing additional outdoor exhibits for public engagement.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A CEPHALIC TENACULUM BEARING HOLOCEPHALAN (CHONDRICHTHYES, HOLOCEPHALI) FROM THE LATE PENNSYLVANIAN ATRASADO FORMATION OF NEW MEXICO

HODNETT, John-Paul M., Maryland-National Capital Parks and Planning Commission, Upper Marlboro, MD, United States of America; GROGAN, Eileen D., St. Joseph's Univ, Philadelphia, PA, United States of America; LUND, Richard, St. Joseph's Univ, Mount Holly, NJ, United States of America; MAISEY, John, American Museum of Natural History, New York, NY, United States of America; DENTON, John S., American Museum of Natural History, New York, NY, United States of America; ELLIOTT, David, Northern Arizona Univ, Flagstaff, AZ, United States of America; LUCAS, Spencer, New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America The holocephalans are a diverse group of chondrichthyans know from approximately 47 living taxa. The fossil record of holocephalans is extensive throughout the Cenozoic, Mesozoic, and Paleozoic, with the oldest holocephalan record extending into late Devonian. However, most of what we know about extinct holocephalan taxa is from isolated tooth plates, dermal plates, and occasional cephalic tenaculae. More complete taxa are known but these specimens are primarily from the Late Mississippian, the Lower Permian and Lower Jurassic. Recently, a new holocephalan was collected from the Late Pennsylvanian Atrasado Formation at Kinney Brick Quarry (KBQ), New Mexico.
The KBQ holocephalan is a male individual that is articulated and mostly complete, missing only parts of its pectoral fins. The cranium is elongate, laterally compressed, and has large orbits. The cranium bares a number of plates and spines around the nasal, orbit, otic, and occipital regions, and on the Meckel's cartilage. Most striking feature of the cranium is the presence of a cephalic tenaculum approximately three-fourths the length of the cranium and preorbital plates that fused to form a midline 'horn' just posterior to the articulation of the cephalic tenaculum. The cephalic tenaculum also bares paired large downward directed thorn-like denticles, small paired hook-like denticles, and small ovate denticles that cover the shaft of the cephalic tenaculum. The dentition of the KBQ holocephalan consists of three upper and lower tooth plates baring tritors. The posterior upper tooth plate is rectangular in shape and the lower posterior tooth plate is triangular in shape. The upper and lower middle tooth plates are whorl-like with three tooth-like lophs. The upper anterior tooth plate is paired with four anterior tritor ridges. The lower anterior tooth plate is a single narrow element. The body of the KBQ holocephalan resembles the extant *Callorhinchus* in having two dorsal fins, an anal fin, and a heterocercal tail. A synarcuum is present and the axial column consists of well-developed rings. The anterior dorsal fin has a single long dorsal spine with three costae and numerous tubercles, and is attached to the synarcuum. A paired field of fused enlarged hook-like denticles are present just anterior of the pelvic fins.
Cladistic anaylsis of the Holocephali placed the KBQ holocephalan as a new genus and species within the Myricanthoidea, a group of crown holocephalans primarily known from the lower Mesozoic. This analysis suggests this lineage had its origins within the Late Paleozoic.

Technical Session VIII (Thursday, October 18, 2018, 1:45 PM)

LARGE CLUTCH OF JURASSIC MAMMALIAMORPH PERINATES AND EVOLUTION OF MAMMALIAN REPRODUCTION AND GROWTH

HOFFMAN, Eva A., The University of Texas at Austin, Austin, TX, United States of America; ROWE, Timothy B., The University of Texas at Austin, Austin, TX, United States of America
Transformations in anatomy and physiology along the mammalian stem lineage were accompanied by profound modifications to reproduction and growth, including the emergence of a reproductive strategy characterized by high maternal investment in a small number of offspring, a reorganization of skeletogenesis leading to the appearance of bony epiphyses and growth plates, and heterochronic changes in early cranial development associated with the enlargement of the brain. Because direct fossil evidence of these transitions is lacking, their timing and sequence are unknown. Here we report the first fossil record of near-hatching young of any non-mammalian synapsid. A large clutch of well-preserved perinates of the tritylodontid *Kayentatherium wellesi* (Cynodontia, Mammaliamorpha) were found surrounded by a presumed maternal skeleton in Early Jurassic sediments of the Kayenta Formation. The single clutch numbers more than three dozen individuals, well outside the range of litter-size variation documented in extant mammals. This discovery confirms that high offspring number is ancestral for amniotes and constrains the timing of a reduction in clutch size along the mammalianstem.
The perinates exhibit a transitional mode of long-bone development in which perichondral ossification has outpaced endochondral ossification, but well-organized cancellous bone is present at the articular ends. Later in mammalian evolution, epigenetic consequences of an increase in the relative rate of endochondral ossification may include the development of sesamoids and secondary ossification centers, which are lacking in non-mammalian synapsids. Derived features of long-bone development in *Kayentatherium* suggest that the first mammaliamorphs may have achieved somewhat faster endochondral ossification in association with the modernization of many aspects of the postcranial skeleton.
Although tiny, the perinates have overall skull shape similar to that of adults, with no allometric lengthening of the face during ontogeny. As in reptiles, positive cranial allometries are largely restricted to the bones supporting the jaw-adductor musculature. *Kayentatherium* diverged just before a hypothesized pulse of brain expansion that reorganized cranial architecture at the base of Mammaliaformes. The association of high offspring number with near-isometric skull growth in a basal mammaliamorph is consistent with a scenario in which encephalization—and attendant shifts in metabolism and development—drove later changes to mammalian reproduction.

Technical Session XIII (Friday, October 19, 2018, 2:30 PM)

RECONSTRUCTING THE ARCHOSAUR RADIATION: QUANTITATIVE DESCRIPTION OF A MIDDLE TRIASSIC ARCHOSAURIFORM TOOTH ASSEMBLAGE FROM THE RUHUHU BASIN (TANZANIA) AND ITS IMPACT ON TRAIT EVOLUTION AND ECOLOGICAL INTERPRETATIONS

HOFFMAN, Devin K., Virginia Tech, Blacksburg, VA, United States of America; EDWARDS, Hunter, Virginia Tech, Blacksburg, VA, United States of America; BARRETT, Paul M., The Natural History Museum, London, United Kingdom; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America
Reconstructing evolutionary radiations is a primary goal of vertebrate paleontology, essential to answering biogeographic and macroevolutionary questions. After the end-Permian mass extinction, archosaurs radiated rapidly and their fossil tooth assemblages have been used to infer alpha diversity during specific intervals. Unfortunately, useful Middle Triassic tooth assemblages are rare, limiting characterizations of morphological diversity during this critical, early period in archosaur evolution. Recent fieldwork (2007, 2017) in the Manda beds of the Ruhuhu Basin, Tanzania, however, recovered a rich tooth assemblage that partially fills this gap. To investigate the taxonomic composition of this collection, we built a sample of comparative tooth measures based on *in situ* teeth of known taxonomic status (e.g., *Nundasuchus*, *Parringtonia*, and one undescribed species) and a series of isolated teeth (N = 31) using continuous (Principal Components Analysis, PCA, linear modelling) and discrete morphological characters (non-metric multidimensional scaling, NMDS) conducted in R and PAST software. PCA (= 70 observations) produced one principal component implying that simple linear relationships can explain tooth morphology. Using crown heights from known taxa to predict tooth base ratio (= base length/base width) we created a morphospace for the tooth assemblage. The majority of isolated, unassigned teeth fall within morphospace shared by several Manda species (e.g., *Nundasuchus* and *Parringtonia*). By contrast, two isolated teeth fall exclusively within *Pallisteria* morphospace, partially due to size similarities. NMDS analysis (= 61 observations) of nine discrete characters removed size and, unlike PCA, morphospace overlap was less prevalent between taxa (e.g., *Nundasuchus* and *Parringtonia*) and differentiates between teeth of different elements in some taxa (e.g., *Parringtonia*). These methods are important because they provide an objective means of identifying patterns of plesiomorphy and plasticity in tooth traits and the ecological niche breadth of these animals. Though it is possible the taxonomic sample is incomplete, our relatively simple model shows that even similar tooth morphologies of archosauriforms can be differentiated and assigned to species level and it is useful for identifying isolated teeth. These combined methods of quantifying tooth shape are transferrable between geographic, taxonomic, temporal, and richness scales, offering a promising lens for characterizing major radiations in Earth history.
Grant Information
NSF EAR 1337291

Technical Session VIII (Thursday, October 18, 2018, 2:00 PM)

LARGE SAMPLING FROM EARLY JURASSIC FISSURE FILLINGS REVEALS VARIATION IN COCHLEAR CANAL SHAPE IN THE BASAL MAMMALIAFORM *MORGANUCODON*

HOFFMANN, Simone, NYIT COM, Old Westbury, NY, United States of America; SHAHID, Ramza, NYIT COM, Old Westbury, NY, United States of America; WATANABE, Akinobu, NYIT COM, Old Westbury, NY, United States of America; GILL, Pamela, University of Bristol, Bristol, United Kingdom
Extant therians can hear higher and greater ranges of frequencies than most other vertebrates. This ability has been associated with changes in inner ear morphology, including elongation of the cochlear canal following loss of the lagenar maculae, coiling of the cochlear canal, and stabilization of the hearing membrane through bony laminae. Acquisition of these features appears in a mosaic fashion in Mesozoic mammaliaforms, but whether this pattern reflects intraspecific or interspecific variation remains uncertain due to limited sampling. Here we used high-resolution computed tomography (CT) imaging on 37 isolated petrosals of the basal mammaliaform *Morganucodon* from Early Jurassic fissure fillings to document intraspecific variation in cochlear morphology. CT scans reveal that the cochlear canal varies in length (1.64–-1.86 mm) and is gently curved. The apex of the cochlear canal is distinctly expanded likely indicating the presence of a lagenar macula. A separate canal for the lagenar nerve is, however, absent. Ossified laminae are not preserved in this sample, but a shallow groove is visible on the ventrolateral surface of the cochlear canal. The groove extends from the base of the canal (between the perilymphatic foramen and the fenestra vestibule) anteriorly towards the apex. We suggest this groove represents the attachment site of the basilar membrane, as seen in some extant monotremes where it is termed base of the secondary lamina. The base of the secondary lamina ends shortly before the apex of the canal and ranges between 1.17–1.45 mm in length. CT images further reveal a dense network of canals within the promontorium, previously described as the circum-promontorium plexus. The plexus enters the cochlear canal through a series of small foramina next to the base of the secondary lamina and extends along the full length of the base. To quantify shape differences we employed a 3D geometric morphometric approach. Major sources of shape variation include cochlear canal curvature, medial expansion of the apex of the cochlear canal, and cochlear canal diameter. Our results indicate the most variable inner ear features in *Morganucodon* (size of lagena, cochlear canal curvature and length) are also those that display evolutionary change among

Mesozoic mammals. Intraspecific variation of these features in basal mammaliaforms might have formed the necessary basis for selection to act on.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

EVOLUTIONARY PATTERNS IN THE OLFACTORY SYSTEM OF DEVELOPING CHICKS

HOGAN, Aneila V., Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; WATANABE, Akinobu, New York Institute of Technology College of Osteopathic Medicine, New York, NY, United States of America; BALANOFF, Amy M., Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; BEVER, Gabriel S., Johns Hopkins University School of Medicine, Baltimore, MD, United States of America

Patterns emerging from the endocranial casts of non-avian dinosaurs (stem birds) reveal an increasingly complex and deep history of the avian brain. The forebrain expansion that in part differentiates crown birds from other reptile groups started early in theropod evolution and is characterized by homoplasy and episodic growth across a variety of taxonomic groups but certainly among dromaeosaurs, troodontids, and early avialans. Associated with this complex evolutionary history is the olfactory bulb, which appeared with the cerebrum on the vertebrate stem lineage somewhere between 500 and 560 million years ago. The sheer antiquity of this sensory modality predicts integrative relationships with neighboring developmental and functional systems that would likely constrain the olfactory bulbs and their evolutionary trajectories. Although such regulatory complexity may well exist, studies from across the vertebrate tree reveal high rates of evolutionary change in the olfactory bulb compared to other sensory systems, suggesting a considerable degree of evolutionary independence. Current fossil evidence suggests that relative olfactory bulb size in crown and stem birds exhibits periods of expansion along the avian stem, with pulses of growth concentrated in the parts of the tree including Maniraptoriformes and around the base of crown Aves. To complement the phylogenetic data we studied the olfactory bulb in a developmental series of chick (*Gallus gallus*) to establish what role ontogeny plays in the mode and tempo of avian olfactory evolution. We assessed the volumetric growth trajectory of the olfactory bulb relative to the cerebrum and total brain to discern whether it adheres to proposed theories of concerted versus mosaic evolution. We then compared these trends to growth patterns in the developing turbinates. Olfactory bulbs show early expansion, with a volumetric increase of 370% between days 9 and 12 and a further 60% increase by day 15. As a ratio of the cerebrum and total brain volume, olfactory bulb volume peaks on embryonic day 12 before being eclipsed by later cerebral growth. This is a conservative temporal pattern predicted by a concerted evolutionary mode. Used as a baseline, these data will be useful in future comparative studies to outline evolutionary shifts in olfaction and the influence of this sensory system on the surrounding cranial morphology as preserved in the fossil record of Pan-Aves.

Grant Information
Supported by NSF DEB-1457181, NSF DEB-1406849

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

INVESTIGATIONS OF THE SKELETON OF *MENISCOTHERIUM* (MAMMALIA) AND ITS PHYLOGENETIC IMPLICATIONS USING MICRO-CT

HOLBROOK, Luke, Rowan University, Glassboro, NJ, United States of America; CHESTER, Stephen G., Brooklyn College, City University of New York, Brooklyn, NY, United States of America; PAPARO, Sabrina, Rowan University, Glassboro, NJ, United States of America

Meniscotherium is an 'archaic ungulate' known from the late Paleocene and early Eocene of North America. Excellent craniodental and postcranial material is known for *Meniscotherium chamense* from the San Juan Basin in New Mexico. Despite this, the evolutionary relationships of *Meniscotherium* are unclear, in part because it combines an unspecialized skull and skeleton with a dentition that is unusually derived compared to that of other 'archaic ungulates.' In addition, results of phylogenetic analyses of placental mammals based primarily on molecular data have supported placing extant taxa formerly included in “Ungulata” in two widely separated clades, Laurasiatheria and Afrotheria. This raises the question of where 'archaic ungulates' such as *Meniscotherium* fit into placental phylogeny. Most previous studies have considered *Meniscotherium* to be related in some way to another collection of 'archaic ungulates,' phenacodontids. Attempts to place phenacodontids, with or without *Meniscotherium*, in the current phylogenetic framework for placentals have placed them either with laurasiatheres or with afrotheres.

We report here a new analysis of *Meniscotherium* that includes micro-CT data from several well-preserved specimens of *Meniscotherium chamense* from the United States National Museum of Natural History (USNM), particularly USNM 22918 and USNM 22673. These specimens include not only excellent skulls but also partially prepared articulated postcrania that can now be observed for the first time, digitally prepared, and disarticulated using three-dimensional visualization micro-CT software. We use these new data in a parsimony analysis of 72 mammalian taxa and 321 cranial, postcranial, and dental characters. Results were constrained to recover Laurasiatheria, Afrotheria, and Euarchontoglires based on the extant orders represented in our data. The results place *Meniscotherium* as the sister-taxon to phenacodontids in a clade that is sister-taxon to Paenungulata and nested within Afrotheria. These results suggest a divergence between the Phenacodontidae + *Meniscotherium* clade and paenungulates by at least the early Paleocene.

Grant Information
Funding provided by the U.S. National Science Foundation (Grant number DEB 1456826) to L. Holbrook and S. Chester.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A NEW UNENLAGIINAE (THEROPDA: DROMAEOSAURIDAE) FROM THE MAASTRICHTIAN OF BRAZIL

HOLGADO, Borja, Museu Nacional / Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; BRUM, Arthur S., Museu Nacional / Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; PÊGAS, Rodrigo V., Museu Nacional / Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; BANDEIRA, Kamila L., Museu Nacional / Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; SOUZA, Rafael G., Museu Nacional / Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; KELLNER, Alexander W., Museu Nacional / Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; CAMPOS, Diógenes A., Museu de Ciências da Terra, Serviço Geológico do Brasil, Rio de Janeiro, Brazil

Unenlagiinae is a lineage of dromaeosaurid theropods from the Late Cretaceous of the Gondwanan landmasses, with all uncontroversial species coming from Argentinean localities. From Brazil, only one vertebra was assigned to this clade as an indeterminate Unenlagiinae, although several teeth and fragments were identified as dromaeosaurids. All specimens are quite incomplete and only two species (*Buitreraptor gonzalezorum* and *Austroraptor cabazai*) preserved cranial elements, including maxillary and dentary teeth, enabling the study of dental traits. The derived features that diagnose the dentition of unenlagiines are high tooth count, absence of denticles and carinae, and presence of longitudinal grooves on the tooth crown. Here we present the first evidence of unenlagiine remains from the Maastrichtian of the Peirópolis site (Bauru Group, Brazil), which also represents the first cranial material of a maniraptoran from the Bauru Group. It comprises a fragmentary right maxilla and a small portion of a right dentary. The maxilla exhibits tooth alveoli along all its extension and lacks on the dorsal margin any sign of the postantral wall, as well as signs of the interfenestral bar, features that indicate that this fragment is located along the anterior portion of the maxilla. The dorsal margin forms an acute angle with the ventral, a feature also found in *Buitreraptor*. The lateral surface of the bone is flat, which indicates that the antorbital fenestra lacks a marked ventral limit in this region of the bone, differing from the lateral flange present in *Buitreraptor*. The specimen presents seven preserved tooth alveoli, with three teeth in situ and one fragmentary root. The tooth alveoli are well spaced, which is similar to the condition in *Buitreraptor*. The teeth are posteriorly curved, especially in the apex. Both labial and lingual surfaces exhibit longitudinal striae. The lingual surface presents a deep longitudinal sulcus. Both carinae lack denticles. The teeth exhibit a labiolingual constriction, forming an eight shaped cross section. The small fragment of a right dentary comprises most of the ventral portion of the bone, lacking the dorsal margin. The ventral margin is marked by a keel, which gives a triangular shape to the cross-section of the dentary. In dorsal view, the broken region reveals at least five alveoli. In this view, the most posterior region of this fragment exhibits a medial ramification, which constricts the alveolar margin and marks the Meckelian cavity, found posteriorly in the dentary, as observed in *Austroraptor*.

Podium Symposium (Wednesday, October 17, 2018, 2:30 PM)

MORPHOMETRIC AND MODELING APPROACHES TO UNDERSTANDING THE EVOLUTION OF PSEUDOSUCHIAN MANDIBULAR SYMPHYSES

HOLLIDAY, Casey M., University of Missouri - Columbia, Columbia, MO, United States of America; HERBST, Eva, Royal Veterinary College, London, United Kingdom; JACOBY, Mackenzie, University of Missouri, Columbia, MO, United States of America; SMOLINSKY, Amanda, University of Missouri, Columbia, MO, United States of America; SELLERS, Kaleb, University of Missouri, Columbia, MO, United States of America

The mandibular symphysis experienced numerous modifications during the radiation of pseudosuchians, reflecting the extraordinary diversity in trophic niches this lineage has occupied since its origins in the early Mesozoic. Aside from general descriptions, little is known about how symphyses are built or how they work among crocodylians, crocodylomorphs, and stem groups. However, understanding the form and function of this important articulation reveals patterns in diet, feeding behavior, cranial performance, and evolution. Here, we present several complementary approaches for determining how changes in shape, construction, and mechanical loading impact the functional morphology of the mandibular symphysis. To demonstrate how interdigitation of the symphysis varies among crocodylians, we used CT-data-derived morphometrics to determine that extant crocodylians have considerable variation in the structure of the rostral symphysis, a region associated with resisting tensile forces derived from a loading environment of inverted wishboning of the joint. We additionally found that all species possess caudal regions of the symphysis built to resist compressive forces. Material properties testing and subsequent finite element modeling of *Alligator* symphyses found that, like many ligamentous joints, the neighboring bone fails before the ligaments themselves. This suggests that the symphysis is quite effective at transmitting bite forces across mandibles despite its seemingly small size. To determine how beaked, edentulous, unfused symphyses behave, we used comparative modeling of the chin of the aetosaur, *Desmatosuchus,* to explore how different connective tissues impact the performance of the lower jaws. Our findings suggest that in lieu of co-ossifying the joint, taxa like aetosaurs may increase the absolute size of articular surfaces as a means of stabilizing the chin. This diversity of pseudosuchian symphyseal morphology and function tracks with concomitant changes in the skull, including the acquisition of secondary craniomandibular articulations and skull flattening. These examples shed light on the biomechanics and evolution of feeding behavior in pseudosuchians and the origin of crocodyliforms, but also provide guidance for exploring similar patterns found in the symphyses of dinosaurs and other tetrapods.

Grant Information
NSF EAR 163753, NSF IOS 1457319, Missouri Research Board

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

CROCNET: A PUBLIC RESOURCE FOR CROCODILIAN IMAGING DATA AND VISUALIZATIONS

HOLLIDAY, Casey M., University of Missouri - Columbia, Columbia, MO, United States of America; CRANOR, Corrine, University of Missouri, Columbia, MO, United States of America; SELLERS, Kaleb, University of Missouri, Columbia, MO, United States of America

Current initiatives in understanding crocodilian biology and evolution have generated a wealth of now publically-available imaging data, 3D models and virtual reality experiences. Here we share our network of online resources that together form CrocNet. Currently, raw data of CT and contrast CT scans and model files of an ontogenetic series of over two dozen American alligator skulls are hosted on Open Science Framework, making this one of the largest resources of Alligator cranial data currently available to the public. These data were developed into 3D models featuring cranial joint histology,

trigeminal nerve pathways, and cranial ontogeny that can also be hosted in Virtual Reality platforms or 3D printed for more immersive experiences through Sketchfab. These models have been mobilized successfully at outreach events making for exciting and educational experiences for the public. These data and their derivatives provide a foundation for future launches of other extant crocodilian species as well as extinct pseudosuchians to better share our understanding of anatomy, paleontology, and evolution.
Grant Information
NSF IOS 1457319, NSF EAR 163753, Missouri Research Board

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A COMPARATIVE FUNCTIONAL ANALYSIS OF THREE-DIMENSIONALLY RECONSTRUCTED CRANIAL MYOLOGY IN PHYTOSAURIA AND CROCODYLIA

HOLLOWAY, Waymon L., Ohio University, Athens, OH, United States of America
Phytosaurs are often compared to extant crocodylians due to similarities in overall morphology and depositional environment of the clades. Such similarities have been the basis for inferences about phytosaur ecology, including hypothesized piscivory in some phytosaurs. However, phytosaurs do not exhibit many cranial characters typical of crocodylians, including a dorsoventrally flattened skull, hypothesized as adaptations for aquatic ambush predatory behaviors. Instead, phytosaur crania possess dorsoventrally tall temporal region morphology with large attachment areas for temporal muscles, similar to other hard-biting sauropsids. Jaw muscles of a phylogenically and morphologically diverse sample of phytosaurs and extant crocodylians were three-dimensionally reconstructed to investigate the relationship between differences in skull configuration and jaw musculature organization and orientation in each clade. Muscle attachment sizes were used to estimate maximum force of individual muscles and bite force. Crocodylian jaw musculature is highly mediolaterally oriented, but some taxa possess jaw joints angled such that muscle angles are close to perpendicular to the joint plane. Jaw muscles are more dorsoventrally oriented in phytosaurs than crocodylians, but because phytosaur jaw joints are horizontally oriented, the muscles are more oblique to the joint plane than in some crocodylians, reducing leverage. Compared to extant crocodylians, the estimated percent contribution of the phytosaur adductor mandibulae internus muscle group to bite force was less, and its orientation likely reduced leverage as gape decreased. The estimated percent contribution of the adductor mandibulae externus and posterior groups to bite force was greater in phytosaurs than crocodylians. Bite force was lower in phytosaurs than crocodylians, even when specimens were scaled to one another. These results show that differences in skull configuration between phytosaurs and crocodylians are correlated with differences in jaw muscle organization and bite performance. Maximum prey to predator body size ratios were likely lower in phytosaurs than extant crocodylians due to lower bite force, muscle leverage, and jaw joint stability reducing their ability to handle large, strugglingprey.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

INITIAL DESCRIPTION OF THORACIC RIB HISTOLOGY FOR THE GENUS *DOLICHORHYNCHOPS* (SAUROPTERYGIA, PLESIOSAURIA)

HOLMAN, Pike L., Fort Hays State University, Hays, KS, United States of America; WILSON, Laura, Fort Hays State University, Hays, KS, United States of America
Dolichorhynchops osborni is a species of polycotylid plesiosaur that roamed the Western Interior Seaway during the Campanian age of the Late Cretaceous. While previous studies have looked at plesiosaur bone microstructure, none have focused on *Dolichorhynchops* and ontogeny. FHSM VP-404 is a nearly complete and large specimen of *D. osborni* from the Niobrara Formation, Smoky Hill Chalk Member of Logan Co., KS. The purpose of this study is to test if skeletal maturity can be assessed for *D. osborni* using the microanatomy of thoracic ribs. Previous research has shown that the most complete record of growth is retained in the proximal 20% to 30% of the rib in some reptiles so the middle thoracic rib shaft of FHSM VP-404 was histologically sectioned at the proximal most 20% of the shaft, the mid-point of the shaft, and the distal most 20% of the shaft. In all three sections, the medullary cavity is relatively small with endosteal trabeculae composed of lamellar bone. The cortex is thick, with the lateral and medial horns of the shaft being the thickest areas. The cortex is composed of a very compact bone tissue that has been extensively remodeled by secondary osteons and appears isotropic under polarized light meaning that the collagen fibers in the bone tissue lack spatial organization. Nearly all primary bone has been replaced by secondary osteons, but the medial side of the distal most section retains the most primary bone of any section. The limited amount of primary bone in the cortex is composed of parallel fiber bone with a thin layer of lamellar bone on the periosteal surface. This area of primary bone appears to preserve four to six closely spaced growth marks and is capped off by a layer of lamellar bone on the periosteal surface. This feature is interpreted as an external fundamental system (EFS) signaling skeletal maturity. The presence of an EFS in the distal section means that this specimen attained skeletal maturity before death at a length of 3 m. Due to the highly remodeled nature of the rib a complete growth record is not known, but growth rates near skeletal maturity can be assessed because of the EFS. This study shows that ribs can be used to determine skeletal maturity in *D. osborni* and the relatively high preservation potential of ribs in general may be useful for histological analysis to determine skeletal maturity in other organisms.
Grant Information
Western Interior Paleontological Society: Karl Hirsch Research Grant;
Geological Society of America: Graduate Student Research Grant

Technical Session IV (Wednesday, October 17, 2018, 3:00 PM)

EXTINCTION SELECTIVITY ACROSS THE K/PG BOUNDARY IN THE CONTINENTAL VERTEBRATE BIOTA

HOLROYD, Patricia A., University of California Berkeley, Berkeley, CA, United States of America; FINNEGAN, Seth, University of California Berkeley, Berkeley, CA, United States of America; CLEMENS, William A., University of California Berkeley, Berkeley, CA, United States of America
The survival of many aquatic non-marine vertebrate taxa across the K/Pg boundary has been long noted as a case of differential survivorship and been used to inform hypotheses about how mass extinctions differ from background extinction. However, these hypotheses are based on local or regional datasets and have typically focused on a short span of time before and after the K/Pg. To try to mitigate those biases and examine a wider range of potential factors thought to affect extinction, we started with a global occurrence data set of non-marine vertebrate genera from the Early Cretaceous through middle Miocene from the Paleobiology Database. These data were iteratively vetted and updates made to the Paleobiology Database and downloaded again over a one-year period. Each genus was then assigned to an ecologic factor (aquatic vs. terrestrial), and geographic range and diversity (richness and occupancy data) data were calculated. With this newly compiled data set, we used logistic regression models to examine extinction selectivity among non-marine vertebrates in the late Mesozoic and Cenozoic. Specifically, we sought to determine which factors had the greatest influence on observed patterns of extinction selectivity and to determine to what extent the pattern of extinction vs. survival at the K/Pg is similar to or different from Mesozoic and Cenozoic background patterns.
We found that preferential survival of aquatic taxa is a general feature of the non-marine vertebrate record for at least the past 150 Ma. Geographic range size, occurrence frequency, and species richness distributions also differ significantly between aquatic and terrestrial genera and can influence extinction risk, but the relationship between aquatic vs. terrestrial life habit and extinction risk remains even after accounting for these factors. Whereas overall extinction rates are much higher during the terminal Cretaceous Maastrichtian Stage than in other Cretaceous and Cenozoic stages, there is not a unique selective signal associated with aquatic vs. terrestrial life habit or other factors during this interval. These results imply that the preferential survival of aquatic taxa across the K/Pg boundary may not require special explanation.
Grant Information
SF's research is supported by the David and Lucile Packard Foundation.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

DISCRIMINANT ANALYSIS OF THE HORSES OF FOSSIL LAKE, OREGON, U.S.A.

HOLT, Eric M., U.C. Berkeley, Berkeley, CA, United States of America
Members of the genus *Equus* represent a major component of the late Pleistocene megafaunal community of North America with at least five morphotypes present during the Rancholabrean NALMA. Horses dominate the Pleistocene playa lake deposits of Fossil Lake in south central Oregon, which preserve a large vertebrate faunal assemblage from the Rancholabrean. Previously published work only found one taxon at Paisley Caves, a mere 72 km away. However, most of what we currently know about Pleistocene horses is based on craniodental remains, and examination of isolated teeth from Fossil Lake indicates the presence of two species of *Equus*, one large-bodied and the other smaller, at the site. Although these remains have generally been attributed to *E. pacificus* (now properly recognized as *E. scotti*), the vast majority of the equid fossils are postcranial elements, largely tarsals, carpals, and phalanges, which have customarily been viewed as nondiagnostic as to species. Subtle differences in the shape of postcrania between species can sometimes be difficult to distinguish qualitatively, but recent quantitative methods have shown great promise in this sector.
In this study, I extend the use of postcrania to test for presence and relative abundance of different species. I took linear measurements in eight dimensions of the most well-preserved horse second phalanges (n = 65) housed in the University of California Museum of Paleontology from the 1901 Fossil Lake excavation by Annie Alexander and the 1923–1924 expeditions by Stock and Furlong. I analyzed my measurements against a previously published reference data set of five species and 436 specimens, using a quantitative approach (discriminant analysis) to determine the species and major clades (stout vs. stilt legged) of the horse phalanges from Fossil Lake. The results confirm the presence of at least two different horse species at this locality. This study provides greater clarity on what members of the equid community were present in south-central Oregon following the LGM.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

3D GEOMETRIC MORPHOMETRICS ON COMPLETE VERSUS PARTIAL FORELIMB ELEMENTS OF CARNIVORANS

HOLTE, Sharon E., The Mammoth Site, Hot Springs, SD, United States of America; FABRE, Anne-Claire, The Natural History Museum, London, United Kingdom
A major challenge in paleontology is to obtain statistically significant sample sizes. Complete specimens are rare in fossil collections due to taphonomic processes, such as the depositional environment, scavenging, or bone modification. However, incomplete specimens can be difficult to classify, measure, and use for functional morphology interpretations. To investigate the feasibility of using partial specimens to interpret phylogeny and functional morphology, quantitative analyses were conducted on the humerus, radius, and ulna of 81 modern carnivoran species. Three-dimensional (3D) geometric morphometrics has become the favored method for interpreting shape variation. We used a combination of traditional, curve sliding semi-landmarks and surface sliding semi-landmarks to create a homologous mesh across the forelimb elements. All analyses were conducted on the complete elements as well as strictly on the proximal and the distal ends (excluding the distal end of the ulna). Criteria, including family-level designation, locomotor behaviors, and hunting strategies, were analyzed using three different methods: principal component analyses (PCA), leave-one-out cross-validated linear discriminant analysis (LDA), and k-nearest neighbors (k-NN) analysis. PCA demonstrated the strong relationship between morphology and phylogeny. LDA and k-NN methods were used to test the classification accuracy of an 'unknown' element. Results of the k-NN show that the distal humerus, distal radius, and the proximal ulna are, in most cases, better for interpreting these criteria than analyzing the complete elements. For example, in the k-NN analysis, the proximal ulna assigned the family designation with 92% accuracy, whereas the complete ulna was only 77% accurate. Overall, the k-NN analyses produce a higher rate of accuracy when classifying than LDA. Therefore, partial elements can provide a more accurate interpretation of phylogeny and behavior depending the methods one uses. With either method, researchers with partial specimens should feel more confident

including proximal or distal ends in their analyses, and they may even end up with more accurate results than if they used complete elements.
Grant Information
This material is based upon work supported by the National Science Foundation under Grant No. 1701587.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

OVER 40 YEARS OF EDUCATION AND PUBLIC OUTREACH AT THE MAMMOTH SITE
HOLTE, Sharon E., The Mammoth Site, Hot Springs, SD, United States of America; MCLAIN, Sharon K., The Mammoth Site, Hot Springs, SD, United States of America; MEAD, Jim I., The Mammoth Site, Hot Springs, SD, United States of America
Since the establishment of The Mammoth Site in Hot Springs, South Dakota in 1974, community participation and citizen science have been at the forefront of its mission. In 2017, The Mammoth Site had around 102,000 visitors to the site. Visitors watch a 10-minute introductory video about the site, take a guided tour of the sinkhole, and then are free to wander the fully accredited museum exhibit hall. Tours provide scientific information on mammoths, the site, and Ice Ages in three very different learning formats, including video-based learning, guided learning, and self-guided learning. Over 40 years, The Mammoth Site has hosted more than 2,000 adult volunteers through programs such as Earthwatch, Elderhostel (now Road Scholars), and our newly created Excavation and Preservation Program. K–12 education is also an integral part of The Mammoth Sites' outreach initiative. Educational courses have been taught to visiting school groups since 1992. Over 46,000 children have participated in The Mammoth Site's educational programs in the last 26 years, of which 10% of children were free of charge due to the site's commitment to the Hot Springs community. Educational kits called Mammoth Trunks bring K–12 educational classes to teachers across the US, reaching over 22,000 students since 1992. Junior and advanced paleontology excavation classes have been widely popular with 54,000 children and adults participating in these classes. Boy Scouts have also found The Mammoth Site to be a popular location to obtain their archaeology and geology badges. One goal of The Mammoth Site educational staff is to collect data on the effectiveness of these educational classes, trunks, tours, and exhibits and find ways to help the public to understand geological, paleontological, and biological concepts. Through data collection and updating materials, The Mammoth Site is expanding its educational outreach, activities, curriculum, and assessment. The site is also adding exhibits to follow growing trends in STEM education and research through hands-on, interactive, and social and digital media. The Mammoth Site's mission is to become a front-runner in STEM education by bringing in new tools, such as an interactive smartphone app, photogrammetry, and 3D printing, to the public. These tools provide the site with new ways to expand outreach and to develop technologically relevant lesson plans and activities.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

"INTEGUMENTARY STATUS: IT'S COMPLICATED": PHYLOGENETIC, SEDIMENTARY, AND BIOLOGICAL IMPEDIMENTS TO RESOLVING THE ANCESTRAL INTEGUMENT OF MESOZOIC DINOSAURIA
HOLTZ, Thomas R., University of Maryland, College Park, MD, United States of America
The discovery of non-squamous integument in heterodontosaurid and neornithischian specimens has led to the inference of the possibility that filamentous structures homologous to avian feathers were present in the most recent common ancestor of Dinosauria. However, initial attempts at maximum-likelihood ancestral state reconstruction analyses found that the ornithischian filaments were best interpreted as having evolved convergently from those in theropods. Subsequently, new hypotheses of the basal relationships of Dinosauria and its immediate outgroups as well as additional discoveries of skin impressions within dinosaurs encourages a re-examination of this situation.
A series of ancestral state reconstruction analyses was performed, under alternative hypotheses of basal dinosaurian relationships (the traditional Saurischia model; the new Ornithoscelida model; and the less-well-supported Phytodinosauria model). Additionally, the presence of filamentous or pennaceous integument were considered a separate character to (rather than an alternative character state of) squamous integument, as both fossil and modern dinosaurs document the shared presence of both conditions on the same individual. Furthermore, some runs were performed using all integument data simultaneously; in others, analyses were conducted separately on distinct different sedimentary preservational environments to assess comparable taphonomic situations.
In some of these analyses, the more likely ancestral status for Dinosauria or Ornithoscelida was recovered as filamentous. However, the fact that the basal relationships are indeed poorly resolved at present requires an acceptance of ambiguity for the integumentary condition of the original dinosaur. This ambiguity potentially reflects a discontinuous distribution of integument within the various branches of Dinosauria. The distribution of the (non-homologous) fur of mammals may reflect a similar situation. Comparison to the degree of fur present on closely-related medium-to-large extant mammals (even when inhabiting in the same environmental setting) reveals a spectrum of furriness, indicating factors beyond environment and phylogeny affect the presence/absence and distribution of body covering. A "general theory of integument" remains elusive at present.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

ISOLATED VERTEBRAE REVEAL A DIVERSE SAUROPOD FAUNA IN THE OXFORD CLAY (CALLOVIAN, PETERBOROUGH, ENGLAND), EQUIVALENT TO THE MORRISON AND TENDAGURU FORMATIONS.
HOLWERDA, Femke M., Bavarian State collection for Paleontology and Geology/ LMU, Munich, Germany; LISTON, Jeff, BSPG Munich, Munich, Germany; TSCHOPP, Emanuel, American Museum of Natural History, New York, NY, United States of America; EVANS, Mark, New Walk Museum & Art Gallery, Leicester, United Kingdom
Two isolated caudal vertebrae (anterior and middle), as well as two associated posterior dorsals, from sauropods of the Oxford Clay (Callovian, Middle Jurassic) near Peterborough, U.K., are described and discussed. The isolated anterior caudal has an extensive covering of bivalves, however, diagnostic features are visible, including the presence of a ventral keel, a 'shoulder' indicating a wing-like transverse process, along with a possible prespinal lamina. This indicates derived eusauropod or neosauropod affinities. The isolated middle caudal also shows diagnostic features, despite the neural spine and neural arch not being preserved and the neural synchondrosis being unfused. The presence of faint ventrolateral crests, as well as a rhomboid anterior articulation surface, show neosauropod affinities. The foramina piercing lateral and ventral surfaces are only tentative evidence of a neosauropod origin, as these also appear in Late Jurassic non-neosauropod eusauropods. Finally, the two associated dorsal vertebrae show a complex neural arch morphology including pre- and postspinal laminae, and probably pneumatic foramina, indicative of a neosauropod origin. As these elements morphologically differ from material of the currently recognised taxa from the Oxford Clay (*Cetiosauriscus stewarti*, '*Ornithopsis*' and an unnamed brachiosaurid), they indicate a higher sauropod taxon count than previously assumed. A phylogenetic analysis using these caudal and dorsal characters shows a diplodocoid affinity for the anterior caudal, a diplodocid origin for the middle caudal, and diplodocoid (dicraeosaurid or even apatosaurine) affinities for the associated dorsal vertebrae. Together with Oxford Clay material assigned to different sauropod taxa, this study shows the sauropod diversity in the Middle Jurassic Oxford Clay to be equivalent to that of both the 'classic' Upper Jurassic Morrison and Tendaguru Formations, when examined at a higher taxonomic level. This underlines that it is essential to examine isolated elements, as these may be indicators for taxonomic richness in deposits that are otherwise poor in terrestrial fauna.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW EARLY RECORDS OF NEOAVIAN BIRD CLADES FROM THE EARLIEST EOCENE BUMBANIAN OF MONGOLIA
HOOD, Sarah C., The University of Texas at Austin, Austin, TX, United States of America; TORRES, Chris R., The University of Texas at Austin, Austin, TX, United States of America; NORELL, Mark A., American Museum of Natural History, New York, NY, United States of America; CLARKE, Julia A., The University of Texas at Austin, Austin, TX, United States of America
The Paleocene-Eocene boundary is well documented as a period of critical importance to the evolution of land mammal lineages in Asia; in contrast, the record of Asian avifauna from this time is sparse. By filling this gap in our knowledge of Paleogene avian diversity, we stand to gain insights into the early evolution of extant lineages and how these lineages potentially responded to the Paleocene-Eocene Thermal Maximum (PETM). Here we describe new avian fossils from the earliest Eocene Bumban Member of the Naranbulag Formation in central Mongolia. These remains represent at least four taxa, including a left distal humerus of a shorebird (Charadriiformes); a left omal coracoid and partial furcula of a galliform; a left distal humerus of a ralloid (Gruiiformes); and a left quadrate with possible affinities to flamingos and relatives (Mirandornithes). These fossils serve to expand our understanding of the Early Eocene avifauna by providing additional skeletal elements for poorly represented taxa, as well as marking the earliest unambiguous record of shorebirds and potentially providing the earliest record of a stem mirandornithine. The timing of these clades in Asia may mirror the first appearances of many mammal lineages during the PETM.

Preparators' Session (Thursday, October 18, 2018, 3:15 PM)

THE CURATION, CONSERVATION, AND DIGITIZATION OF A PLEISTOCENE FAUNA FROM GYPSUM CAVE, NEVADA, U.S.A.
HOOK, Juliet A., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; RHUE, Vanessa R., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America
The relationship between early humans in North America with Ice Age megafauna has been an ongoing debate for many decades. Excavations at Gypsum Cave, Nevada in the early 1930s sparked the interest of archaeologists and paleontologists alike, as both artifacts and vertebrate fossils were found immaculately preserved in situ. The xeric conditions within the cave yielded exceptional preservation of soft tissue remains, such as ground sloth hair, skin, and horny claw sheaths, as well as plant material from ground sloth dung. Despite the intriguing aspects of the fauna, not much research has been done on the collection in the last 80 years.
In order to increase accessibility and thereby use of the collection for research, a federal grant was obtained to complete the curation, conservation, and digitization of this significant vertebrate fossil collection. An emerging professional was hired to work on the project and learn how to implement best practices concerning the curation of a historical collection. An initial condition assessment was conducted of an estimated 700 specimens housed in 31 drawers and 30 cubic feet of ground sloth dung housed in wooden crates. As a result, the following priorities were identified: creating space in the collection to accommodate expansion of the cataloged material, sorting and identification of elements and taxonomic groups, cataloging and archival labeling, taxonomic organization, specimen cleaning and repairs, archival housings, and digital photography. An inventory of accessory data showed that correspondence, cave maps, and photographs could be digitally scanned to supplement the contextual information about the site.
Applying modern conservation principles to the collection resulted in less crowded drawers and proper labeling of the material for easier access. Potential data loss was minimized due to improved specimen housings to mitigate the effects of abrasion, poor handling, and breakage of delicate specimens. Trays were lined with inert, non-abrasive materials, such as closed-cell polyethylene foam and polyester spun olefin. Deteriorated labels were digitally photographed and encapsulated in polyester mylar. The sloth dung previously stored in wooden crates was cleaned using a variable controlled vacuum and re-housed in Coroplast boxes so that the material would be protected from ambient pollutants. A public outreach component of the project will feature a blog about the curation process, historical significance of the site, and 3D photogrammetry models for public viewing on the museum web page.
Grant Information
This work was supported by a grant from the Bureau of Land Management, Cooperative Agreement No. L17AC00191.

Technical Session XI (Friday, October 19, 2018, 3:45 PM)

HIGH DIVERSITY OF NYCTITHERIIDAE (MAMMALIA, LATE EOCENE, U.K.) REVEALS NEW RELATIONSHIPS AND A COMPLEX PATTERN OF DISPERSALS, FLEETING DOMINANCE, GRADUAL EVOLUTION, AND EXTINCTION

HOOKER, Jeremy J., The Natural History Museum, London, United Kingdom

Bulk sampling and screen washing of 18 principal horizons through nearly 4 million years of superposed late Eocene strata in the Hampshire Basin, U.K., has recovered 14 species of nyctithere, including five new, in eight genera, of which one is new. Fine screens have allowed recovery of most tooth loci, except of the rarest taxa, and also jaws, postcranials, and a few petrosals. Inclusion of these species in a phylogenetic analysis of European late middle Eocene to Oligocene taxa shows the subfamily Amphidozotheriinae to be a well-characterized monophyletic group, sharing P3 protocone reduction, P4 with strongly oblique buccal wall, near-symmetrically arranged M1–2 paraconule and metaconule, mesially tapering dp4, and degrees of molar dilambdodonty. Five episodes of sudden appearance in the Hampshire Basin indicate European dispersal events and suggest the reason for certain ghost ranges in the phylogenetic tree. A new genus and species occurs at only two isolated horizons at c. 36 and 36.5 Ma, where it dominates the other nyctithere species. The four other dispersal events occur between c. 34 and 35 Ma, bringing in fresh taxa. The most major of these was at 34.4 Ma in the Bembridge Limestone, when four species appeared for the first time. This event coincided with a transient warm interval within an overall long-term cooling. The source of at least one of the species, *Amphidozotherium cayluxi*, from southern France, suggests a climate-induced northerly range shift. In the single case of gradual morphological change, increasing dilambdodonty in a species of *Euronyctia* ends in the highly derived *'Sigenyctia' oligocaena*, in reality a species of *Euronyctia*. The earliest Oligocene 'Grande Coupure' saw near complete extinction of nyctitheres in the U.K. The complex patterns of occurrence in the Hampshire Basin late Eocene suggest that, apart from a few generalists, most of these nyctitheres were adapted to relatively specific microhabitats and that climate also played a part.

Podium Symposium (Wednesday, October 17, 2018, 10:15 AM)

APPLICATIONS OF UNITARY ASSOCIATIONS TO THE SIMULTANEOUS ANALYSIS OF BIOGEOGRAPHY AND BIOSTRATIGRAPHY: CHALLENGES AND OPPORTUNITIES

HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America; DAVIS, Edward B., University of California Berkeley, Eugene, OR, United States of America; FAMOSO, Nicholas A., National Park Service John Day Fossil Beds, Kimberly, OR, United States of America; THEODOR, Jessica M., University of Calgary, Calgary, AB, Canada

Biostratigraphy is the most widely used dating technique for vertebrate assemblages, as it is inexpensive and requires little additional data besides the species identifications that are necessary for most paleontological studies. However, the biostratigraphic framework in which we identify the ages of vertebrate assemblages is primarily based on qualitative analysis of the vertebrate record, as the limitations of taphonomy and sampling challenge most quantitative approaches to biostratigraphy. In addition, biogeographic variation in species distributions has proven challenging to many biostratigraphic analyses, as illustrated by the controversy over the timing of arrival of proboscideans in North America. Application of a graph-theory-based approach, Unitary Associations (UA), to the MIOMAP database of terrestrial vertebrates has shown that the North American vertebrate record, while irregular, uneven, and incomplete, is amenable to this relatively simple approach, which makes it possible to simultaneously analyze biostratigraphy and biogeography. Using primarily the associations implied by taxonomic co-occurrence in individual localities supplemented by sections where real first and last appearance data are known, this method reconstructs biostratigraphic relationships based on the most parsimonious sequence of taxonomic appearance and disappearance. However, the substantial biogeographic differences between regions in some time periods (e.g., the early Arikareean) sometimes led this method to reconstruct stratigraphic differences where the distinction (as we know from independent age proxies) is only spatial. While this result offers the potential to simultaneously examine biostratigraphy and biogeography, it also means that areas and time periods where there are few known stratigraphic relationships between taxa are subject to greater error and uncertainty in biostratigraphic placement. While this problem is significant in any biostratigraphic analysis, quantitative methods are particularly handicapped by the absence of key sections that illustrate real sequences of first and last appearance data. Because these stratigraphic relationships can be hard to obtain from the published record, quantitative biostratigraphy based on paleontological databases is limited in its capacity to achieve what qualitative approaches have done in the past. Improvements to the quality of stratigraphic data in databases such as FAUNMAP and MIOMAP may yield more robust answers.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

EVIDENCE THAT 'FOUR-WINGED' PARAVIAN DINOSAURS MAY HAVE USED HINDLIMB FEATHERS FOR BROODING

HOPP, Thomas P., Protein Research Laboratories, Bellevue, WA, United States of America; ORSEN, Mark J., Protein Research Laboratories, Bellevue, WA, United States of America

Recent fossil discoveries have revealed a substantial number of theropod dinosaurs possessing feathers of various forms on their hind limbs, including some specimens with long, pennaceous, 'wing' feathers on their tibiae and tarsi, similar to the flight-capable primary and secondary feathers of birds. Several investigators have proposed that these leg feathers may have had roles in flight in some species, or in gliding, and have suggested models of 'four-winged' flight or gliding locomotion. However, as we first pointed out earlier, pennaceous feathers in modern birds and non-flying dinosaurs can rationally be ascribed brooding, as well as flight functions. Here we present evidence gleaned from our studies of a number of fossils that possess hind-limb feathers, as well as two examples of nesting *Citipati*. Taken together, these fossils allow us to develop a model of brooding postures that make use of pennaceous hindlimb feathers to cover and incubate eggs and hatchlings. In the case of *Citipati*, two well preserved individuals sitting on nests with large egg clutches (IGM-100/979, IGM-100/1004) clearly demonstrate a lack of complete coverage of the eggs by the animals' bodies and limbs. We previously showed that pennaceous feathers would have aided the coverage of eggs near the ulna and manus. We also noted a deficiency of egg coverage at the rear quarters laterally adjacent to the pelvis and tail. Here we demonstrate how pennaceous feathers, recently described on the tibiae and tarsi of several non-flying theropods and some primitive birds as well, could have served very effectively to cover eggs in these rear quarter positions. In recent literature, considerable attention has been given to possible flight-related or visual display related functions for hindlimb pennaceous feathers, while their nest-covering capabilities have been neglected. As with forelimb feathers, we conclude that pennaceous hindlimb feathers could have evolved primarily for the purpose of brooding, without requiring selective pressure for other uses such as flight or display. Hopefully our observations will bring a better balance to the understanding of potential functions of hindlimb feathers in non-flying, ground-dwelling, bipedal dinosaurs, and perhaps in primitive birds as well.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

EARLY PALEOGENE AVIFAUNA OF THE CLARKS FORK BASIN, NORTH-CENTRAL WYOMING

HOUDE, Peter, New Mexico State Univ, Las Cruces, NM, United States of America

Acid preparation of calcareous nodules collected from Clarkforkian–Wasatchian beds in the Willwood Formation of the Clarks Fork of the Bighorn Basin, Park County, north- central Wyoming, has yielded a diversity of fossil birds that were not previously represented despite more than a century of surface collecting and screen washing. Although most often disarticulated and incomplete, many are exceptionally undeformed, thus greatly facilitating comparison to modern osteological specimens. The avifauna is strongly dominated by *Lithornis*, *Sandcoleus*, and *Plesiocathartes*, although only the former two are widely distributed across sites. There is considerable taxonomic overlap with that of better-sampled localities such as the coeval London Clay and somewhat younger Green River Formation and Messel Oil Shale. The latter two typically preserve articulated specimens often including feather impressions, but specimens are flattened and usually severely deformed. Taxa shared among these deposits include lithornithids, screamer-like waterfowl, and stem representatives of Caprimulgiformes sensu lato, Coliiformes, Leptosomiformes, and Coraciiformes. However, the Clarks Fork and Green River avifaunas notably differ in that the former includes predatory birds but is devoid of waterbirds and gruiforms. The predatory birds include owls and possibly the earliest records of the flightless phorusrhacid "terror birds" and New World vultures. Thus, this fauna is comprised of basal members of several major clades of landbirds (Telluraves). As noted previously, the closest extant or recent relatives of these birds are mostly endemic to southern landmasses.

Technical Session IX (Friday, October 19, 2018, 9:15 AM)

FUNCTIONAL, PHYLOGENETIC, AND ALLOMETRIC SIGNALS IN THE SHAPE EVOLUTION OF THE ASTRAGALUS AND CALCANEUS OF MODERN AND FOSSIL RHINOCEROTOIDEA

HOUSSAYE, Alexandra, CNRS/Museum National D'Histoire Naturelle, Paris, France; ETIENNE, Cyril, CNRS/Museum National D'Histoire Naturelle, Paris, France; MALLET, Christophe, CNRS/Museum National D'Histoire Naturelle, Paris, France; CORNETTE, Raphaël, Muséum National d'Histoire Naturelle, Paris, France

The morphology of the ankle bones is strongly linked to the locomotor capacities of the appendicular skeleton. However, it also contains diagnostic features and it is very likely that some patterns of shape are allometric. Although the shape of these bones has been studied relatively well from a systematic but also functional point of view in artiodactyls, this is not the case in perissodactyls. This study investigates the shape of the astragalus and calcaneus of a sample of about 25 perissodactyl species (140 bones) of different morphologies, sizes, and functional adaptations (e.g., running, graviportal, facultative bipeds versus mandatory quadrupeds), including the five modern rhinoceroses but also modern tapirs and equids, and fossil rhinocerotoids and chalicotheres, in order to offer an evolutionary and deep time context. It utilized photogrammetry and 3D geometric morphometrics, and comparative analyses, which took phylogeny into account, and covariation analyses. The results of these analyses indicate that the various modern species differentiate rather well, mainly in the shape of the articular facets and of the trochlea. The separation between African and Asiatic rhinos seems to bear both phylogenetic and functional signals. Allometry is significant for the calcaneus but not for the astragalus. In chalicotheres, there is an interesting separation in the astragalus shape between the possibly knuckle-walking Chalicotheriinae with short hind limbs and the Schizotheriinae with longer hind limbs. The shape of the calcaneus is conversely rather homogeneous. Relationships between the shape data and the body size, global morphology, posture, and phylogenetic position of the various taxa is analyzed and peculiarities highlighted, such as the fact that the calcaneus of the giant *Paraceratherium* is close to those of rhinos, but not its astragalus. The co-variation of these two bones of the ankle joint and the factors involved in the evolution of these bones in rhinos, and in perissodactyls more generally, are discussed in the light of these results.

Grant Information
ERC-2016-STG GRAVIBONE

Podium Symposium (Friday, October 19, 2018, 9:00 AM)

HIGH-THROUGHPUT 2D AND 3D MORPHOLOGICAL DATA ACQUISITION USING AUTOMORPH: VERTEBRATE AND INVERTEBRATE CASE STUDIES

HSIANG, Allison Y., Swedish Museum of Natural History, Stockholm, Sweden; FIELD, Daniel J., University of Bath, Bath, United Kingdom; NELSON, Kaylea, Yale University, New Haven, CT, United States of America; ELDER, Leanne E., Yale University, New Haven, CT, United States of America; SIBERT, Elizabeth C., Harvard University, Cambridge, MA, United States of America; HULL, Pincelli M., Yale University, New Haven, CT, United States of America

Automated methods can reduce the amount of time and labor required for morphological data collection, allowing researchers to focus on analyses and interpretation. The ability to rapidly measure morphology is also necessary in order to feasibly study morphological evolution at large scales (e.g., when studying community-level spatiotemporal variation). Here, we present the software package AutoMorph, which we developed for high-throughput 2D and 3D morphological data acquisition from photographs. AutoMorph is able to identify and segment out individuals from specimens imaged in bulk, automatically extract 2D outlines and shape measurements (e.g., major/minor axis length, perimeter, aspect ratio, centroid location), and estimate 3D volume and surface area (when z-stacked images are provided). We demonstrate the utility and application of AutoMorph with two case studies: (1) quantifying bird wing shape evolution; and (2) exploring community shape evolution in planktonic foraminifera from the Atlantic Ocean. Our vertebrate case study illustrates the utility of this method for rapidly generating data germane to questions of macroevolution, functional morphology, and allometry. Our invertebrate case study shows the application of this method to understanding community macroecology and assemblage dynamics. These methods can easily be applied to fossil specimens, as demonstrated by the use of AutoMorph to extract shape measurements from icthyoliths to explore pelagic ecosystem evolution. Through these examples, we demonstrate that AutoMorph greatly speeds up the acquisition of shape data, facilitating large-scale morphological studies in both paleontological and neontological contexts.

Grant Information
Support was provided in part by the American Chemistry Society Petroleum Research Fund (PRF no. 55837-DNI8). Travel funding for AYH provided by the Wenner-Gren Foundations.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

ONTOGENETIC LONG BONE GROWTH AND DWARFISM IN PLEISTOCENE PROBOSCIDEA

HTUN, Thein, California State Polytechnic University Pomona, Pomona, CA, United States of America; PROTHERO, Donald R., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; HOFFMAN, Jonathan, Santa Barbara Museum of Natural History, Santa Barbara, CA, United States of America

Elephants, much like other terrestrial megafauna, are supported by thick robust limbs, which are necessary to accommodate their larger body mass. How do these limbs grow between different species? Do baby mammoth and mastodon limbs get more robust as they grow, as might be expected? Thanks to the large sample of juvenile limb bones at Rancho La Brea, we were able to construct growth curves of two different species of proboscideans (the extinct American Mastodon, *Mammut americanum*, and the Columbian Mammoth, *Mammuthus columbi*) to determine their ontogenetic patterns and compare their growth to published data from extant African elephants. We also looked at the ontogenetic growth trends in juvenile and adult dwarfed mammoths, *Mammuthus exilis*, from the Pleistocene of the Channel Islands of California. Contrary to expectations of increasing robustness, analysis of these measurements suggests that elephant, Columbian mammoth, and mastodont limbs became less robust and more gracile as they grew, i.e., length increased more than circumference (up to 70%). Finally, we compare this trend to the ontogenetic growth of dwarfed mammoths to see if dwarfing affected allometry. In the case of the Channel Islands dwarves, the slopes are slightly more robust between adult *M. columbi* and *M. exilis* (0.5–0.88), so they are not isometric, but the difference in slope is within error limits and not significant.

Podium Symposium (Wednesday, October 17, 2018, 10:30 AM)

DIFFERENT DIVERSIFICATION PROCESSES UNDERLAY THE INCREASE OF UNGULATE BODY SIZE IN NEOGENE EUROPE AND NORTH AMERICA

HUANG, Shan, Senckenberg Biodiversity and Climate Research Centre, Frankfurt, Germany; ERONEN, Jussi T., University of Helsinki, Helsinki, Finland; JANIS, Christine M., University of Bristol, Bristol, United Kingdom; SAARINEN, Juha J., University of Helsinki, Helsinki, Finland; SILVESTRO, Daniele, University of Gothenburg, Göteborg, Sweden; FRITZ, Susanne A., Senckenberg Biodiversity and Climate Research Centre, Frankfurt, Germany

Because body size correlates with many other aspects of a species, understanding of broad-scale patterns of body size variation can shed light onto the processes underlying the morphological and functional diversity of our biota. In this study, we investigated the evolution of body size in two regional faunas to test whether a widely hypothesized increase of mammalian body size through time is driven by species selection, i.e., higher origination and/or lower extinction rates of large-bodied species. We took advantage of the fossil record as a direct window to the evolutionary history and applied a Bayesian analytical approach to an extensive dataset (part of the larger NOW database) of fossil occurrence and body size for Neogene Artiodactyla and Perissodactyla in Europe and North America. Our dataset contained 6432 occurrences for 971 species and average adult body size for 483 species (~50%; size data also from published literature and measurements from museum collections), allowing investigation of the two orders in the two regions separately (thus four assemblages). Using the program PyRate, we estimated species- specific regional origination and extinction times from distributions of fossil occurrences and assessed whether body size covaried with rates of origination, extinction, and sampling among lineages. We found significant increases of maximum body size through time in all four assemblages and increases of minimum size in three (except European perissodactyls; based on Spearman's rank-order test against time with alpha = 0.05) so that their assemblage-level patterns are most likely driven by selection for large bodies, rather than a bounded diffusive process. In Artiodactyla, we found a significant correlation of large body size with both higher species origination rates and lower extinction rates in North America, but only with higher origination rates in Europe, while in Perissodactyla, we found larger-sized species to have lower extinction rates in North America. These results further support the idea of a driven evolution towards larger body sizes in these assemblages (through species selection). Notably, further sampling effort is unlikely to alter the patterns, as larger bodies were not associated with higher sampling rates in any of our groups. Collectively, our results of different diversification processes generating a similar trend of increasing body size in different clades and regions highlight the value of large scale fossil databases that allow investigation of macroevolutionary dynamics in a biogeographic context.

Grant Information
Funded by Alexander von Humboldt Foundation, German Research Foundation, Kone Foundation, Oskar Huttunen Foundation, Jenny & Antti Wihuri Fund, Swedish Research Council

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE EVOLUTION OF RESPIRATORY SYSTEMS IN THEROPODA AND PARACROCODYLOMORPHA AND THE END-TRIASSIC EXTINCTION

HUDGINS, Michael N., George Mason University, Yorktown, VA, United States of America; UHEN, Mark D., George Mason University, Fairfax, VA, United States of America; HINNOV, Linda N., George Mason University, Fairfax, VA, United States of America

The end-Triassic extinction occurred 200 million years ago and is marked by a major faunal turnover of Paracrocodylomorpha and Theropoda, with the former experiencing low biodiversity and the latter radiating after the extinction. Reasons for this turnover remain unknown, but atmospheric conditions during this time, which involves high CO_2 and low O_2 levels, are thought to be associated with this phenomenon. Evidence of bird-like pneumatic post-crania, present in both groups as pleurocoels and fossae, correlates with an avian-like respiratory system, allowing organisms to survive during CO_2 heavy environments. This study examines the morphological rate of change in skeletal remains of Theropoda, focusing on pneumatic bones, compared with Paracrocodylomorpha during the Late Triassic and across the Triassic-Jurassic boundary. The change in pneumaticity is quantified by a pneumatic index (PI), in which the number of pneumatized units is divided by the total number of bones examined. Patterns of pneumaticity are individually scored for the presence or absence of pneumatic bones. Morphological data are compared to corresponding pCO_2 and atmospheric O_2 reconstructions. Preliminary data suggests PI values increase in Theropoda and decrease in Paracrocodylomorpha throughout the late Triassic and into the Jurassic. In theropods, high PI values increase in more derived taxa, while paracrocodylomorphs have PI values varying by clade and generally decrease in more derived taxa. This suggests that the common ancestor of both groups originally had an avian-like respiratory system. Paracrocodylomorpha experienced a reduction of this trait, while Theropoda retained the study interval. A Kolmogorov-Smirnov test between the sets of data produced a value of D=0.5335 (p=0.0001). When morphological data was compared with CO_2 levels and O_2, weak correlation with pCO_2 and a negative correlation of O_2 with high PI values. Future directions will focus on digital scanning of individual bones from both groups to analyze the changing internal structure of pneumatic bones over time.

Grant Information
Awarded $1500 from the Office of Student Scholarship, Creative Activities, and Research, and the Undergraduate Research Scholars Program at George Mason Univeristy.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

ORIGIN AND DISPERSAL OF GORGONOPSIA: A PHYLOGENETIC APPROACH TO PERMIAN THERAPSID BIOGEOGRAPHY

HUMMEL, Rudolph R., Montana State University, Bozeman, MT, United States of America; GARDNER, Jacob D., Montana State University, Bozeman, MT, United States of America

Gorgonopsia is an order of carnivorous Permian therapsids known from eastern Europe and Africa. The origin, evolution, and dispersal of gorgonopsians (and other therapsids) is poorly understood. Specifically, Permian climate data supports the existence of large desert regions in central Pangaea, which would have separated major gorgonopsian occurrences. In the past, some authors have treated these deserts as significant ecological barriers. Since a comprehensive, statistically-supported phylogeny for Gorgonopsia is not currently available, this study aims to produce such a phylogeny and use it to test for a biogeographical origin and dispersal path within the order. Character data for 43 cranial characters were collected from 14 African taxa and four eastern European taxa thus far. Bayesian phylogenetic analyses were completed in MrBayes and produced a consensus tree. Chronological and geographic occurrence data was obtained from the Paleobiology Database and used with the consensus tree to perform a biogeographical analysis in BayesTraits, which estimated the ancestral paleolocation for each node and modelled them onto the surface of a globe. Several models were tested and a Bayes factor test was used to determine the most well-supported model. Preliminary results suggest a Gondwanan origin for Gorgonopsia around 273 Ma. Furthermore, it appears that two separate Gorgonopsian clades dispersed northward into Laurasia between 265 and 261 Ma, potentially implying that the deserts were indeed significant barriers.

Grant Information
This project has been supported by the Montana State University Undergraduate Scholars Program.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE AQUATIC VERTEBRATE COMMUNITY OF A BONE-DRY POND: THE HISTORIC STOVALL QUARRY 8, MORRISON FORMATION IN THE PANHANDLE OF OKLAHOMA

HUNT, Tyler C., University of Oklahoma, Norman, OK, United States of America; RICHMOND, Dean R., University of Oklahoma, Norman, OK, United States of America

Stovall Quarry 8, the "Gator" quarry, is located stratigraphically 34 m above the unconformable contact with the underlying Lower Jurassic Exeter Sandstone. The bone-bearing horizon consists of a 20 cm thick fossiliferous lacustrine mudstone, which grades vertically to a 50 cm thick paludal mudstone facies. Capping the paludal facies is a 5 m wide, 50 cm thick silty mudstone splay distributary channel. A 10 cm thick floodplain mudstone overlies the silty mudstone, grading into banded mudstone paleosols. Several multistory anastomosing fluvial channel sandstone beds overlie the mudstones. A southward migration of several lateral accretion sets suggests an eastward flow direction.

Thick mudstone drapes (10 cm) are present between each lateral accretion set. Mud cracks at the base of the sandstone beds indicate ephemeral deposition. The sedimentological sequence of mudstones and sandstones records the wetland desiccation and subsequent transition to an ephemeral fluvial facies.
Aquatic vertebrate communities are scarce in the Morrison Formation and represent a glimpse of the local fauna. Quarry 8 includes six individuals (five right femora and one larger left femur) of the goniopholidid crocodyliform *Goniopholis stovalli*, with estimated body lengths of 2.2 to 3.1 m. Numerous (> 1000) shed crocodile teeth suggest *Goniopholis* was a perennial resident. A few atoposaurid crocodile teeth were found in the deposit, indicating this crocodile was an infrequent resident of the pond. Two varieties of chelonids are identified from carapaces and plastrons; two *Glyptops plicatulus* and three large *Dinochelys whitei*. These turtles, along with *Goniopholis*, are represented by numerous scutes and other isolated elements. The lungfish *Ceratodus guentheri* and *C. frazieri*? and a very small unidentified piscivorous osteichthyan have been found. Non-aquatic fauna is represented by appendicular material from a minimum of two (right femora) *Dryosaurus altus* and a small unidentified tetanuran theropod. All three Voorhies Groups are present. Most of the fossils discovered, excluding shed crocodile teeth, represent Groups One and Two. Many fossils are incomplete and exhibit Stage One or Two weathering fractures. More than half the specimens display distortion. A few bone surfaces and teeth show evidence of insect grazing. The exposed bones weathered for several years prior to burial by floodplain mudstones. Taphonomic data indicate an attritional autochthonous fossil deposit and support the sedimentological interpretation.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

EDUCATION AT BUREAU OF LAND MANAGEMENT PUBLIC FOSSIL SITES IN SOUTHEASTERN UTAH: NEW LIFE FROM OLD BONES

HUNT-FOSTER, ReBecca K., Bureau of Land Management, Moab, UT, United States of America; ENGH, Brian, Dontmesswithdinosaurs.com, Camarillo, CA, United States of America; BREITHAUPT, Brent H., Bureau of Land Management, Casper, WY, United States of America; MATTHEWS, Neffra A., Bureau of Land Management, Denver, CO, United States of America; MCDONALD, Greg, Bureau of Land Management, Salt Lake City, UT, United States of America

In 2009, the Paleontological Resources Preservation Act was enacted, instructing the Secretary of the Interior to manage and protect paleontological resources on Federal land using scientific principles and expertise, as well as develop plans to increase public awareness about the significance of paleontological resources. The exceptional fossil record that exists in southeastern Utah provides an excellent venue to communicate the history of life in that area. To that end, the Bureau of Land Management (BLM) has partnered with academic researchers, the Utah Friends of Paleontology, and young and old citizen scientists to develop on-site interpretive material at fossil sites in the Canyon Country District. A series of six trails and an "outdoor classroom" (at an unimproved dinosaur tracksite) are the focus of both onsite tours and In-school educational presentations developed to increase public understanding of scientific and stewardship principals, as well as provide place-based learning experiences. New signage at the sites showcases BLM's message of "Respect and Protect" campaign to engage the public in the stewardship of cultural and natural resources. Signage was created to help interpret the fossils seen during visitation, and to discuss the common problems of vandalism and theft to paleontological resources. Often, these actions are the result of a lack of appreciation of the significance of fossils, and how to visit the sites, without damaging the resources; thus preserving them for future enjoyment and study. The signs were translated into the seven common languages used by the 2.8 million visitors to the southeastern Utah annually, including Navajo (for the local Native American community). An effort is also underway to create signage for the blind, utilizing accessible signage, braille, and touchable graphics. In-school educational opportunities are also offered, giving students a chance to gain additional background before visiting a site. Students have more time to develop and answer questions and be more prepared for their site activities. The physical lesson plans, activities, and videos have been developed for use both onsite and in the classroom. The Mail Station Dinosaur Tracksite is an example of an "outdoor classroom" with no on site interpretation. Directed, interactive projects allow students to discover scientific information at the site for themselves. These fossil experiences enhance the public's onsite experiences, while also educating students, and enriching their appreciation of the rich fossil history of Utah.

Grant Information
Bureau of Land Management - Utah

Technical Session VI (Thursday, October 18, 2018, 10:15 AM)

TERRESTRIAL LIFE ELEVATED: NEW DATA ON CARBONIFEROUS–PERMIAN VERTEBRATE BIOCHRONOLOGY IN SOUTHEASTERN UTAH AND ITS GLOBAL IMPLICATIONS

HUTTENLOCKER, Adam K., University of Southern California, Los Angeles, CA, United States of America; BERMAN, David S., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; HENRICI, Amy C., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; JUNG, Jason, California State University, San Bernardino, Ontario, CA, United States of America; PARDO, Jason D., University of Calgary, Calgary, AB, Canada; SCHLOTTERBECK, Tyler, South Dakota School of Mines, Rapid City, SD, United States of America; SUMIDA, Stuart S., California State University San Bernardino, San Bernardino, CA, United States of America

The Carboniferous–Permian transition (CPT) records shifts in the composition and environment of vertebrate assemblages in western Pangea ca. 300 Ma, associated with increasing xeric-adapted floras, emplacement of continental amniote-dominated communities, and continental aridification. Its similarities to modern climate warming have prompted investigations into the dynamics of CPT biodiversity losses in paleotropical wetlands, but little is known about the geographic extent and pacing of this turnover. Renewed collecting in the underexplored Cutler Group of southeastern Utah is shedding light on CPT vertebrate diversity and succession in western Pangea. Channel deposits of the lower Cutler beds of southern Bears Ears National Monument are known to have yielded disarticulated dissorophid temnospondyls (*Platyhystrix*), diadectomorph stem amniotes (limnoscelids), and synapsid remains. However, an exceptional freshwater bonebed in the lower Cutler includes aquatic and semi-terrestrial taxa, including xenacanth chondrichthyans, actinopterygians, *Sagenodus*, and the temnospondyl amphibian *Eryops*,together with terrestrial taxa including the synapsids *Ophiacodon navajovicus*, *Edaphosaurus novomexicanus*, and *Sphenacodon*, and an undescribed araeoscelidan reptile. A new bonebed discovered in 2017—the Three Buttes bonebed—preserves large amniote remains dominated by a sphenacodontid predator. Comparison with Cutler vertebrates in New Mexico, U.S.A., and preliminary microfossil analysis of marine marker beds are consistent with a late Carboniferous age for these beds, with the exception of vertebrate sites from the stratigraphically higher Organ Rock Formation of the Monument Valley area, which include Permian (Artinskian) elements. At least two and possibly three assemblages are recognized in the Cutler Group spanning the CPT. Ongoing paleodiversity and ecological ordinance analyses of 283 Euramerican CPT localities show that tropical wetland reductions gave way to emerging dryland-adapted, amniote-dominated faunas from a western Pangean epicenter prior to the Permian. This work highlights the importance of paleontological fieldwork in the Paleozoic of the southwestern U.S.A. and reinforces geographic variation in the colonization of terrestrial ecosystems by land vertebrates.

Grant Information
BLM National Conservation Lands Grant L17AC00064 (AKH); M. Graham Netting Fund and the National Geographic Society (DSB)

Preparators' Session (Thursday, October 18, 2018, 2:15 PM)

THE PREPARATION PROJECT: A GLOBAL PARTNERSHIP BETWEEN THE MIFUNE DINOSAUR MUSEUM, KUMAMOTO, JAPAN, AND THE MUSEUM OF THE ROCKIES, MONTANA, U.S.A.

IKEGAMI, Naoki, Mifune Dinosaur Museum, Kumamoto Prefecture, Japan; LEIGGI, Patrick, Museum of the Rockies - MSU, Bozeman, MT, United States of America; ANCELL, Carrie, Museum of the Rockies - MSU, Bozeman, MT, United States of America

In 2011, the Mifune Dinosaur Museum (MDM) proposed a unique collaborative partnership to the Museum of the Rockies, Montana State University (MOR) . This partnership, known as the Preparation Project, has allowed MDM staff to receive extensive training by MOR in curatorial techniques and the preparation of large dinosaur fossils. Fossils are prepared in the MDM viewing lab so that visitors can observe the process. The paleontology department at MOR benefits from this project as more than 700 fossils have been prepared over the course of the last 6 years, and are now available for research and exhibition purposes.
The first phase of this project began in 2012 when a large field jacket collected from the Morrison Formation of southern Montana in the early 1990s by MOR was shipped to the MDM. Believed to contain sauropod vertebrae, it was only upon preparation at MDM that the jacket was found to contain a rare nearly complete diplodocid skull. With wide spread media coverage, phase one of the Preparation Project attracted considerable attention throughout Japan, and visitation at the MDM increased significantly. Phase one was completed in the spring of 2013, and the project's success story was used by the MDM when they applied for a federal grant to fund the construction of a new museum which was completed in April, 2014.
The second phase of the project began in April 2014 and was completed over a two-year period. Field jackets containing *Daspletosaurus horneri* cranial and postcranial material were sent to the viewing lab at the MDM. The densely concreted sandstone encasing the fossils was a challenge for the MDM staff, but with additional training they skillfully prepared more than 150 specimens.
The third phase was also a two-year project and the MDM staff prepared additional sauropod specimens which were used in MOR's *Dinosaur Dynasties* exhibition at the MDM in 2017. Although the project was interrupted when a massive earthquake struck Kumamoto in 2016, preparation was completed in early 2018.
There are few museums in Japan that hire fossil preparators, but the Preparation Project has attracted the attention of many natural history museums. It is our hope that this partnership will foster new relationships and be a model for future global collaborations.

Grant Information
This project is supported by the National Government of Japan, Kumamoto Prefecture, the Mifune Dinosaur Museum, and the Museum of the Rockies.

Technical Session XVII (Saturday, October 20, 2018, 4:00 PM)

A NEW CROCODYLIAN FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION OF SOUTHERN UTAH, U.S.A., INDICATES DIVERSIFICATION OF ALLIGATORIDAE PRIOR TO THE END-CRETACEOUS MASS EXTINCTION

IRMIS, Randall B., University of Utah, Salt Lake City, UT, United States of America; SERTICH, Joseph J., Denver Museum of Nature & Science, Denver, CO, United States of America; GREEN, Todd, Oklahoma State University, Tulsa, OK, United States of America

Alligatoroid crocodylians comprise a taxonomically diverse and ecologically disparate clade that is an important component of Late Cretaceous and Cenozoic non-marine ecosystems across Laurasia as well as South America, often comprising the most diverse crocodyliform component of these assemblages. Our current understanding of the alligatoroid fossil record suggests that all Late Cretaceous taxa are early-diverging forms, and that the crown clade Alligatoridae (common ancestor of alligatorines and caimanines and all their descendants) originated in the early Paleocene, after the end-Cretaceous mass extinction. Thus, all extant alligatoroids are thought to comprise an exclusively Cenozoic radiation. Here, we report a new taxon of small-bodied crocodylian from the upper Campanian (~76 Ma) Kaiparowits Formation of southern Utah, U.S.A., known from at least two individuals: a beautifully-preserved nearly complete articulated skull and skeleton, and a second nearly complete skull. The new taxon is similar to other alligatoroids in possessing a brevirostrine skull, an ectopterygoid that is broadly separated from the maxillary tooth row, foramen aereum that is set in from the medial margin of the retroarticular process, and a highly reduced anterior process of the ilium, but lacks the strongly heterodont dentition observed in many early alligatoroids (e.g., *Brachychampsa*). It shares a number of synapomorphies with caimanine alligatorids, including a dorsally upturned margin of the orbits, dermal bones of the skull roof that overhang the rim of the supratemoral fenestra, an expansive dorsal exposure of the supraoccipital, and ventral

processes of the exoccipitals that contact the basal tubera. Placing the new taxon in aphylogenetic analysis of Crocodylia (with dense sampling of alligatoroids), we recover it in a well-supported clade including caimanines but excluding alligatorines and early alligatoroids. This phylogenetic position suggests that many caimanine character states previously interpreted as apomorphies may instead be the plesiomorphic conditions for Alligatoridae. The placement of the new Kaiparowits taxon as a caimanine strongly suggests that Alligatoridae originated at least ten million years prior to the end-Cretaceous extinction, and its radiation was not purely a result of post-extinction recovery.

Grant Information
Bureau of Land Management National Landscape Conservation System Research and Science Grant

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

FIRST GIANT SAUROPOD TRACKWAY WITH METER-SIZED FOOTPRINTS FROM THE UPPER CRETACEOUS OF THE GOBI DESERT, MONGOLIA

ISHIGAKI, Shinobu, Okayama University of Science, Okayama, Japan; MAINBAYAR, Buuvei, Institute of Paleontology and Geology, Ulanbaatar, Mongolia; TSOGTBAATAR, Khisigjav, Institute of Paleontology and Geology, Ulanbaatar, Mongolia; NISHIMURA, Ryotaro, Okayama University of Science, Okayama, Japan; TSUTANAGA, Sayaka, Okayama University of Science, Okayama, Japan; HAYASHI, Shoji, Okayama University of Science, Okayama, Japan; SANEYOSHI, Mototaka, Okayama University of Science, Okayama, Japan

Upper Cretaceous Mongolian strata preserve abundant dinosaur fossils, but sauropod specimens are only represented by limited numbers of body fossils and isolated footprints. During the field seasons in 2016 and 2017, Institute of Paleontology and Geology, Mongolian Academy of Sciences–Okayama University of Science Joint Expedition Team (IPG-OUS JE) recovered the first sauropod trackway in Mongolia. The trackway is putatively in the Upper Cretaceous Bayanshiree Formation, Khavirgiin Dzo, South Gobi Aimag, Mongolia. The precise stratigraphic position is under investigation. These are the first sauropod footprints in the formation of this area.

The trackway consists of four consecutive hind footprints represented as sandstone infills. The remarkable feature of the trackway is very small pace angulation (88°), indicating the slow walking speed of the trackmaker. The average stride length and pace length are 188 cm and 122 cm, respectively. The trackway ratio is 50%. The hind footprint axis is greatly rotated outward at 40°. The best-preserved hind footprint among them is 106 cm in length, and 77 cm in width. The footprint length varies from 102 to 120 cm, which are the largest footprints in Mongolia. Fore footprints are appeared to be overlapped with the hind footprints, showing no clear impression. The overall outlines of the hind footprints are roughly oval with prominent claw impressions of the digits I to III. The impression of the digit IV is a rather rounded tip, and that of the digit V is unclear. The claw impressions curve downward with strong medial inclinations, suggesting the trackmaker gripped the ground strongly during walking. The general morphological features of the footprints are congruent with those of *Brontopodus*, indicating that the trackmaker was a very large sauropod.

The estimated body size of the trackmaker significantly exceeds the body size of the previously known sauropod body fossils in Mongolia, indicating that the diversity and the size disparity of Mongolian sauropods are yet underestimated. The existence of extremely large-sized sauropods implies the presence of rich ecosystem that could sustain such giants in Cretaceous Mongolia.

Grant Information
This research is supported by Private University Research Branding Project of Japanese Ministry of Education, Culture, Sports, Science and Technology.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

DENTAL ARRANGEMENT OF *PSEPHODUS* (CHONDRICHTYES, COCHLIODONTIFORMES), BASED ON A NEW SPECIMEN FROM THE MISSISSIPPIAN OF INDIANA

ITANO, Wayne M., University of Colorado Museum, Boulder, CO, United States of America

Psephodus is a cochliodontiform, chondrichthyan fish known mainly from isolated tooth plates having polygonal or rectangular outlines and crenulated edges. Occasionally, a few such plates are found in an articulated series. The location within the jaws of these series and their orientation is not obvious. The dentition of *Psephodus* has been reconstructed with several such series arranged along each ramus and with each series oriented labiolingually, the largest plates being the most labial. Recently, a partial dentition of *Psephodus* was collected from the Big Clifty Formation (Mississippian, Viséan) of Crawford County, Indiana, U.S.A. The new specimen, UCM (University of Colorado Museum) 111373, comprises four tooth plates arranged in a linear series. The plates fit closely together and are in their original positions with respect to each other. The plates are presumed to belong to a single ramus and to be oriented mesiodistally, in contrast to the previous reconstruction. The largest plate is presumed to be the most distal and the smallest the most mesial. The presumed outline of the dentition is then similar to that of *Cochliodus contortus*. The most distal plate, which is rhomboidal and mesiodistally elongated, is much larger than the other three plates, which are oblong and labiolingually elongated. The mesiodistal and labiolingual dimensions of the rhomboidal plate are 23 mm and 15.5 mm, respectively. The corresponding dimensions of the adjacent oblong plate are 3.0 mm and 8.0 mm, respectively. The mesiodistal dimension of the entire series is 33 mm. The anterior tooth plates or tooth files (if originally present) are not preserved. The largest plate of UCM 111373 resembles the holotype of *Psephodus regularis*, also from the Viséan of Indiana. A set of associated but mostly disarticulated teeth and tooth plates having morphologies corresponding to *Psephodus magnus*, *Helodus planus*, and *Lophodus* sp., NMS (National Museum of Scotland) G.1950.38.51, has been described previously. It has been presumed that all of the teeth and tooth plates belong to the same individual. However, given the state of disarticulation of the teeth and tooth plates of that specimen, it is also possible that it represents the remains of more than one individual or of more than one species. The arrangement of tooth plates in UCM 111373 confirms that tooth plates similar to *Psephodus magnus* and to *Helodus planus* can belong to the same individual. It neither confirms nor rules out the possibility that teeth resembling *Lophodus* sp. were part of the *Psephodus* dentition.

Technical Session XII (Friday, October 19, 2018, 4:00 PM)

BUILDING A BACKBONE FOR SNAKE ECOMETRICS USING MIDDLE TRUNK VERTEBRAL MORPHOLOGY.

JACISIN, John J., Texas A&M University, College Station, TX, United States of America; LAWING, A. M., Texas A & M University, College Station, TX, United States of America

Anthropogenic global change threatens to overwhelm the ability of ecosystems and species to sustain historical function. Integrative science merging the fields of paleontology, conservation biology, and Earth sciences is vital to securing the future of Earth's organisms, resources, and natural systems. Ecometrics—the community-level study of functional traits exhibiting quantifiable relationships with environmental gradients or climate—synthesizes modern, historical, and paleontological data across space and time for an array of organisms. Snakes are good candidates to expand ecometric research as ectotherms that have shown significant reactions to environmental change. Snakes use their vertebrae to locomote and interact with the environment, making vertebral shape a good element to investigate trait-environment relationships through deep time. We used geometric morphometrics to quantify anterior shape of middle trunk vertebrae with 23 homologous landmarks. We used generalized procrustes superimposition and a PCA to extract shape scores for 110 extant snake species from the continental United States. We tested differences between vertebral shape and ecological categories (fossorial, semifossorial, arboreal, semiarboreal, aquatic, semiaquatic, or terrestrial) and found that five of the first six PCs showed a significant difference between shapes for at least one ecological category ($P < 0.01$). Relative neural spine height (PC1; $R^2 = 0.33$), vertebral height-to-width ratio (PC2; $R^2 = 0.22$), relative neural canal size (PC3; $R^2 = 0.15$), relative prezygapophyseal facet length (PC5; $R^2 = 0.20$), and relative parapophysis length (PC6; $R^2 = 0.24$) explain ~85% of the shape variance and separate by ecological category. Loss of historical habitat in the New Mexico Middle Rio Grande changed the mean shape and decreased the variation for that population in < 20 years, while three adjacent snake populations in northeastern Texas varied in the means and ranges of vertebral shape with environments. Our ecometric analysis suggests that relative neural spine height and relative neural canal size, vertebral height-to-width ratio, and relative parapophysis length are proxies for vegetation cover, annual precipitation, and mean annual temperature, respectively. These newly described ecometrics add to the toolbox of paleontological proxies to help interpret past climates and environments.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

WHERE DID THE SAUROPODS ROAM? USING GASTROLITHS OF THE EARLY CRETACEOUS WESSEX FORMATION, WEALDEN GROUP OF THE ISLE OF WIGHT, ENGLAND TO INFER PALAEOGEOGRAPHY AND PALAEOECOLOGY

JACOBS, Megan, University of Portsmouth, Portsmouth, United Kingdom; GALE, Andrew S., University of Portsmouth, Portsmouth, United Kingdom; BULLEN, Dean, University of Portsmouth, Portsmouth, United Kingdom; LOCKWOOD, Jeremy, University of Portsmouth, Portsmouth, United Kingdom

The Wessex Formation, Wealden Group, on the Isle of Wight is a series of fine-grained sandstones and floodplain clays, which yield a high diversity of vertebrate remains, including dinosaurs. Amongst these remains, are rare erratics, often referred to as gastroliths due to a high surface polish and association with sauropod remains. We carried out an extensive analysis of all possible gastroliths in current collections on the Isle of Wight, amounting to around 200 specimens. From this we identified common lithologies, which included chert, limestone with *Trigonia* bivalves, silicified wood, and a variety of metamorphic and igneous rocks, including basalt.

Using mineralogy and fossils preserved within gastroliths, we identified individual horizons which were the source of the pebbles. This allows for a palaeogeographical map of the Wessex Basin to be constructed, as well as a greater understanding of the areas the sauropods targeted to acquire gastroliths. The study shows a large number of gastroliths originating from exposed Triassic/Jurassic conglomerate beds to the west, as well as from the Jurassic aged Portland and Purbeck limestone beds. Additionally, sauropods preferentially selected pebbles that are extremely fine-grained, due to no occurrence of grains larger than 0.5 mm.

We also conducted a series of experiments to replicate the polish created within the stomach of sauropods, using a rock tumbler and a mix of *Equisetum*, pine, water and pebbles with a lithology typical of that found in the gastroliths of the Wessex Formation. Within one week, the pebbles had taken on a polish, which improved over another 3 weeks. The surface texture of collected gastroliths, pebbles from the rock tumbler and beach polished pebbles were compared to see any correlations. The collected gastroliths and rock tumbled gastroliths showed a close similarity, suggesting that the sauropods diet consisted of high levels of *Equisetum* and pine.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

GLOBAL MAMMALIAN RESPONSE TO MID-MIOCENE PEAK IN ATMOSPHERIC CARBON DIOXIDE

JANIS, Christine M., University of Bristol, Bristol, United Kingdom; DAMUTH, John D., University of California Santa Barbara, Santa Barbara, CA, United States of America; TRAVOUILLON, Kenny, Western Australian Museum, Welshpool, Australia; HAND, Suzanne, University of New South Wales, Sydney, Australia; ARCHER, Mike, University of New South Wales, Sydney, Australia

Studies of North American Neogene mammalian ungulate faunas showed a phenomenon of 'too many browsers' in the mid Miocene. These non-analogous communities were over-rich in browsing species compared with other fossil and extant assemblages. These browser-rich communities have been interpreted as reflecting a response to a rise and subsequent fall in levels of atmospheric carbon dioxide in the mid-Miocene that resulted in elevated levels of terrestrial primary productivity (a greater increase than could be explained by the well-documented Neogene rise and fall in global temperatures alone). Although plant stomatal data have consistently supported a Neogene rise and fall inatmospheric CO_2, with a mid-Miocene peak, broadly following the paleotemperature curve, interpretations from geochemistry have fluctuated; but the consensus is now for mid-Miocene levels of around 600 ppm, over twice the Recent pre-industrial levels.

Using data from the NOW database, and including all localities that are comparable, in faunal sampling and taxonomic practice, to the single quarry localities of the North American study, we show a similar mid-Miocene (~ 17–14 Ma) peak in brachydont (= browsing) ungulates that occurred independently in five different Old World regions (including Europe, Asia, and East Africa), supporting the original hypothesis from the North American data. Furthermore, data on Australian fossil herbivorous mammals spanning the same time period, representing faunas with different taxonomic affinities (marsupials versus placentals), and which evolved in unique habitats independently of faunal or tectonic events affecting other continents, show a comparable response to the same global atmospheric change, most evident in the local species diversity of terrestrial browsers. We conclude that the patterns of mammalian herbivore diversity worldwide support the hypothesis of a faunal response to changing levels of primary productivity driven by changing levels of atmospheric carbon dioxide.

Grant Information
NSF EAR-0958579 to CMJ, NSF EAR-0958250 to JJD

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

FOSSIL EMYDIDS (TESTUDINES, EMYDIDAE) FROM EASTERN TENNESSEE AND THEIR IMPLICATIONS FOR THE EVOLUTION OF THE EMYDIDAE

JASINSKI, Steven E., University of Pennsylvania, New Freedom, PA, United States of America

Emydid turtles (Testudines, Emydidae) are the most diverse and widespread family of turtles in the New World today. The family consists of 10 to 12 extant genera and over 50 species but has been diverse in the past as well. While the fossil record has shown a lot of disparity, many of the fossil taxa have been fragmentary and/or synonymized or later considered nomina dubia. The Gray Fossil Site in northeastern Tennessee is a fossil locality from the latest Hemphillian-earliest Blancan and is interpreted as an ancient pond-like sinkhole. The site has at least 4 fossil emydids among its turtle fauna. These include representatives of *Trachemys*, *Chrysemys*, *Terrapene*, and *Emydoidea*/*Emys*. All these turtles represent distinct species. Based on phylogenetic analyses, these turtles show similarities with species from various geographic regions, suggesting these represent a non-analog turtle fauna and add to the distinctiveness of the site. *Trachemys haugrudi* from the site is found to be closely related to fossil species from Florida. The new species of *Chrysemys* is mostly closely related to fossil *Chrysemys* from Nebraska. A new species of *Terrapene* lies outside crown *Terrapene* and near the base of the *Terrapene* clade while also being most closely related to species from the midwestern United States. The fourth, enigmatic emydid shows affinities with *Emydoidea* and *Emys*. It would represent the southern-most extent of *Emydoidea*, further south than other fossil records and distinctly further south than the modern biogeographic range, which extends to central Illinois and Indiana. The distinct turtle fauna at the Gray Fossil Site provides significant new information in understanding the evolution of the most diverse family of New World turtles today.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PALEOECOLOGICAL TRENDS OF THE ADAMANIAN–REVUELTIAN FAUNAL TURNOVER EVENT WITHIN THE LATE TRIASSIC (NORIAN) CHINLE FORMATION (U.S.A.)

JENKINS, Xavier A., Arizona State University, Tempe, AZ, United States of America; GAY, Robert J., Colorado Canyons Association, Fruita, CO, United States of America

The Upper Triassic Chinle Formation preserves the most complete Triassic terrestrial fauna in North America. Deposition began during the late Carnian and continued into the early Rhaetian. Geographically extensive, the Chinle Formation is present in Arizona, Colorado, New Mexico, and Utah, with equivalent terrestrial deposits known from Texas, Oklahoma, and Nevada. The Chinle Formation preserves a diverse archosauromorph-dominated fauna with phytosaurs, aetosaurs, crocodylomorphs, azhendosaurids, pterosaurs, dinosauromorphs, and dinosaurs. Non-archosauromorphs, such as temnospondyl amphibians and procolophonids, are also present in the Chinle but are not major components of any preserved ecosystem. Additionally, dozens of unnamed but distinctive tooth morphotypes are recognized from the Chinle Formation, hinting at greater diversity both taxonomically and ecomorphologically than is currently recognized by formally described taxa. Here, we describe trends in body size, diet, locomotion, and species richness through time for Chinle Tetrapoda, and tested if it coincided with the purported Adamanian–Revueltian faunal transition.

We use a database of tetrapod assemblages within the Chinle Formation downloaded from the online Paleobiology Database and edited for accuracy. We lumped 103 taxa into geographic (state) and time (member-based radiometric date) bins. No obvious trends in body size, diet, or locomotion, were present in the data. Diversity, however, has a strong trend over time and we find that phytosaur diversity plummets during the Adamanian–Revueltian transition. The 'Leptosuchus' morphotype is restricted to the Adamanian, with seven species of phytosaurs becoming extinct through the transition. The only surviving phytosaurs are members of the genus *Machaeroprosopus* (a pseudopalatine). Newly discovered phytosaurs in the Petrified Forest Member of Fry Canyon, Utah have been identified as *Pravusuchus* by others, which would make it the only non-pseudopalatine phytosaur to survive the transition. Our analyses suggest that the Adamanian–Revueltian faunal transition, at least within the Chinle, may have been broadly phytosaur specific. Aetosaurs and temnospondyl amphibians seem largely unaffected, while most other taxa are not broadly distributed enough to track a true signal.

Technical Session VI (Thursday, October 18, 2018, 11:45 AM)

A STEM HYNOBIID (AMPHIBIA, URODELA) FROM THE UPPER JURASSIC OF WESTERN LIAONING PROVINCE, CHINA, SHEDS NEW LIGHTS ON EVOLUTION OF SALAMANDER LIMBS

JIA, JIA, PEKING UNIVERSITY, BEIJING, China; GAO, KE-QIN, PEKING UNIVERSITY, BEIJING, China

The Middle–Late Jurassic (166–157 Ma) Yanliao Biota, known by fossils from western Liaoning, northern Hebei and southeastern Inner Mongolia of China, contains a taxonomically diverse assemblage of salamanders, including early representatives of Cryptobranchoidea (e.g., *Chunerpeton* and *Jeholotriton*) and Salamandroidea (e.g., *Beiyanerpeton* and *Qinglongtriton*). Noticeably, these are predominantly neotenic forms, with the mesopodium remaining cartilaginous in manus and pes; only two taxa (*Pangerpeton*, *Liaoxitriton daohugouensis*) were reported as metamorphosed, but the mesopodials are either not (*Pangerpeton*) or incompletely (*L. daohugouensis*) ossified in all known specimens, impeding our understanding of the evolution of salamander limbs in the Jurassic Era.

Here we report a new metamorphosed salamander based on μCT scan of two specimens in Peking University Paleontological Collections from the Upper Jurassic Lanqi Formation cropped out at the Daxishan locality in western Liaoning Province, China. Cladistic analysis based on an updated datamatrix with 15 new morphological characters recovered the new taxon as a basal member of the Hynobiidae, a primitive clade with its fossil record (*Liaoxitriton zhongjiani* and *Nuominerpeton*) previously known from the Lower Cretaceous of China. Interestingly, the new taxon represents the first Jurassic salamander known with a completely ossified mesopodium.

The carpal elements are dislocated, but the tarsals are fully articulated, with six and seven elements ossified on the left and right pes, respectively. The tibiale remains cartilaginous. Presence of a single centrale and an amalgamated distal tarsal 4+5 on both sides of the hindlimb displays derived patterns different from most crown-group hynobiids, which plesiomorphically have two centralia and separated distal tarsal 4 and 5. The centrale is obviously smaller than the basale commune; thus, unlikely derives from possible amalgamation of two centralia as seen in the primitive hynobiid *Onychodactylus*, but resembles the condition in the derived *Hynobius* with one centrale lost. The amalgamation of distal tarsal 4+5 is previously seen only in extant hynobiid *Salamandrella*, with homoplastic occurrences in Plethodontidae and Salamandridae. The simplified tarsal pattern in this new stem hynobiid salamander reveals that amalgamation and loss, as two essential mechanisms driving the reduction of the number of mesopodial elements in limb evolution of salamanders, has been in effect during the Late Jurassic Oxfordian Stage.

Grant Information
Funded by National Natural Science Foundation of China (grant 41702002, 41672003).

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

PALATINE VIEW OF *WANGOSAURUS BREVIROSTRIS*, A BASAL PISTOSAUR SAUROPTERYGIAN FROM THE LATE MIDDLE TRIASSIC (LADINIAN) OF XINGYI OF SOUTHWESTERN CHINA

JIANG, Da-yong, Peking Univ, Beijing, China; MOTANI, Ryosuke, University of California - Davis, Davis, CA, United States of America; TINTORI, Andrea, Malgrate, Italy; RIEPPEL, Olivier C., The Field Museum, Chicago, IL, United States of America; ZHOU, Min, Peking University, Beijing, China; LU, Hao, Peking University, Beijing, China

Triassic pistosauroids are believed to be important in the search for the origin of Plesiosauria. *Wangosaurus brevirostris* is a basal pistosauroid from the late Ladinian at Xingyi in Guizhou Province of southwestern China, confirmed by the strict consensus tree which revealed *Wangosaurus* to be sister taxon to the (*Yunguisaurus* + ((*Augustasarus* + *Pistosaurus*) + (*Bobosaurus* + *Plesiosaurus*))) clade. The features to support its pistosauroid affinity include: the distinct sagittal crest, the presence of 33 cervical vertebrae, and the hyperphalangy in the hind limb. And in addition, the horizontally oriented supraoccipital below the occipital exposure of the parietal also distinguishes *Wangosaurus* from *Nothosaurus*. However, *Wangosaurus* also shares some morphological similarities with *Nothosaurus*, such as fused frontal, plate-like occiput without a distinct paroccipital process, and the somehow horizontally oriented supraoccipital. Previous study only observed the dorsal view of the skull and postcranial skeleton. After detailed preparation, the palatine view of the skull of the holotype, GMPKU-P-1529 is available. The vomers are paired and elongate elements and extend far posterior beyond the internal nares, forming the medial margins of the internal naris and separating the internal nares from one another. The plate-like palatines are well preserved on both sides and separated from each other by the vomers and the pterygoids, forming the posterior margins of the internal nares. The pterygoids are paired, and of typical nothosaurid pattern. It sends a weakly developed transverse process, which together with the ectopterygoid to form the pterygoid flange, which is more pronounced ventrally projecting, unlike those of *Nothosaurus* but similar to *Cymatosaurus*. The posteriormost pterygoids meet each other in a weakly interdigitating sagittal suture, without interpterygoid vacuity. The palate characters reconfirm that *Wangosaurus*, as the basal pistosauroid, is more similar to *Nothosaurus*.

Technical Session XIV (Saturday, October 20, 2018, 9:00 AM)

3D IMAGING OF A JUVENILE *DUNKLEOSTEUS* PROVIDES INSIGHTS INTO THE DEVELOPMENT OF THE SYNARCUAL IN ARTHRODIRES ("PLACODERMI")

JOHANSON, Zerina, Natural History Museum, London, United Kingdom; TRINAJSTIC, Kate, Curtin University, Perth, Australia; CUMBAA, Stephen L., Canadian Museum of Nature, Ottawa, ON, Canada; RYAN, Michael, Cleveland Museum of Natural History, Cleveland, OH, United States of America

Fusion in the vertebral column occurs normally in jawed vertebrates, with structures such as the sacrum and pygostyle providing rigidity, support, and increased area for muscle attachment. The synarcual represents the fusion of the anterior part of the vertebral column and occurs in a number of jawed vertebrates, including a variety of placoderms, chondrichthyans, and mammals. Placoderm fishes (Silurian–Devonian) are resolved phylogenetically to the base of the jawed vertebrate clade, with vertebrae comprising neural and haemal arches composed of perichondral bone. Although the synarcual in other placoderms has been described, a juvenile specimen of the pachyosteomorph arthrodire *Dunkleosteus terrelli* preserves substantial developmental information from anterior (oldest) to posterior, where new vertebrae are incorporated. Micro-CT scanning of this synarcual provides details of a transitional zone of vertebral fusion, providing unprecedented detail of how each vertebrae is modified and incorporated into the synarcual. These elements still retain vertebral identity, showing less fusion overall, more comparable to other arthrodires such as *Compagopiscis*. By comparison, synarcuals of other taxa such as ptyctodont placoderms, batoids, holocephalans (Chondrichthyes), and mammals (syncervical) show more complete fusion of vertebral elements. Reduced fusion in the arthrodire synarcual may be a specialization of the group, potentially related to the functional support of the headshield directly on the trunkshield, with only minor support provided by the anterior vertebral column.

Grant Information
Australian Research Council Discovery Grant DP140104161

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE GEOGRAPHIC DISTRIBUTION OF *PANTHERA ATROX* (CARNIVORA, FELIDAE) REMAINS IN TEXAS, U.S.A.

JOHNSON, Eileen, Museum of Texas Tech, Lubbock, TX, United States of America; MORETTI, John A., Museum of Texas Tech University, Lubbock, TX, United States of America

The American lion, *Panthera atrox*, is among the largest mammalian predators of late Pleistocene (Rancholabrean Land Mammal Age) North America. The geographic range of *P. atrox* is broad, stretching from Alaska into Mexico. Yet, records from this geographic range are relatively sparse and individual sample sizes typically are small. The size and functional morphology of *P. atrox* suggest it occupied a dominant, top-tier ecological position. Accordingly, occurrence of this feline likely has influenced local species diversity. Understanding the biogeography of *P. atrox*, therefore, has implications for exploring late Pleistocene faunal composition and community ecology. Investigations of latest Pleistocene alluvial deposits and associated vertebrate fauna at Macy Locality 100 have produced the first record of *P. atrox* from the Southern High Plains of Texas and New Mexico. A review of Texas lion distribution results in lion specimens from a total of five localities in Texas: Macy Locality 100, Texline, Good Creek, Kincaid Rockshelter, and Ingleside. With the exception of Texline (an isolated occurrence), each of these localities has an associated Rancholabrean vertebrate fauna that indicates a late Pleistocene age. Only the Macy Locality 100 American lion has associated radiometric ages. Radiocarbon ages obtained from organic sediments and charcoal place the Macy Locality 100 specimens at ~11,000 ^{14}C yrs BP, bracketed between dates of 11,305 ± 65 and 10,934 ± 34 ^{14}C yrs BP. All of the Texas specimens are consistent in size and morphology with the large samples of *P. atrox* from Rancho La Brea and Natural Trap Cave. Although mentioned in the literature, the remains from Kincaid Rockshelter and Texline have not been described previously. Large predators are expected to be sampled poorly in the paleontological record and the Texas specimens represent a minimum of five individuals. This low number perhaps reflects the relatively low live abundance of a top-tier carnivore. The combined assemblage documents the presence of *P. atrox* across the Texas southern grasslands, from the Panhandle and Southern High Plains to the Gulf Coast.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A NEW SPECIES OF *CEUTHOLESTES* (MAMMALIA, NYCTITHERIIDAE) FROM SOUTHERN WYOMING, INCLUDING THE FIRST UPPER DENTITION REPORTED FOR THE GENUS

JONES, Matthew F., University of Kansas, Lawrence, KS, United States of America; BEARD, K. C., University of Kansas, Lawrence, KS, United States of America

Ceutholestes is an enigmatic nyctithere from the late Paleocene (Clarkforkian) of western North America notable for its completely molariform lower fourth premolar. The type species, *Ceutholestes dolosus*, is known from a middle Clarkforkian site in the Clark's Fork Basin of northern Wyoming. Although *C. dolosus* was originally assigned to its own family, Ceutholestidae, recent phylogenetic analyses indicate that *Ceutholestes* is highly nested within Nyctitheriidae, sister to the European taxon *Placentidens*. Here we describe a new species of *Ceutholestes* from the early Clarkforkian locality of Big Multi Quarry in Sweetwater County, Wyoming. This new species consists of several nearly complete dentaries, isolated lower cheek teeth, and the first reported upper dentition of *Ceutholestes*—represented by the upper fourth premolar, upper first molar, and upper second molar. *Ceutholestes* possesses a completely molariform upper fourth premolar and, like *Placentidens*, molars with well-developed conules and a pericone anterior to the protocone. Unlike *Placentidens*, *Ceutholestes* has a much larger pericone on M1 and a pronounced stylar shelf with a prominent mesostyle. In upper molar morphology, *Ceutholestes* more closely resembles the putative nyctithere *Remiculus*, although it possesses much larger conules and a better developed pericone. The upper P4 of *Ceutholestes* also resembles that of *Remiculus* in being completely molariform with noticeable conules and pronounced pre– and postcingula. The upper dentition of *Ceutholestes* supports a close relationship with both *Placentidens* and *Remiculus*, and supports the placement of *Ceutholestes* in the nyctitheriid subfamily Placentidentinae.

Grant Information
This research was supported by a grant from the David B. Jones Foundation.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

EVOLUTIONARY CONVERGENCE AND EVIDENCE FOR A MACROEVOLUTIONARY RATCHET IN THE FAMILY HYAENIDAE

JUHN, Mark, University of California Los Angeles, Los Angeles, CA, United States of America; ALFARO, Michael, University of California Los Angeles, Los Angeles, CA, United States of America; VAN VALKENBURGH, Blaire, University of California Los Angeles, Los Angeles, CA, United States of America

Diversity declines are well documented and widespread in the fossil record. However, the mechanisms that drive the observed dynamics are still unclear. Macroevolutionary ratchets have been proposed as a potential driver of decline, where selection favors the loss of early generalized forms resulting in specialized forms late in the history of the clade. The tension between individual selection and greater vulnerability to species extinction due to specialization has been demonstrated in the North American canid record. Here, we used simulations to explore the relationship between trait evolution, extinction, and clade decline under macroevolutionary ratchet-type scenarios. To simulate the macroevolution ratchet, we model the extinction rate of each lineage as a function of its trait value. Furthermore, we used a Brownian motion model with drift to reflect the ratchet-like effect of specialization, where the clade is forced to become more specialized in its evolutionary history. Our simulations confirm that a macroevolutionary ratchet-type scenario will lead to a diversity decline trajectory. However, the diversity trajectory after peak diversity is not always unidirectional, suggesting that clades may be able to recover from short periods of decline. Additionally, different relationships between the simulated trait value and extinction strongly impacts the total duration of the clade. We also tested for the presence of a macroevolutionary ratchet within the family Hyaenidae, a group that experienced a drastic loss of diversity in the early Pliocene. We used craniodental measurements of fossil hyenas to construct dietary indices as a proxy for specialization and tested whether increasing specialization predicted clade decline. Preliminary results support the presence of a macroevolutionary ratchet in hyenas, suggesting a convergence of evolutionary modes in carnivorans. Our results clarify how trait evolution can drive decline under a range of parameter values and reveal that the macroevolutionary ratchet may explain Pliocene clade dynamics within the Hyaenidae.

Technical Session IX (Friday, October 19, 2018, 8:15 AM)

DIVERSITY AND BIOGEOGRAPHY OF SOUTH ASIAN PLIOCENE HIPPARIONINE HORSES

JUKAR, Advait M., George Mason University, Fairfax, VA, United States of America

North American hipparionine horses dispersed into the Old World in the middle Miocene and diversified into several lineages during the late Neogene and early Quaternary. The Siwalik Group of South Asia, which spans this period of time, preserves an excellent record of some of these lineages, ranging from 10.8 Ma to 2.6 Ma. The well-studied Miocene record from the Potwar Plateau in Pakistan preserves three hipparionine lineages, *Cormohipparion*, *Sivalhippus*, and *Cremohipparion*, which range from 10.8–10.3 Ma, 10.5–6.8 Ma, and 8.8–6.2 Ma, respectively. Pliocene hipparionines are best known from the Indian Siwaliks. They range in age from 3.6–2.6 Ma, and have been variously classified as *Hipparion* sp., *Cremohipparion antelopinum*, and *Sivalhippus theobaldi*, oftentimes without rigorous morphological comparisons. This raises questions about the persistence of these Miocene lineages into the Pliocene. An understanding of the taxonomy of these Pliocene hipparionine horses will help resolve questions about the relationship of these horses with the Miocene lineages and Neogene equid biogeography in the Old World.

In this study, I reappraise material attributed to hipparionine horses from the late Pliocene of the Indian Subcontinent stored in museum collections in the U.K. and India. A detailed morphological analysis showed the presence of three species: the historically known *Cremohipparion antelopinum*, and surprisingly, two taxa previously unknown in the Siwaliks, *Plesiohipparion huangheense* of Chinese origin, and *Eurygnathohippus* sp. of African origin. There is no conclusive evidence of *Sivalhippus* persisting into the late Pliocene; this lineage likely went extinct during the late Miocene. This reassessment shows that the late Pliocene record of hipparionines consists of both species derived from Miocene lineages and species originating from China and Africa. The occurrence of *Eurygnathohippus* in the Siwaliks rejects the convention that this genus was endemic to Africa, and the presence of *Plesiohipparion huangheense* shows that faunal interchanges between northern China and South Asia, while rare, did occur during the Pliocene.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

ANATOMICAL REDESCRIPTION AND PHYLOGENETIC ANALYSIS OF THE MATERIALS ASSIGNED TO THE TAXON "*CAPTORHINIKOS*" *CHOZAENSIS*

JUNG, Jason, California State University San Bernardino, Ontario, CA, United States of America; SUMIDA, Stuart S., California State University San Bernardino, San Bernardino, CA, United States of America; SUES, Hans-Dieter, National Museum of Natural History, Washington, DC, United States of America

The Late Paleozoic family Captorhinidae is generally considered the basal-most clade of the Eureptilia. Although Late Pennsylvanian and Early Permian members are exclusively North American, the group achieved a global distribution by the Middle Permian. Captorhinids are well known for the development of multiple rows of maxillary and dentary teeth in some, though not all, members. Traditionally Captorhinidae have been characterized as generalized reptiles with a fairly conservative morphology, suggesting they are a useful model as a basal amniote. Recent phylogenetic analyses have suggested multiple tooth rows likely developed more than once and a greater diversity of dental structure than previously realized. *"Captorhinikos" chozaensis* is a multiple-tooth-rowed captorhinid reptile from the Lower Permian Clear Fork Group, undivided formation. Upon re-examination of the several specimens associated with the taxon from the Chicago Field Museum of Natural History and the Smithsonian National Museum of Natural History, we reaffirm their affinity and collective identity as a valid taxon. Our study recovers a hypothesis of relationships of the Captorhinidae wherein *"Captorhinikos" chozaensis* does not belong with either of the two members of its assigned genus, *C. valensis* or *"C." parvus*. Instead it occupies its own branch within the Captorhinidae: [*Protorothyris*

[*Paleothyris* [*Thuringothyris* [*Concordia* [[*Romeria prima*, *Romeria texana*] [*Reiszorhinus* [*Protocaptorhinus* [*Rhiodenticulatus* [*Saurorictus astralis*, [[*Captorhinus laticeps* [*Captorhinus aguti*, *Captorhinusmagnus*], [*"Captorhinikos"parvus*[*"Captorhinikos" chozaensis*[*Labidosaurus*, Moradisaurinae]. This conclusion is based on strong results from a phylogenetic parsimony analysis combined with an analytical apomorphy analysis.

Technical Session XIX (Saturday, October 20, 2018, 3:15 PM)

A NEW TAXON OF GORGONOPSIAN FROM THE LATE PERMIAN OF ZAMBIA, REVEALING THE ORIGINS OF THE ENIGMATIC GORGONOPSIAN GENUS *ARCTOGNATHUS*

KAMMERER, Christian F., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America

Gorgonopsian therapsids were the dominant predatory tetrapods of the late Permian. Gorgonopsians are notorious for their cranial conservatism, which has historically obscured phylogenetic relationships and taxonomy within the clade. A notable exception to the idea that all gorgonopsians look the same, however, is the species *Arctognathus curvimola* from the South African Karoo Basin. This taxon is highly aberrant compared to other gorgonopsians, with a tall, short snout, high tooth count (seven postcanines), maxillary concavity, and greatly reduced postfrontal and lacrimal. In phylogenetic analyses, *Arctognathus* has occupied an unstable position—although it shares some features with the gigantic rubidgeines (e.g., loss of the prearietal, reduction in palatal teeth), these features are highly homoplastic within Therapsida and *Arctognathus* does not exhibit any other typically rubidgeine characters (e.g., cranial pachyostosis). Here, I present a new gorgonopsian taxon from the Luangwa Valley of Zambia, represented by a small (~10 cm), nearly-complete skull and jaws, which elucidates the evolutionary origins of *Arctognathus*. The new taxon exhibits several characters (e.g., maxillary concavity, reduced lacrimal) previously considered autapomorphic for *Arctognathus*, but can be distinguished by the presence of a prearietal, elongated postfrontals, and extensive palatal dentition. The new Zambian taxon was included in an expanded phylogenetic analysis of Gorgonopsia with substantially greater sampling of small-bodied gorgonopsians than previous studies. The results indicate that Gorgonopsia can be divided into two major subclades, one containing only Russian and the other only African taxa, indicating a remarkable degree of endemism for a Permian clade. Within the 'African clade', the new Zambian taxon was recovered as the sister-taxon of *Arctognathus*, with both of these taxa deeply nested within a well-supported, newly-recognized clade containing the smallest known gorgonopsians (e.g., *Aelurosaurus*). This 'aelurosaur' group represents one of the earliest-diverging clades among African gorgonopsians, supporting the idea that gorgonopsians originated at a small body size and did not become apex predators until after the extinction of large-bodied therocephalians. *Arctognathus* represents an independent origin of larger size (>20 cm skull length) within an otherwise small-bodied gorgonopsian clade, suggesting that its shared features with rubidgeines represent convergent adaptations for macropredation.

Grant Information
Supported by KA 4133/1-1 from the Deutsche Forschungsgemeinschaft

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

BIOMECHANICAL RECONSTRUCTION OF HEAD-BOBBING IN THE DODO (*RAPHUS CUCULLATUS*)

KANE, John, College of the Holy Cross, Worcester, MA, United States of America; KELLY, Bridget N., College of the Holy Cross, Worcester, MA, United States of America; PETERSEN, Lynsey M., College of the Holy Cross, Worcester, MA, United States of America; HILDRETH, Lucas B., College of the Holy Cross, Worcester, MA, United States of America; RUSSELL, Daniel L., College of the Holy Cross, Worcester, MA, United States of America; ZOGBY, Leah A., College of the Holy Cross, Worcester, MA, United States of America; CLAESSENS, Leon, College of the Holy Cross, Worcester, MA, United States of America

Head-bobbing is a distinct trait that has been observed during terrestrial locomotion in many columbiforms and other bird taxa. This unique head movement pattern produces several functional advantages such as optokinetic response (visual stabilization), balance maintenance, and energetically efficient gait kinematics. Head-bobbing is defined by two distinct phases: the hold phase, in which the head is extended and remains static relative to the environment, and the thrust phase, in which the head translates forward. Head-bobbing is synchronized with the stride cycle; one thrust phase is associated with each step that the bird takes. Previous research on head-bobbing in pigeons has shed light on the biomechanics of head-bobbing in this group. Considering the close phylogenetic relationship between the dodo and other, smaller living columbiforms that exhibit head-bobbing, we hypothesize that this cranial movement would likely be conserved in the dodo. We analyzed head and neck displacement in columbiforms, and non-columbiforms with a similar body size to the dodo, to create a biomechanical reconstruction of head displacement while walking. Using the Froude number, we scaled up walking speeds of smaller columbiforms to the dodo. Head-bobbing amplitude is directly correlated with speed of locomotion in pigeons. We used this correlation to estimate head displacement and angular changes in the cervical vertebral column in columbiforms at different walking speeds. By calculating the change in neck angle between neutral and extended position, we applied a trigonometric model to a 3-D surface scan of the dodo skeleton, which indicates a range of displacement of approximately a half to a full head length at a walking speed of 1.2 m/s. The anatomical limit of anterior head displacement for our model is greater than two head lengths. At this stage, the neck begins to hyperextend to a point where zygapophyses are no longer in contact with the adjacent vertebrae, reaching a maximum limit of vertebral articulation. Understanding the biomechanics of head-bobbing in columbiforms allows us to reconstruct an increasingly more life-like picture of the dodo and the biomechanics of locomotion in this iconic extinct bird.

Grant Information
Funding was provided by National Science Foundation (DBI 0743327) and by the College of the Holy Cross.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PERIOSTEAL REACTION IN A GORGONOPSIAN RADIUS: INSIGHTS INTO THE EVOLUTION OF MAMMALIAN HEALING RESPONSES

KATO, Kyle, University of Southern California, Los Angeles, CA, United States of America; HUTTENLOCKER, Adam K., University of Southern California, Los Angeles, CA, United States of America; REGA, Elizabeth, Pomona, CA, United States of America; SIDOR, Christian A., Seattle, WA, United States of America

Gorgonopsians were dominant, saber-toothed predators during the middle to late Permian (ca. 265–252 million years ago). While only distantly related to mammals, the external morphology of these terrestrial, nonmammalian synapsids has shed light on the origins of classic 'mammal-like' anatomical traits. However, little is known of their behavior or physiology, which would aid in reconstructing the paleobiological context in which familiar mammalian features arose. A discrete osseous lesion recording acute periosteal reactive bone deposition provides insights into the origins and diversity of mammalian skeletal healing responses. The left radius described here was discovered in the Luangwa Basin, Zambia (upper Permian Madumabisa Mudstone Formation). High-resolution CT scanning and histological sectioning permitted analysis of the healing response of this solitary lesion, localized on the anterodorsal edge of the radial shaft. Roughly ovoid and elevated above the shaft surface, this lesion presents with a rugose texture characteristic of reactive bone that forms in response to lifting of the periosteum membrane. Microscopic cross sectioning reveals a thickened, disorganized osseous layer localized to a single growth zone. In addition to the rugose texture, this provides evidence of a rapid healing response. Surprisingly, the reactive bone proliferation surrounds half of the radial midshaft at its extreme and is far greater than the external appearance of the lesion. The tissue is comprised of a homogenous meshwork of fine cancellous spicules with few radial spicules. There is internal remodeling of the perimedullary bone near the distal metaphysis and a dense outer layer of poorly vascularized periosteal bone across the length of the lesion. Differential diagnoses for such reactions includes trauma, infection, enthesopathy and neoplasm. This region is not a discrete tendon or ligament attachment site and additional evidence of infection or neoplasm is lacking. We suggest that the periostosis is most conservatively attributed to a post-traumatic subperiosteal hematoma and subsequent bone deposition and remodelling. In surveys of modern reptiles—crocodylids, varanids—such hematomas are rare. The extent and rapidity of the response may indicate bone dynamics which differ from these reptiles and is more reminiscent of mammals. This report adds to a list of putative disease entities recognized in early synapsids and broadens comparative baselines for the evolution of bone responses and pathologies in mammalian forebears.

Grant Information
University of Southern California Undergraduate Research Associates Program (URAP)

Technical Session XV (Saturday, October 20, 2018, 8:00 AM)

IDENTIFICATION OF MORPHOLOGICALLY UNIDENTIFIABLE BONE USING COLLAGENOUS PROTEIN

KEENAN EARLY, Erin M., University of Texas at Austin, Austin, TX, United States of America

One of the major building blocks of vertebrate paleontology is the morphological identification of skeletal remains. Despite this, many faunal assemblages are plagued by highly fragmented remains that cannot be identified by traditional morphological methods. In 2008, researchers in the U.K. developed a methodology to address this problem by looking at type I collagen, the most abundant protein in bone. This methodology, known as Zooarchaeology by Mass Spectrometry (ZooMS), allows for the identification to the genus or species level of morphologically unidentifiable bone fragments by use of a reference database. ZooMS has been applied with great success in Europe, but the lack of a North American reference database has restricted its usefulness for North American faunal assemblages. I am now building a ZooMS reference database for North American taxa. The utility of this is demonstrated by ZooMS analysis of a late Pleistocene/early Holocene zooarchaeological assemblage from the Gault Site in Bell County, Texas. Using MALDI-TOF mass spectrometry, I generated peptide mass fingerprint (PMF) data for multiple unidentifiable bone fragments from this site. These PMFs allow for restricted identifications where previously none were possible. One such example is a fragment that, when compared to the existing database, indicates it is canid in origin. However, the signal does not match the database species of dog, gray wolf, red fox, or arctic fox, nor does it match non-database preliminary PMF data I have taken for coyote. No other canids are currently in the database. The inability to match this bone fragment to a canid species using the database and preliminary PMF data indicates that the fragment originates from an animal that gives a canid signal but has not yet been analyzed, and so is not identifiable using ZooMS. This could be a canid such as gray fox or red wolf, or it could be from another species that shares the canid PMF marker; a relationship of which we are currently not aware. Overall, this fragment serves as an excellent example of both the information to be gained by the application of ZooMS and the intense need for a database of North American taxa.

Grant Information
Ronald K. DeFord Field Scholarship Fund

Technical Session XV (Saturday, October 20, 2018, 9:00 AM)

SMALL MAMMAL PALEOECOLOGY FOLLOWING THE TERMINAL PLEISTOCENE MEGAFAUNAL EXTINCTION

KELLER, Jonathan S., University of New Mexico, Albuquerque, NM, United States of America; CORDOVA, Johnathan T., University of New Mexico, Albuquerque, NM, United States of America; SMITH, Felisa A., University of New Mexico, Albuquerque, NM, United States of America; NEWSOME, Seth D., University of New Mexico, Albuquerque, NM, United States of America

During the terminal Pleistocene extinction (TPE) 10–14 ka, human invasion of the New World drove 100+ genera of megafauna extinct. Here, we examine the ecological consequences of the TPE with respect to changes in the small mammal community. We use a multi-proxy approach, exceptionally preserved fossils, and a fine-grained age model of Hall's cave in Texas to study effects of the TPE on body size and isotopic dietary niche of several taxa with an emphasis on the grasshopper mouse, *Onychomys*. We measured bone collagen carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) values to estimate isotopic niche widths over time using Bayesian-based spatial metrics. We also constructed a dichotomous key to identify specimens, which revealed some previously sampled '*Onychomys*' were actually granivorous/insectivorous *Reithrodontomys* and omnivorous *Peromyscus*. *Onychomys* ranged from -12.4‰ to -19.4‰ $\delta^{13}C$ and 7.4 to 12.5‰ $\delta^{15}N$. We found the greatest average $\delta^{15}N$ values (12.0‰) in the oldest strata ~11.5 ka, declining ~2‰ by ~7 ka, which closely matches contemporaneous declines in other co-occurring small mammal taxa. We suspect this drop reflects a baseline shift in vegetation nitrogen due to changing climate. Post-baseline shift *Onychomys* are larger than the largest modern individuals, and bone collagen $\delta^{15}N$ values positively correlate with proxies of body size. This may indicate ancient *Onychomys* fed at a higher trophic level. Our ongoing work couples isotope data with novel ecomorphological measures to more finely characterize ecological shifts in *Onychomys*, *Reithrodontomys*, *Peromyscus*, and other small mammal taxa after the TPE. Grant Information
Research made possible by NSF DEB #1555525 and the University of New Mexico Gaudin Scholarship.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

FUNCTIONAL MORPHOLOGY OF THE NECK IN PINNIPEDS: THE LONG AND SHORT OF IT

KELLER, Justin, University of California Los Angeles, Los Angeles, CA, United States of America; VAN VALKENBURGH, Blaire, University of California Los Angeles, Los Angeles, CA, United States of America

Vertebrates have returned to aquatic environments in at least 30 distinct lineages of both extinct and extant clades, including archosaurs, lepidosaurs, and mammals. With these transitions came numerous morphological and physiological adaptations to accommodate life in water. The axial and appendicular skeleton are of particular interest in this transition due to their role in locomotion. Although several studies have focused on the limbs and thoracolumbar spine, less attention has been paid to the cervical region. In fully aquatic cetaceans, the cervical vertebrae are compressed or fused, largely because a loss of neck mobility reduces drag. We ask if this pattern of cervical evolution is present in the pinnipeds that have more recently invaded a marine habitat but retain some terrestrial habits. Here, we quantitatively compare neck morphology and function in two groups of pinnipeds with different degrees of aquatic adaptation, the Otariidae and Phocidae, as well as between pinnipeds and their terrestrial arctoid relatives (ursids and mustelids). Using cranial CT scans of museum specimens, we quantified the occipital surface area for neck muscle attachment and also took linear measurements of the cervical vertebrae to capture vertebral size and shape. Results show that the pinnipeds have a relatively larger occipital surface area than ursids and terrestrial mustelids. This suggests that marine carnivorans have enlarged their neck muscles to assist with stabilizing the head during swimming. Within pinnipeds, there are functional differences in cervical morphology between otariids and phocids that coincide with how aquatic the two groups are. Otariids are more specialized for terrestrial locomotion than phocids and have relatively longer cervical vertebrae centra that allow for greater neck flexibility. By contrast, phocids are more specialized for aquatic locomotion and consequently have shorter cervical vertebrae and less flexible necks. The quantitative measures used in our analysis are applicable to fossil vertebrate taxa, such as *Enaliarctos* or *Allodesmus*, and enable the tracking of progressive adaptations to life in water during the transition from land to sea.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A JUVENILE HADROSAUR FROM THE UPPER CRETACEOUS (LOWER CAMPANIAN) ALLISON MEMBER, MENEFEE FORMATION, NEW MEXICO

KELLEY, Kara A., University of Arizona, Tucson, AZ, United States of America; MCDONALD, Andrew T., Western Science Center, Hemet, CA, United States of America; WOLFE, Douglas G., Zuni Dinosaur Institute for Geosciences, Springerville, AZ, United States of America

Historically, the vertebrate fauna of the Upper Cretaceous (lower Campanian) Menefee Formation has been poorly known. New discoveries since 2011 by the Western Science Center, White Mountain Dinosaur Exploration Center, Southwest Paleontological Society, and University of Pennsylvania have begun to flesh out the Menefee's dinosaurs and other vertebrates.

In 2016, the nearly complete left maxilla of a juvenile hadrosaur was discovered in the upper part of the Allison Member of the Menefee Formation in the San Juan Basin, northwestern New Mexico. The specimen has a preserved length of 6.4 cm. The lateral surface of the maxilla is well-preserved, as are a number of in situ teeth. The lateral surface exhibits a row of three large foramina and a well-developed lateral ridge on the ectopterygoid shelf. Nine tooth positions are preserved. The teeth are symmetrical with a single median ridge and fine marginal denticles.

The morphology of the teeth and ectopterygoid shelf indicate that the maxilla represents a derived hadrosauromorph, though it is impossible to tell at present if the maxilla belongs to a saurolophine, lambeosaurine, basal hadrosaurid similar to *Eotrachodon*, or a close outgroup similar to *Claosaurus*. Previous authors have reported fragmentary hadrosaur material from the Menefee Formation. Our discoveries, including this juvenile maxilla, isolated limb bones, and fragmentary but associated material, add to this record, and hopefully ongoing field work will produce more complete specimens that will allow full characterization of the Menefee's hadrosaurs.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

LARGE PTEROSAUR FOOTPRINTS FROM THE UPPER CRETACEOUS JINDONG FORMATION OF SOUTH KOREA: OCCURRENCE AND PALEOECOLOGICAL IMPLICATIONS

KIM, Hyun Joo, Pukyong National University of Korea, Busan, Korea, Republic of (South); PARK, Jung Gyu, Pukyong National University of Korea, Busan, Korea, Republic of (South); PAIK, In Sung, Pukyong National University of Korea, Busan, Korea, Republic of (South)

Large pterosaur footprint fossils were discovered in the Upper Cretaceous Jindong Formation in Goseong-gun, Gyeongsangnam-do, South Korea. In this study the pterosaur tracks from the Jindong Formation are described, and their paleoecological implications are given preliminary interpretation. They are observed on planar- to cross-laminated fine-grained sandstone to siltstone covered with mudstone film that was deposited by sheet flooding on a lake margin. The tracks consist of nine large and tetradactyl pes only impressions. The pes tracks are plantigrade, with distinctive digit and subrounded to subangular heel. Although some of them are overlapped and indistinctive, they are considered as three trackways. Trackway I (P1) which trends S52°W is composed of four tracks. The pes tracks of P1 are 25.5–26.5 cm in length and 12–14 cm in width. The pace length and stride are 39.5–42.5 cm and 79–80 cm, respectively. Trackway II (P2), composed of two tracks, trends S40°W. The length and width of the pes tracks in P2 are 27 cm–28 cm and 13–14 cm, respectively, and the pace length is 49.5 cm, which are slightly larger and longer than those of other trackways. Trackway III (P3) consists of three tracks and trends N42°E. The tracks of P3 show relatively indistinct heel impressions. The pes tracks of P3 are 23 cm in length and 13–13.5 cm in width. The pace length and stride of P3 is 41.5 cm and 77 cm, respectively. The large and tetradactyl pes only tracks in these trackways indicate that track makers were erect, bipedal and large pterosaurs. The footprint fossils described here are classified as *Haenamichnus gainensis*, previously documented from the Lower Cretaceous Haman Formation underlain by the Jindong Formation. The track sites of *Haenamichnus gainensis*, in which lake margin deposits of the Haman Formation are distributed, are located about 6–7 km from the study area. They suggest that Cretaceous lake margins in the vicinity of the study area were continuously exploited by the similar species of large pterosaurs from Early to Late Cretaceous. Abundant dinosaur and bird footprint fossils have been reported from the Jindong Formation and diverse pterosaur ichnotaxa were established in the Cretaceous formations of South Korea. Therefore, discovery of large pterosaur tracks from the Jindong Formation supports that pterosaurs coexisted with dinosaurs and birds during the Cretaceous in South Korea and the Cretaceous lake margin provided good habitats for vertebrates.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

EMERGED FROM THE DARKNESS: THE DISCOVERY OF INSECTIVOROUS BAT SUBFOSSILS FROM AN OCEANIC ISLAND IN JAPAN

KIMURA, Yuri, National Museum of Nature and Science, Tsukuba, Japan; FUKUI, Dai, University of Tokyo Hokkaido Forest, Furano, Japan; KAWADA, Shin'ichiro, National Museum of Nature and Science, Tsukuba, Japan; YOSHIYUKI, Mizuko, Miyakonojo, Japan; SUZUKI, Nozomi, Tokyo Institute of Technology, Yokohama, Japan

An oceanic island is surrounded by a vast body of oceanic water and is separated from its closest landmass since the time of its emergence. In such isolated settings, a peculiar structure of faunal and floral assemblages is formed with a high proportion of endemic species that evolved independently from continental populations. The Daito Islands and the Ogasawara Islands (archipelago of over 30 islands) in Japan are two examples of this occurrence. With strong environmental and geographic filtration, vertebrate animals incapable of flying and swimming were filtered out of the island ecosystems. A single species of fruit bats is the only native mammals (*Pteropus dasymallus daitoensis* in the Daito Islands, *Pteropus pselaphon* in the Ogasawara Islands). These frugivorous bats feed on the fruits and nectars of the subtropical to tropical vegetation in both islands. Insectivorous bats, which colonize in caves, are not present in the current faunas. However, small bat bones were discovered from a tourist cave in the Daito Islands and were briefly reported in a scientific document in 1978. Based on recent information about bones of small bats, we conducted a preliminary field investigation in the tourist cave and another cave, and we found bones of insectivorous bats and guano-like deposits. Here, we aim to identify whether or not the guano-like deposits are mainly composed of bat feces by SEM observation, FT-IR, XRD, and stable carbon and nitrogen isotope analyses in order to further utilize the samples for radio carbon dating. Two types of guano-like deposits were collected. One type is millimeter-scale pellet-like deposits scattered on the relatively dry floor of the caves. The other is sheet-like deposits with various thicknesses. The combined analyses suggest that, among examined samples, a pellet-like sample and a sample of the sheet-like deposit can be considered as bat feces. The wide distribution of the guano-like deposits suggest that insectivorous bats certainly colonized the Daito Islands sometime in the past and went extinct before or after human colonization on the oceanic island.
Grant Information
The Fujiwara Natural History Foundation (2018)

Technical Session XIII (Friday, October 19, 2018, 3:30 PM)

ENDOCRANIAL SHAPE CHANGE AND VASCULAR IMPRESSIONS IN *PSITTACOSAURUS*: EFFECT OF ONTOGENY ON A CHINESE CERATOPSIAN'S NEUROANATOMY

KING, Logan, University of Bristol, Bristol, United Kingdom

The Psittacosauridae were a family of ceratopsian dinosaurs known from many specimens. Prior descriptions of adult *Psittacosaurus* neuroanatomy have indicated that the endocast may closely represent the true form of the brain due to its unique shape. The vascular impressions found on the endocast of IVPP V15451, a hatchling stage *Psittacosaurus lujiatunensis* from the Yixian Formation (Early Cretaceous) of northeastern China, are restricted to the olfactory tract and bulbs. These vascular valleculae provide the first evidence that portions of the brain closely fit the surrounding braincase in ceratopsians for at least part of ontogenetic development. Similar impressions have been described in some ornithopods, pachycephalosaurs, and theropods as well as modern avians and crocodilians. How much of the braincase was volumetrically filled with neural tissue instead of the dura mater or cartilage is still open for debate, but the presence of vascular impressions helps to

determine that younger psittacosaur endocasts are fairly accurate representatives of the brain's true form. The presence of vascularization was not noted in adult specimens. Additionally, the overall shape of IVPP V15451 differs from adult forms in that the forebrain is rounded instead of elongate and "tube-like". The mid- and hindbrain are similar in shape to the condition in the adult and are only truly different in size. This indicates that *Psittacosaurus* experienced a period of extreme shape change during growth as portions of the brain became elongated during maturation, especially along the mid- and forebrain. It should be noted that the olfactory bulbs of IVPP V15451 are still enlarged for a ceratopsian and are approximately one-third the size of the cerebral hemispheres, thus suggesting that some senses were well-developed in juveniles and were behaviorally important throughout the life of *P. lujiatunensis*.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A PRELIMINARY ANALYSIS OF THE MOGAN SITE, A NEW LATE JURASSIC VERTEBRATE MICROFOSSIL SITE IN THE MORRISON FORMATION IN NORTHEASTERN, WYOMING

KING, Lorin R., Western Nebraska Community College, Scottsbluff, NE, United States of America; HECKERT, Andrew B., Appalachian State Univ, Boone, NC, United States of America

The Mogan Site vertebrate assemblage represents a Late Jurassic biota of the Morrison Formation (dating to about 150 Ma) in northeastern Wyoming. The formation has been studied extensively by paleontologists and geologists since the late 19th century. The area is dominated by nonmarine mudstones and shales in the lower part of the formation. The dinosaurian materials are represented by some very sparse incomplete skeletal material and bone fragments. The vertebrate microfossils consist of disarticulated to fragmentary limb elements, vertebrae, possible cranial elements, belonging to osteichthyans, turtles, crocodilians, lizards, and mammals, as well as loose teeth and some invertebrate fossils (gastropod shells). Importantly, the microvertebrate sites in this area are proving to be prolific and the fossils relatively diagnostic, recording a greater diversity of taxa (at higher taxonomic levels) than do the more frequently collected large dinosaur elements. The elements being presented here were collected from a fifty pound bucket of matrix that was then screen washed. Many microfossil beds are multi-individual accumulations consisting of disarticulated and usually dissociated vertebrate hard parts in the millimeter to centimeter size range. Like most Morrison Formation fossil quarries in the western United States, small vertebrate specimens are not as common as the larger dinosaurian material, but the Mogan Site is proving to be an exception, but it is very hard to tell if all the micro-fossils are coming from one site (Mogan Site), or if the Mogan Site itself is an area with several sites that are interconnected. Importantly, the microvertebrate fossils, while not frequently recovered and relatively non-diagnostic, still record a greater diversity of taxa (at higher taxonomic levels) than do the more frequently collected large dinosaur elements, and hold the potential to better elucidate the small vertebrate component of the Morrison ecosystem in this region.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

RECORD OF OSTEOPATHOLOGIES IN LATE PLEISTOCENE–EARLY HOLOCENE SLOTHS (MAMMALIA, PILOSA, MEGALONYCHIDAE) FROM HISPANIOLA

KIRCHHOFF, Claire A., Marquette University, Milwaukee, WI, United States of America; MCAFEE, Robert K., GA Campus - Philadelphia College of Osteopathic Medicine, Suwanee, GA, United States of America; COOKE, Siobhan B., Johns Hopkins School of Medicine, Baltimore, MD, United States of America

Documentation of osteopathologies within the sloth fossil record is rather sparse, in part due to the rare nature of fossils themselves. Fossils have been collected over the last 40 years from caves within Hispaniola that represent a sort of Laggerstätten; some caves have provided an incredibly rich sample, which may be reflective of actual populations during the late Pleistocene–early Holocene, and several specimens with pathological morphology have been recovered. We present five examples of osteopathologies from Hispaniolan sloths, representing several genera and localities. There are two elements with bony remodeling consistent with osteomyelitis: an *Acratocnus* femur and a *Parocnus* radius. Two additional elements exhibit morphological changes consistent with healed chronic fractures. The left radius from an *Acratocnus* exhibits significant remodeling that includes a possible avulsion fracture at the distal end and the resorption of most of the pronator flange. This element also exhibits lytic lesions on the distal, medial aspect possibly attributable to a local infection. The left ulna of a *Neocnus* may also exhibit characteristics of a healed fracture. Increased anterioposterior flexion of this element and the short length of this specimen may indicate a 'green-stick' fracture to the proximal diaphysis sustained during the early growth period. The other elements associated with this forelimb are also much shorter than other *Neocnus comes* specimens, however, making metabolic or other pathologies difficult to exclude. An additional right ulna, this one from *Parocnus*, exhibits an area of reactive bone on the olecranon process approximately 10 x 10 mm, adjacent to which is a 5 mm osteophyte with smooth margins. This may correlate with injury to the triceps brachii, which inserts at this location. Of the 289 complete limb elements observed from these collections so far, only these five cases exhibit significant osteological lesions. Injuries and illnesses likely to leave skeletal signs may have therefore been rare among sloths on Hispaniola during this time period. Overall, the currently identified pathologies demonstrate a hardiness in the sloths as their survival was not adversely hindered by the sustained traumas, nor are they indicative of site-specific difficulties due to their widespread occurrences across Hispaniola.

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

MACROPHOTOGRAMMETRIC RECONSTRUCTION OF *ARCHAEOPTERYX*

KIRK, Alexander M., University of South Florida, Tampa, FL 33620-5200, FL, United States of America; BAINES, Alec, University of South Florida, Tampa, FL, United States of America; KAPLAN, Howard, University of South Florida, Tampa, FL, United States of America; CARNEY, Ryan, University of South Florida, Tampa, FL, United States of America

Macrophotogrammetry (MP), the process of creating 3D models from macro photographs, is a non-destructive method of digitizing small specimens and features. In order to create high-resolution, photorealistic bone models of the Thermopolis specimen of *Archaeopteryx* (WDC-CSG-100), we developed an optimized processing workflow, along with an approach for compositing the resulting color texture maps onto X-ray generated volumetric models. Data included 16,780 .jpg files out of ~21K photographs taken with a Canon EOS 7D 18.0MP DSLR camera, using 100mm (n=14,667) and 18-135mm (n=2,113) lenses. Photos were taken without a flash, with the specimen lit from opposing directions using two LED fixtures (Genaray GESPE360DK1, Bescor BELED500SB). The first phase of reconstruction implemented RealityCapture photogrammetry software (Capturing Reality), used to create a point cloud and polygonal mesh model for each anatomical region (e.g., skull, individual limbs). ZBrush digital sculpting software (Pixologic) was then used to manually unwrap models in order to create custom UV maps for each bone, which were then reimported into RealityCapture to create individual texture maps (minimum resolution of 4096x4096; .tif). The second phase included 3D models previously generated using multiplanar X-ray microtomosynthesis, and segmented using Avizo Fire software (FEI). Here, ZBrush was used to similarly create UV maps of these unwrapped models. Next, the X-ray and MP models were imported into Maya (Autodesk) for scaling and alignment, using the initial regional meshes for spatial registration. MP textures were then transferred and baked onto the X-ray model of each individual bone, and then post-processed using Geomagic (3D Systems). Overall, minor challenges included reflections of light on bone surfaces in the photographs, as well as the computational demands of photogrammetric processing. Results demonstrated the utility of MP for generating high-resolution 3D models, including as a complementary approach to X-ray scanning. Specifically, the multimodal compositing of MP compensated for data loss artifacts, present at certain bone surfaces, that were inherent to the X-ray methodology. In addition to the 3D morphology, the color data captured by the MP was useful for analysis as well as visualization, including virtual reality and augmented reality platforms.

Grant Information
This work was supported by software donations from Capturing Reality and FEI to Ryan Carney.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

EARLY BIRD: A NEW MIDDLE EOCENE VERTEBRATE FOSSIL LOCALITY FROM THE CANOE FORMATION OF SOUTHWEST TEXAS

KIRK, E. Christopher, University of Texas at Austin, Austin, TX, United States of America; LUNDEEN, Ingrid K., University of Texas at Austin, Austin, TX, United States of America; EGBERTS, Sebastian, Philadelphia College of Osteopathic Medicine, Philadelphia, PA, United States of America

The Canoe Formation is a middle Eocene sequence of sedimentary and igneous rocks exposed in the Tornillo Basin of southwest Texas. The most extensive outcrops of the formation occur in the Tornillo Flat area of Big Bend National Park. The Big Yellow Sandstone Member forms the base of the Canoe Formation and unconformably overlies the early Eocene (Wasatchian) Hannold Hill Formation. The remainder of the Canoe Formation is composed of >250 m of mudstones and sandstones with intercalated basalt flows. Here we report the discovery of a new vertebrate fossil locality, Early Bird (TMM 44063), in a mudstone unit overlying the Big Yellow Sandstone Member. The vertebrate fauna recovered from Early Bird consists primarily of ganoids, turtles, crocodilians, squamates, and isolated teeth of small- to medium-sized mammals, including insectivores, chiropterans, marsupials, plesiadapiforms, hyopsodontids, equoids, tapiroids, carnivorans, and abundant rodents. This faunal assemblage is noteworthy in three main respects. First, Early Bird provides the most extensive record of mammals from a single locality in the entire Canoe Formation. Indeed, the mammalian diversity represented at Early Bird exceeds the mammalian diversity of all other Canoe Formation fossil localities combined. Second, Early Bird documents the first plesiadapiforms known from the Canoe Formation, including a diverse array of both large and small microsyopids. Third, the lower Canoe Formation has been variously interpreted as late Bridgerian (Br3) or early Uintan (Ui1) in age, and the mammalian fauna otherwise known for the lower Canoe Formation includes genera (i.e., *Peratherium*, *Hyopsodus*, *Helohyus*, cf. *Isectolophus*, and *Hyrachyus*) that are known from both the Bridgerian and Uintan in other regions. The mammalian fauna recovered thus far from Early Bird is conspicuous in its lack of characteristic Uintan taxa, increasing the probability that the lower part of the Canoe Formation is late Bridgerian. If so, Early Bird would represent one of the lowest latitude Bridgerian sites in North America, along with Br2 localities in the Delmar Formation of Southern California and Br3 localities in the Hart Mine Formation of central New Mexico.

Grant Information
Funding provided by a Billy Carr Distinguished Teaching Fellowship from the Environmental Sciences Institute at the University of Texas at Austin.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE MORRISON FORMATION IN THE WESTERN BLANDING BASIN, SOUTHEASTERN UTAH: THE POORLY DOCUMENTED TYPE AREA OF ITS HIGHLY FOSSILIFEROUS BRUSHY BASIN MEMBER

KIRKLAND, James I., Utah Geological Survey, Salt Lake City, UT, United States of America; DEBLIEUX, Donald D., Utah Geological Survey, Salt Lake City, UT, United States of America; FOSTER, John R., Museum of Moab, Moab, UT, United States of America; HUNT-FOSTER, ReBecca K., Bureau of Land Management, Moab, UT, United States of America; TRUJILLO, Kelli C., Laramie County Community College, Laramie, WY, United States of America

In 2016 and 2017, the Utah Geological Survey partnered with the Bureau of Land Management to conduct a paleontological inventory of the Morrison Fm. (MF) south and west of Blanding, Utah, on land along the former eastern margin of the Bears Ears National Monument. The MF in this region is critical to understanding Upper Jurassic stratigraphy across the Colorado Plateau because it is the type area for the Bluff Sandstone, Recapture, Westwater Canyon, and Brushy Basin Mbrs. of the MF, which are the basis for nomenclature in New Mexico and Arizona. Researchers have disagreed about nomenclature and correlation of these units, which transition northward into the Tidwell, Salt Wash, and Brushy Basin Mbrs. within the study area. Numerous vertebrate localities make inclusion of the interfingering Bluff and Recapture in the Middle Jurassic San Rafael Group unlikely. The Salt Wash does not separate the Bluff Sandstone and Recapture at Recapture Wash, but sandstone lenses of Salt Wash facies occur high in northern Recapture exposures. Northward, along the outcrop belt east of Comb Ridge, the Bluff Sandstone-Recapture interval thins, interlenses, and pinches out into the Tidwell and lower Salt Wash, with the main lower sandstone interval of the Westwater Can. merging northward into the upper Salt Wash. The partly covered, 1938 type section of the Brushy Basin Mbr. is identified along Elk Mt. Rd., southern end of Brushy Basin. We described a detailed, accessible MF reference section (~7 miles south) along Butler Wash with 81.68 m of Brushy Basin well-exposed on road between the top of the Westwater Can. Mbr. and the base of the Lower Cretaceous Burro Canyon Fm. on northwest end of Black Mesa. We informally call the upper sandstone bed(s) of the Westwater Can. Mbr. “No-Mans Island beds” mapped as capping mesas and benches in the region. Smectitic mudstones between the No-Mans Island beds and the main sandstone body of the Westwater Canyon suggest that the Salt Wash-Brushy Basin contact to the north may be somewhat older than the base of the Brushy Basin as originally defined in its type area. Determining whether the No-Mans Island beds pinch out to the north or are removed by erosion below the regional basal Brushy Basin paleosol requires further research. Numerous significant fossil vertebrate and plant sites have been documented in the Brushy Basin type area. Newly identified volcanic ashes are providing zircons for Pb-U dates. Ferruginous paleosols at the top of the Brushy Basin suggest wetter climatic conditions during the Jurassic-Cretaceous transition in the Blanding Basin.

Grant Information
Funded by Bureau of Land Management and Utah Geological Survey; Bears Ears, Morrison Paleontological Inventory.

Technical Session XIII (Friday, October 19, 2018, 3:15 PM)

LADINIAN–CARNIAN (MIDDLE–LATE TRIASSIC) EVOLUTION OF DINOSAURIFORMES: INDICATIONS FROM THE FOOTPRINT RECORD

KLEIN, Hendrik, Neumarkt, Germany; LAGNAOUI, Abdelouahed, El Jadida, Morocco; ZOUHEIR, Tariq, El Jadida, Morocco; HMINNA, Abdelkbir, El Jadida, Morocco; LUCAS, Spencer, Albuquerque, NM, United States of America; SABER, Hafid, El Jadida, Morocco; SCHNEIDER, Jörg, Freiburg, Germany

The rise and early evolution of Dinosauromorpha is documented by skeletal remains, beginning during the Middle Triassic (Anisian). Small lacertoid footprints from Olenekian-Anisian deposits of North America and Europe (*Rotodactylus*, *Prorotodactylus*) have also been attributed to this group, but this relationship is still debated. Mesaxonic tridactyl footprints (*Atreipus*/*Grallator*), widely considered as those of the dinosaur stem (Dinosauriformes), are documented from the Anisian-Ladinian, together with tetradactyl-pentadactyl, functionally tridactyl footprints (*Parachirotherium*). They were described with trackways demonstrating facultative bipedality of their producers from the late Ladinian of the Germanic Basin. In recent years, similar ichnofaunas with abundant *Atreipus*/*Grallator* and *Parachirotherium* footprints were discovered in Carnian deposits of the Argana Basin, Morocco. Other records are from the early late Carnian of eastern North America and Argentina. In particular, their dominance on surfaces of the Central European and North African localities suggests a larger diversification and dispersal of Dinosauriformes near the Ladinian–Carnian boundary, about 3–5 million years before the so-called Carnian pluvial event and climate change in the mid-Carnian, which has recently been proposed as a crucial factor favoring the diversification of dinosaurs. This was partly based on data from the track record of Northern Italy. However, Triassic tridactyl footprints mostly lack diagnostic dinosaurian features and therefore scarcely permit a distinction between non-dinosaurian dinosauriforms and "true" dinosaurs. Although skeletal remains provide no evidence of Dinosauria before the late Carnian (~ 231 Ma), the footprint record suggests an earlier appearance, and assemblages with abundant footprints that can be attributed to Dinosauriformes/Dinosauria are observed beginning from the late Ladinian (238 Ma). Therefore, a more continuous evolution and diversification of dinosaurs and some basal sister groups (e.g., silesaurids) from the Middle Triassic, rather than the proposed "explosion" in the mid-Carnian, is the likely scenario. This may have been unrecognized thus far due to a collecting bias in late Ladinian–early Carnian deposits outside of the Germanic Basin and Morocco.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

SPHENODONTIAN ASSEMBLAGES OF THE CHINLE FORMATION (LATE TRIASSIC, NORIAN), AND THEIR PHYLOGENETIC, BIOGEOGRAPHIC, AND ECOLOGICAL IMPLICATIONS

KLIGMAN, Ben, Virginia Tech, Blacksburg, Virginia, VA, United States of America

Sphenodontian reptiles have been well documented in rocks of Triassic age in eastern North America, South America, and Europe, but are only known from a few fragmentary occurrences in Triassic rocks of the southwest U.S.A. Here I describe and discuss sphenodontian material collected from three microvertebrate-bearing horizons in the Blue Mesa Member and Sonsela Member of the Chinle Formation, in and around Petrified Forest National Park (PEFO) in northeastern Arizona. These microvertebrate localities include the coprolite layer locality in PEFO (PFV 396: ~221 Ma), the *Placerias* Quarry near Saint Johns (MNA 207: ~219 Ma), and the Bowman locality in PEFO (PFV 089:~213-217 Ma). Recent collections from PFV 396 and PFV 089 have resulted in the discovery of three new sphenodontian taxa, based on nearly complete dentaries and fragmentary bones from the upper jaws. Additionally, a reassessment of sphenodontian material from the *Placerias* Quarry housed at the Museum of Northern Arizona resulted in the discovery of one new sphenodontian taxon, as well as the first occurrence of the opisothodontian genus *Fraserosphenodon* outside of Europe.

Analyses of the new taxa show that sphenodontians in the Chinle Formation reached high phylogenetic diversity by the middle Norian, about 20 million years after the estimated divergence of rhynchocephalians and squamates. Two newly-discovered sphendontians, one from the *Placerias* Quarry, and one from the Bowman locality, exhibit a novel mode of tooth implantation and ontogenetic change, where additional teeth are added to the posterior of the dentary with pleurodont implantation, and through ontogeny these teeth move from the lingual surface of the jaw dorsally to the crest of the jaw, developing acrodont implantation. The morphological diversity of these sphenodontian taxa adds new small bodied insectivores and herbivores to the known ecological niches of tetrapods in the Chinle Formation. Biostratigraphic comparisons to European Triassic lepidosaur assemblages, aided by U–Pb chronostratigraphy of the Chinle Formation, allow for a refined understanding of the timing and biogeography of sphenodontian evolution in the Triassic, and show a degree of homogeneity between European and North American lepidosaur assemblages.

Grant Information
Funding provided by Petrified Forest Museum Association, and Petrified Forest National Park

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A PARTIAL DENTARY FROM A LARGE BONY-TOOTHED BIRD (AVES: PELAGORNITHIDAE) FROM THE EOCENE LA MESETA FORMATION OF SEYMOUR ISLAND, ANTARCTICA

KLOESS, Peter A., University of California, Berkeley, Berkeley, CA, United States of America; POUST, Ashley W., University of California, Berkeley, Berkeley, CA, United States of America; STIDHAM, Thomas, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

Bony-toothed birds (Odontopterygiformes: Pelagornithidae) are a cosmopolitan, pelagic clade of large, volant birds known from the late Paleocene to the late Pliocene. The readily diagnostic characteristic of this clade is the modification of the tomial crest of the premaxillae, maxillae, and mandibles into a variety of tooth-like bony projections lacking any dental mineralization (or homology to teeth). The size and spacing of these projections vary across the clade and are consistent within species, following a set sequence of large and smaller pseudoteeth covered by the rhamphotheca.

We report a new partial dentary of a bony-toothed bird from Antarctica, discovered from the highest stratigraphic unit within the middle to late Eocene La Meseta Formation (Telm 7) of Seymour Island, peninsular Antarctica. This >12 cm long partial left dentary derives from a region of the mandible rostral to the intraramal joint, and preserves the remains of four low, worn pseudoteeth. Based on the regular pattern of pseudotooth spacing, a couple of bony projections may have been worn away, and the past occurrence of smaller intermediately spaced pseudoteeth cannot be ruled out. However, there are no exposed neurovascular openings that would be associated with the broken or worn base of such smaller pseudoteeth. As in other known pelagornithids, the mandibular fragment also preserves the medial and lateral rostrocaudally oriented groove and lamina on the ventral aspect of the fragment. Given the size of the specimen, the morphology and pattern of the preserved pseudoteeth, and the age of the fossiliferous sediments (late Eocene), an affinity possibly with a *Dasornis* or *Lutetodontpteryx*-like pelagornithid is likely (and consistent with the allocation of the published La Meseta tarsometatarsus as similar to the *Dasornis* morphotype). The Eocene La Meseta pelagornithid specimens (from a large-sized species) suggest the presence of an extinct (possibly unnamed) species larger than some known Eocene taxa. The addition of this fossil record reinforces the ideas that along with penguins, pelagornithids were among the common and dominant avian clades of Antarctica in the Eocene, and that they would have occupied a high trophic role in the Antarctic seas, today filled by albatrosses and other pelagic avian clades.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

THE REPTILES AND AMPHIBIANS FROM THE LATE MIOCENE OF ZAHLEH, LEBANON

KNOLL, Fabien, ARAID—FCPTD, Teruel, Spain; AZAR, Dany, Université libanaise, Fanar, Lebanon; MAKSOUD, Sibelle, Université libanaise, Fanar, Lebanon; LÓPEZ-ANTOÑANZAS, Raquel, CNRS—Université de Montpellier, Montpellier, France

In 2013, we found a layer rich in vertebrates in the 'Zahleh Formation' close to the spring of Aïn-el-Daouk, immediately North-West of the town of Zahleh (Bekaa Valley, central Lebanon). On the basis of its rodent content, we correlate this horizon with the European MN9 (~10 Ma). In addition to numerous fishes and a variety of micromammals, which are under study, the site also yielded remains of reptiles and amphibians. The most common reptilian elements pertain to crocodiles. These are primarily teeth but also osteoderm and skull fragments. The teeth are small and show a range of morphologies from slender-crowned ones (caniniform) to proportionally much shorter ones (molariform). The labial and lingual sides are more or less fluted. The surface of the enamel is textured to a varying degree. Some of the ridges of this texture diverge toward the carinae, where they accentuate and form small denticulations in a pseudozyphodont fashion. The systematic position of the available material of crocodilian from Zahleh cannot be determined precisely. These fossils do not belong to a slender-snouted form such as the osteolaemine *Euthecodon* and the tomistomine *Tomistoma,* nor do they seem to pertain to the alligatoroid *Diplocynodon*. In contrast, all the observed characters are also found in *Crocodylus*. The crocodilian from Zahleh is, therefore, tentatively identified as Crocodylidae indet. A fragment of plastron of a middle-sized chelonian was also found. Although it is difficult to identify, it may belong to a testudinid. Finally, a diminutive isolated amphibian trunk vertebra is reminiscent of those of some alytid frogs, but does not allow a definitive identification. Additional minute skeletal elements, yet to be identified, may belong to other herpetofaunal taxa. Although poor, the record of reptiles and amphibians from Zahleh offers a stimulating point of comparison with the few Late Miocene sites with reptiles and amphibians known in central Middle East. In the Levant, Late Miocene vertebrates had only been signalled near the Lebanese town of Kefraya, some 25 km South-West of our site. There, abundant shell fragments of a tortoise identified as *Testudo* sp. were found together with egg remains attributed to the same species. In comparison, the Mukdadiya Formation in northeastern

Iraq (about 800 km to the east), which is somewhat more recent (MN11; ~8 Ma), has yielded remains pertaining to a variety of chelonians, including a testudinid (*Geochelone*) but also a trionychid and maybe a pelomedusid, a small boid snake and the gavialid crocodile *Gavialis*.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

LATE TRIASSIC (CARNIAN) TEMNOSPONDYL ICHNITES FROM SUBURBAN BRISBANE, AUSTRALIA

KNUTSEN, Espen, Queensland Museum, Townsville, Australia

Temnospondyls were a hugely diverse, cosmopolitan lineage of amphibian tetrapods inhabiting aquatic and terrestrial habitats from the late Paleozoic (Early Carboniferous) to late Mesozoic (Early Cretaceous). Temnospondyl ichnites span a similar time interval as their body fossils, albeit extremely rare in the Mesozoic record, with only one confirmed (Jurassic of South Africa) and a handful of proposed occurrences (Europe and North America). Heretofore undescribed tracks and trackways held at the Queensland Museum were collected in the 1950s and 1960s from Late Triassic (Carnian; Aspley Formation) deposits at the closed Petrie's Quarry in the Brisbane city suburb of Albion, Australia. The specimens preserve tetradactyl manus prints, indicative of an amphibian trace-maker. The specimens show no signs of body or tail drag marks, resulting either from the animal lifting its body and tail above the substrate while in locomotion, or that the collected series of samples do not cover the areas where these would have been preserved. The track sizes, morphology and patterns suggest a large individual, most likely a temnospondyl, with relatively short limbs compared to body length, walking across a water-saturated muddy substrate.

Now made inaccessible by urban development, sampling from Petrie's Quarry has been impossible for decades. These specimens, possibly representing the only definite evidence of Triassic temnospondyl trace fossils worldwide, thus excellently illustrate the importance of fossil collection and the role museums play in storing this material for perpetuity.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A NEW IGUANODONTIAN DINOSAUR WITH A "PYGOSTYLE" FROM THE LOWER CRETACEOUS KHUKHTEEG FORMATION OF DORNOGOVI PROVINCE, MONGOLIA

KOBAYASHI, Yoshitsugu, Hokkaido University, Sapporo, Japan; TSOGTBAATAR, Chinzorig, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; KHISHIGJAV, Tsogtbaatar, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; TAKASAKI, Ryuji, Hokkaido University, Sapporo, Japan; TANAKA, Tomonori, Museum of Nature and Human Activities, Hyogo, Sanda, Japan; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada; FUNSTON, Gregory F., University of Alberta, Edmonton, AB, Canada; YOSHIDA, Junki, Hokkaido University, sapporo, Japan; KOPPELHUS, Eva B., University of Alberta, Edmonton, AB, Canada

Mongolia has long been known as one of the richest countries for dinosaur fossils, especially from the Upper Cretaceous deposits; however, the Lower Cretaceous dinosaurs are relatively poorly known. *Altirhinus kurzanovi* has been the only definitive, non-hadrosaurid iguanodontian dinosaur from the Early Cretaceous of Mongolia. In 2015, a joint expedition of the Institute of Paleontology and Geology of the Mongolian Academy of Sciences and Hokkaido University in Japan discovered a nearly complete skeleton of a new iguanodontian from the Khukhteeg Formation (Aptian–Albian) at Khuren Dukh in Dornogovi Province in Mongolia.

The new iguanodontian differs from *Altirhinus* in cranial and iliac morphologies. For example, the external nares and narial fossae are small, there is an extensive contact between the nasal and prefrontal, the infratemporal fenestra of the jugal is narrow, the olfactory cavity of the frontal is wide and large, the frontal does not participate in the orbital rim, and the preacetabular process of ilium is directed anteriorly. The occurrence of two non-hadrosaurid iguanodontians in the same formation in Mongolia reflects the situation in the Lower Cretaceous deposits of other countries (Belgium, China, England, Japan, Niger, and U.S.A.). Our phylogenetic analysis places this new taxon within the Eurasian clade (*Altirhinus*, *Batyrosaurus*, *Gongpoquansaurus*, *Koshisaurus*, *Proa*, *Ratchasimasaurus* and *Xuwulong*), sharing three synapomorphies.

The specimen has most of the caudal vertebrae, which include four fused terminal caudals. The fused caudals show some pathological features: the longitudinal axis curves laterally, there is a small knob between the second and third fused caudals, and two cavities and drainage canals that can be seen in CT images are indicative of osteomyelitis. The general morphology of the fused caudals of this iguanodontian is similar to the "pygostyle" in the ornithomimosaur *Deinocheirus* in having massive and dorsoventrally flattened fused caudals with a concave anterior articular surface. The three caudals anterior to the fused caudals are also procoelous (other caudals are amphicoelous). Whether the terminal caudals are fused because they are pathologic, or were a fused "pygostyle" that became pathologic is uncertain at this point. However, the presence of the procoelous caudals and a deeply concave anterior surface of the fused caudal segment suggests that the tip of the tail may have had a greater stiffness for a gravitational load with a wider range of motion than the rest of the tail.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

NOT JUST SMALL: THE SMALLEST-KNOWN NEONATAL INDIVIDUAL OF *TYLOSAURUS* (MOSASAURIDAE, TYLOSAURINAE) SHEDS NEW LIGHT ON ONTOGENY AND EVOLUTION OF THE TYLOSAURINE ROSTRUM

KONISHI, Takuya, University of Cincinnati, Cincinnati, OH, United States of America; JIMENEZ-HUIDOBRO, Paulina, University of Alberta, Edmonton, AB, Canada; CALDWELL, Michael W., University of Alberta, Edmonton, AB, Canada

We here report on the smallest-known, neonate-sized *Tylosaurus* specimen, FHSM VP-14845, recovered from the lower Santonian portion of the Niobrara Chalk exposed in Kansas, U.S.A. Lacking any associated adult-sized material, FHSM VP-14845 comprises fragmentary and associated cranial bones, here considered to represent a single neonatal individual with an estimated skull length of 0.3 m. Despite its small size, a suite of cranial characters diagnoses FHSM VP-14845 as a species of *Tylosaurus*, including the elongate basisphenoid with a pair of closely spaced basipterygoid processes. At the same time, FHSM VP-14845 unexpectedly lacks a conical predental rostrum on the premaxilla, generally regarded as diagnostic of this genus. Further, the first and the second premaxillary teeth are closely spaced, with the second set positioned posterolateral to, rather than posterior to, the first, contributing to the overall shortness of the dentigerous premaxilla. Because a conical predental rostrum is already present in specimens of *T. nepaeolicus* and *T. proriger* with skull lengths of approximately 0.4 m and 0.6 m respectively, formation of such a rostrum must have taken place very early in the postnatal ontogeny. Thus, sexual selection must have contributed very little to evolution of a tylosaurine rostrum, and its function(s) must have been shared by the two sexes. Given the lack of a conical rostrum in plioplatecarpines, a well-established sister clade of tylosaurines, we further conclude that hypermorphosis is a major heterochronic driver behind the evolution of this iconic tylosaurine feature.

Grant Information

NSERC Discovery Grant, no. 238458; NSERC Accelerator Grant, no. 412275; Faculty of Science Chairs Research Allowance (to M.W.C.)

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

ECOMORPHOTYPES IN THE FAMILY PHOCIDAE (TRUE SEALS) SUPPORTED BY EVIDENCE FROM SOME OTHER VERTEBRATES

KORETSKY, Irina, Howard University, Washington, DC, United States of America; ALEXANDER, Ashley, Howard University, Washington, DC, United States of America; RAHMAT, Sulman, Howard University, Washington, DC, United States of America

The Family Phocidae (true seals) has four subfamilies: three extant (Cystophorinae, Monachinae, Phocinae) and one extinct (Devinophocinae). Each subfamily is classified based on distinguished morphological characters, both cranial and postcranial. Dividing seals into ecomorphological groups requires a different set of morphological characters, combined with the ecological specializations of different taxa. Due to the fragility of fossil seal skulls, the three most commonly found dissociated bones (mandible, humerus, and femur) are used. In the Family Phocidae, ecomorphs of only representatives of the subfamily Phocinae have been demonstrated. Ecomorphs for seals of the other three subfamilies will be compared with those already described in Phocinae. In each subfamily, (Cystophorinae, Devinophocinae, Monachinae) characters do not fit precisely into the groups already created for members of subfamily Phocinae. Fossil seals have natural morphological units similar to those of Recent species, providing a rationale for associating the many dissociated fossil elements. Specific ecological distinctions (diving depths, habitat, diet, speed, body size, etc.) of extant seals are examined to correlate to analogous fossil seals. Placing seals into specific ecomorphological groups does not use alpha taxonomy, instead combining morphological and ecological characters. Ecomorphs are also found in other vertebrates, including but not limited to rabbits, anole lizards, and finches.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

PRESERVATION OF THE THERIZINOSAUR *BEIPIAOSAURUS INEXPECTUS* FROM THE YIXIAN FORMATION OF CHINA: IS IT AS CHEMICALLY EXCEPTIONAL AS IT IS VISUALLY?

KORNEISEL, Dana E., Virginia Polytechnic Institute and State University, Blacksburg, VA, United States of America

Exceptional preservation, today, is described in terms of articulation and the anatomical details visible in a specimen. The next step is to understand whether these specimens are chemically exceptional; are cellular and molecular remains available to us? The holotype of *Beipiaosaurus inexpectus* is excellent in its level of articulation, completeness, and the preservation of feather imprints in articulation with its limbs. It has been suggested that this exceptional detail goes deeper–with the presence of red blood cells visible in thin sections of the bone. In this study, we have examined bone fragments and thin sections from the holotype of *B. inexpectus* in addition to fragments of petrified wood from the same formation with Raman spectrometry (spectra indicate specific minerals at a measured point) and ToF-SIMS (a secondary ion mass spectrometer with the capacity to map element and molecule presence in a sample) to better understand the taphonomic history and the chemical composition of the specimens and identify the composition of the purported blood cells. The alternative hypothesis to the blood cell hypothesis is that the structures are composed of pyrite or iron oxides, so we have used Raman to look for signals indicative of these minerals in new thin sections of material from *B. inexpectus*, as well as collected ToF-SIMS data on non-sectioned bone fragments. Prevalent organics in the blood vessels and in the wood sections obscure the clarity of Raman spectra, but we have found that we can reliably detect major minerals (such as apatite in bone sections, quartz and calcite in wood sections). There is a pattern of increased fluorescence, indicative of high organic content, in the vessels. In addition, the presence of round red structures in the sections of wood which are similar in size and morphology to those in the bone significantly weakens the blood cell hypothesis. The chemical story of this visually stunning specimen indicates that the classic definition of exceptional preservation may not point clearly to exceptional chemical preservation.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

NICHE DIFFERENTIATION IN EOCENE CARNIVORES: UNIQUE LUMBAR SPECIALIZATIONS IN THE OXYAENID *PATRIOFELIS*

KORT, Anne E., Indiana University, Bloomington, IN, United States of America; POLLY, P. David, Indiana University, Bloomington, IN, United States of America

Oxyaenids were one of three diverse clades of terrestrial mammalian carnivores in the Eocene: carnivorans survive to the present day, hyaenodontids persisted into the Miocene, but oxyaenids became extinct in the Eocene. Key adaptations either inflexibly coupled oxyaenids to disappearing tropical environments or put them in direct competition with the emerging carnivorans. An almost complete specimen of *Patriofelis ulta*, one of the last oxyaenids in North America, shows that the lumbar vertebrae had highly specialized convolute zygopophyseal joints. We used geometric morphometrics to compare the shape of this joint with those of 20 extant mammals from nine orders. Ten landmarks were used to measure overall shape of the vertebrae, and 30 semilandmarks were used to measure the

curvature of the articulation surface of the prezygapophyses. For overall lumbar shape, PC1 explained 36.8% of the variance, and while a multiple linear regression of the log of centroid size compared to principal components 1–16 was not significant with a $p > 0.1$, a bivariate regression of PC1 with log of centroid size shows that centroid size varies significantly with PC1 with a $p < 0.01$. For shape of the articular surfaces, PC1 explained 77.2% of the variance, but no tested factors, including locomotor category, order, or size significantly correlated with the variation. Articular shape appears to correlate with lumbar stiffness, with animals such as the peccary, armadillo, and goat grouping together at the positive end of PC1 and otter, bobcat, and rabbit at the negative. *Patriofelis ulta* grouped with the stiff-backed species. Paradoxically, other features of *P. ulta*, such as its long body and tail, relatively short limbs, and plantigrade posture, are incongruent with other dorsostable mammals of comparable size in which stabilization is useful for jumping or running. *Patriofelis ulta* has no cursorial features, and although it lived in a forested environment where climbing and jumping may have been useful, it has no clear scansorial features either. Our results suggest that late oxyaenids may have had a combination of postcranial specializations that sharply distinguished them from the other carnivore groups.
Grant Information
Robert R. Shrock Professorship in Sedimentary Geology

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

ASSESSING METHODOLOGICAL BIASES ON TOOTH-AGE AND DENTIN DEPOSITION RATE ESTIMATES IN EXTINCT TAXA: A STUDY ON *ALLIGATOR MISSISSIPPIENSIS*

KOSCH, Jens C., North Carolina State University, Raleigh, NC, United States of America; CANOVILLE, Aurore, North Carolina State University, Raleigh, NC, United States of America; ZANNO, Lindsay E., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America

Von Ebner lines (VELs) are incremental growth marks of daily dentin apposition, which are widely used to calculate the: (1) age of teeth; (2) dentin deposition rate (DDR, estimated by mean VEL increment width VEIW); and (3) tooth replacement rate (TRR) in extinct taxa. However, the influence of methods used to assess TRR and mean VEIW is rarely considered. We used histological thin-sections of 12 tooth positions from the jaws of a young *Alligator mississippiensis* to study the effects of tooth position in the jaw, sampling location within the tooth, and estimation method for sections in which not all VELs are visible (comparable to an inability to histologically section fossil specimens) on VEIW and TRR.

We find tooth position in the jaw has no direct correlation to mean VEIW; rather, variation is largely driven by sampling location within a tooth and orientation of measurement axes. Mean VEIW decreases laterally, whereas increment widths are thicker along the central axis (CA) from above the pulp cavity to the crown apex. We find age estimates based on VEL count of transects along the mesio-distal or labio-lingual axis (lateral to the pulp cavity) are always lower than those derived from VEL counts on the CA (1/6 on average). Orientation of measurement axes relative to VEL orientation also asserts a strong influence. Transects that cross VELs obliquely (e.g., top of the pulp cavity to the enamel dentine junction EDJ, in areas adjacent to the apex) yield VEIWs nearly twice the width than those made perpendicular to VELs. However, because the increase in mean VEIW in oblique transects is coupled with a longer transect length, age estimates are similar to those produced by perpendicular transects, which are composed of shorter VEIWs across a shorter transect. Nonetheless, both approaches underestimate age compared to transects along the CA because they fail to account for the apical-most component.

Estimates based on crown height and mean VEIW from around the crown and estimates from transects along the CA yield ages comparable to data based on observed tooth growth and exfoliation rates (77–200 days with an average of 130). Crown height is more influential on estimated ages than tooth specific calculations of VEIW. Our results suggest that for volumetric estimates of fossil teeth the regions adjacent to the pulp cavity should be taken into account, and for age estimates, the crown height alone should be used. Importance of this approach increases in teeth with long tooth portions lateral to the pulp cavity. Estimates of tooth age should be based on actual counts of VEL whenpossible.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

LOWER JAW MORPHOLOGY OF A NEW GONDWANATHERIAN MAMMAL FROM THE LATE CRETACEOUS OF MADAGASCAR

KRAUSE, David W., Denver Museum of Nature & Science, Denver, CO, United States of America; HOFFMANN, Simone, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; WIBLE, John R., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; ROUGIER, Guillermo, University of Louisville, Louisville, KY, United States of America; HU, Yaoming, Stony Brook University, Stony Brook, NY, United States of America

We describe and analyze here the lower jaw morphology of the only known specimen—a complete skull and postcranial skeleton—of a new basal gondwanatherian mammal from the Late Cretaceous (Maastrichtian) of Madagascar. The specimen was recovered from the Maevarano Formation in the Mahajanga Basin, the same rock unit that has yielded specimens of other gondwanatherians, including isolated teeth of *Lavanify* and the cranium of *Vintana*. Each half of the lower jaw of the new gondwanatherian is composed of only one bone, the dentary. The preserved right and left dentaries are the most complete yet known for any gondwanatherian, revealing for the first time the morphology of the character-rich ascending ramus. The dentary is short and deep, has an unfused symphysis and sizeable diastema, and houses only five teeth: an enlarged, laterally compressed, procumbent incisor and four highly unusual postcanine teeth. It lacks a postdentary trough, Meckelian sulcus, and any trace of a coronoid bone. In comparable parts of its anatomy, the dentary of the new gondwanatherian is strikingly similar to that of *Sudamerica*, the only other undoubted gondwanatherian represented by a complete horizontal ramus. Among Mesozoic mammaliaforms, the dentary of the new gondwanatherian is most similar to those of the largely Laurasian group Multituberculata, most notably in being short and deep, bearing a large diastema and reduced dentition, articulating with the squamosal via a mediolaterally narrow condyle, absence of an angular process, and presence of a large pterygoid fossa and pterygoid shelf (with a flat ventral surface). Most, if not all, of these features are derived and stand in stark contrast to the relatively primitive morphology exhibited by the mandible of the haramiyidan *Haramiyavia*. The lower jaws of euharamiyidans, although derived in their own right, differ from that of the new gondwanatherian in the following features: presence of reduced postdentary trough, presence of angular process, rounded ventral surface of angular region, presence of vestigial coronoid bone, and mental foramen positioned below p4 (rather than below diastema). The general shape and structure of the lower jaw of the new gondwanatherian differs considerably from those of other Mesozoic mammaliaforms across a broad spectrum of taxonomic and ecomorphological types.
Grant Information
Supported by National Science Foundation grants EAR-9706302, EAR-1123642, and EAR-1664432, and the National Geographic Society

Technical Session VII (Thursday, October 18, 2018, 3:45 PM)

EVOLUTION OF AVIAN BRAIN SIZE: COMBINING FOSSIL AND MODERN EVIDENCE

KSEPKA, Daniel, Bruce Museum, Greenwich, CT, United States of America; BALANOFF, Amy, John Hopkins University, Baltimore, MD, United States of America; SMITH, N. Adam, Clemson University, Clemson, SC, United States of America; SMAERS, Jeroen, Stony Brook University, Stony Brook, NY, United States of America

Birds are the only vertebrates that rival mammals in relative brain size (i.e., a positive deviation from the expected brain/body scaling relationship). The exceptionally large brain volumes of birds such as parrots and crows has long been recognized, and relative brain size has furthermore been correlated with traits including cognition, social complexity, and flight. In order to reconstruct the timing and pattern of avian brain evolution, we investigated allometric patterns and rates of evolution using a dataset of 418 brain endocasts, sampling 284 extant bird species, 22 extinct bird species, and 12 non-avian theropod dinosaurs. Sampling extinct taxa is key: only fossil data can shed light on the theropod to bird transition, and many flightless lineages of crown birds, which may provide insight into concerted changes in brain and body size, have gone extinct in the past millennium.

Using a combination of multi-regime Ornstein-Uhlenbeck approaches and least-squares phylogenetic analysis of covariances, we inferred both rates of evolution and deviations from the common scaling relationship of brain volume and body size. Our analyses recover no significant increase in relative brain size across the transition from non-avian theropods to *Archaeopteryx*, or at the base of the crown bird radiation. Instead, we find evidence for a shift in relative brain size at the deeper phylogenetic node representing the most recent common ancestor of Paraves (i.e., dromaeosaurids, birds, and allies). More strikingly, we infer a significantly higher rate of change in relative brain size (i.e., lower integration of the brain-body relationship) among non-avian theropods and deeply diverging birds, with most crown birds showing a significantly slower rate of evolution. These results indicate that the deep history of the avian crown radiation conforms to the expectations of an adaptive radiation with a rapid, early diversification setting the stage for subsequent selection and stabilization. Despite a stem lineage that extends back more than 150 million years, birds only recently reached their apex in relative brain size later in the Cenozoic, with the most notable post K-Pg extinction events being the increases in evolutionary rate that manifested in the profound expansions of brain size in parrots and crows.
Grant Information
This research support was provided by the following awards: NSF EF-0905606, NSF DEB 1457181, and NSF DEB 1655736.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

TAPHONOMY OF TWO LATE TRIASSIC STEREOSPONDYL MASS DEATH ASSEMBLAGES FROM THE POPO AGIE FORMATION (FREMONT COUNTY, WYOMING)

KUFNER, Aaron M., University of Wisconsin-Madison, Madison, WI, United States of America; LOVELACE, David M., University of Wisconsin-Madison, Madison, WI, United States of America

Recent exploration of the often overlooked Late Triassic Popo Agie Formation of Wyoming has yielded two new stereospondyl death assemblages including a non-metoposaurid stereospondyl mass mortality bed. These sites have been dubbed the Nobby Knob Quarry and the stratigraphically lower (~5 m) Serendipity Bed, respectively. NK Quarry: The degree of articulation of limbs, cranial, and pectoral girdle elements as well as the presence and articulation of small appendicular elements (i.e., phalanges and metapodials) suggest that hydrodynamic sorting was not a significant factor during deposition. Azimuths of bones whose lengths are four times their diameter or greater were plotted and no evidence of flow direction or sorting is observed. The host silty-mudstone was pedogenically modified after deposition resulting in the loss of small scale sedimentary structures. The dissociation of some elements and vertically oriented articulated limbs may be the result of trampling and is suggestive of a time-averaged accumulation. Serendipity Bed: Partial to fully articulated individual skeletons of a small (6–30 cm) non-metoposaurid stereospondyl are preserved in vertical (15–35 cm depth) burrows (4–12 cm diameter) throughout the 150 m of the exposed horizon. The burrows are preserved in pedogenically modified fine-grained lateral accretion surfaces where the burrow entrance is often missing due to truncation. The burrows terminate in a hemispherical projection that extends just below the sandstone into the underlying mudstone. The change in lithology appears to have been a trigger for the burrow-maker to cease excavation. At one locality (Dojo), burrow density is greater than 40 burrows per square meter with more than half preserving vertebrate specimens, and cross-cutting relationships between burrows suggest a time-averaged accumulation. Considering the global distribution of stereospondyls, there are only seven known mass death assemblages, two of which were previously known in the southwestern U.S.A. These two new mass mortality sites from the Popo Agie of Wyoming are providing insights into the paleoecology and niche distributions of this clade.
Grant Information
We would like to thank the David B. Jones Foundation for funding the excavation and preparation of these specimens.

Technical Session XIX (Saturday, October 20, 2018, 2:30 PM)

THE ORIGINAL BONEHEADS: HISTOLOGICAL ANALYSIS OF THE PACHYOSTOTIC SKULL ROOF IN PERMIAN BURNETIAMORPHS (THERAPSIDA, BIARMOSUCHIA)

KULIK, Zoe T., University of Washington, Seattle, WA, United States of America; SIDOR, Christian A., University of Washington, Seattle, WA, United States of America

Thickened, pachyostotic skulls are best known in pachycephalosaur dinosaurs, but convergently evolved in some Triassic archosauromorphs as well as in Permian tapinocephalids and burnetiamorphs, both early members of the synapsid lineage. Until now, only pachycephalosaur domes have been histologically sampled to reveal patterns of bone tissue microstructure and growth. Using computed tomography and osteohistology, we serially thin-sectioned two burnetiamorph skull caps (intertemporal regions) of varying sizes and here report the first cranial histological data from this clade.

The smaller of the two skull caps represents one of the smallest burnetiamorphs ever recovered (estimated skull length = 10 cm), while the other individual is nearly twice as large. Both specimens preserve a thickened dome and supraorbital bosses. Coronal thin-sections reveal highly vascularized, spongey tissue that can be separated into three histological zones, analogous to the three zones previously reported in pachycephalosaur domes. Zone 1 is made up of typical dermal bone consisting of two layers of parallel-fibered bone surrounding a cancellous interior. More superficially, Zone 2 includes highly vascularized primary radial canals surrounded by thin layers of woven and parallel-fibered matrix. The outermost Zone 3 consists of radial vascular canals that have smaller canal diameters compared to Zone 2. Unlike in pachycephalosaurs, where primary vascular porosity decreases through ontogeny, both burnetiamorph skull caps preserve thick zones of highly vascularized Zone 2 tissue types. Vascular porosity slightly decreases in the most superficial tissue in the larger specimen but does not approach the dense and avascular tissue seen in mature pachycephalosaurs. Additionally, in each thin-section, remnant suture patterns are visible as radial struts that taper superficially, leaving no trace on the surface of the skull. Even in the smallest individual, the sutures are completely closed, which is unusual given that some large pachycephalosaur domes preserve open sutural gaps.

While pachycephalosaur and burnetiamorph skull domes share similar external morphology, histological analysis reveals differences in vascularity and construction suggesting that there are multiple ways to form a dome. Future work should expand the comparative sample by including tapinocephalids and even larger, and presumably more mature, burnetiamorph skulls.

Grant Information
National Science Foundation EAR - 1337569

Technical Session XVIII (Saturday, October 20, 2018, 2:00 PM)

TWO-CUSP ADDITION EVENTS UNDERLIE THE EVOLUTION—BUT NOT THE DEVELOPMENT—OF MOLARS IN ARVICOLINAE (RODENTIA, CRICETIDAE)

LAFUMA, Fabien O., University of Helsinki, Helsinki, Finland; CLAVEL, Julien, École Normale Supérieure, Paris, France; CORFE, Ian J., University of Helsinki, Helsinki, Finland; ESCARGUEL, Gilles, Université Claude Bernard Lyon 1, Villeurbanne, France; RENVOISÉ, Élodie, University of Helsinki, Heksinki, Finland

Patterns of pervasive phenotypic convergence have been of longstanding interest to evolutionary biologists studying adaptation and its underlying mechanisms (including genetics and development). Notably, the diversification of several mammal groups is attributed to the repeated and independent evolution of increasingly complex teeth through the addition of cusps—the positive reliefs of the occlusal surface—during development. With phylogenetic comparative methods, we investigated the evolution of highly multicuspid molars in the recorded history of Arvicolinae (voles, lemmings, muskrats) using both fossil and living species. Then, through observation and experimentation on molar development in an extant vole species (*Myodes glareolus*), we tested whether mechanisms of odontogenesis can explain the observed macroevolutionary pattern.

We reconstructed the evolution towards higher cusp numbers (considered a proxy for higher tooth complexity) as a convergent phenomenon in the first lower molars of Arvicolinae, having occurred independently in at least 20 lineages. Molar complexity decreases also appear in the arvicoline record, but are rare. The observed macroevolutionary pattern of increases and decreases is best explained through a two-cusp stepwise model. However, in vivo observations of the development of complex first lower molars in *Myodes glareolus* reveal a different mechanism: a burst of cusps developing rapidly characterizes the early days of vole tooth growth, compared to a relatively slower dynamic in the less complex teeth of mice. The size of the developing tooth bud—and especially the extent of its anterior region—appears to be one of the determinants of final tooth complexity, as in vitro experiments on *Myodes* molars show that longer buds develop higher cusp numbers. In addition, a similar relation exists at the macroevolutionary level, for which we identify a strong phylogenetic component. Therefore, we propose that increasing molar size during odontogenesis was a contributing factor/potential driver of the evolution of increasingly complex teeth in Arvicolinae. Nevertheless, this two-cusp stepwise macroevolutionary pattern has no direct equivalent at the developmental scale. Ontogeny does not recapitulate phylogeny in the molars of arvicolines.

Grant Information
Four-year research grant from the Integrative Life Science Doctoral Program, University of Helsinki; Academy of Finland funding

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

QUANTIFYING ORGANIC PRESENCE IN YOUNG FOSSIL SPECIMENS WITH RAMAN SPECTROSCOPY

LAKER, Rachel, University of Wyoming, Laramie, WY, United States of America; CLEMENTZ, Mark, University of Wyoming, Laramie, WY, United States of America

Diagenetic alteration is an inherent part of the fossilization process, with the extent of alteration varying widely depending on preservation conditions. Assessing bone alteration in an efficient and non-destructive manner is becoming increasingly important as geochemical studies pervade paleontology.

We established a streamlined analysis for the organic components of bone with Raman spectroscopy. Raman spectroscopy, a light laser that excites chemical bonds betweenmolecules, can analyze organic content of bone non-destructively. We focused on the organic component of bone because distinguishing poor-quality spectra from poor-quality samples has yet to be established. Bone fragments from Buldir Island, AK (Holocene) and Last Canyon Cave, MT (Pleistocene) were selected to represent differing ages and environmental conditions, potentially showing different stages or pathways of the fossilization process. Three standards (NIST 1486, a synthetic hydroxyapatite, and an in-lab bone standard) were utilized, along with a suite of modern small mammal bones, to bracket the potential variation of the fossil samples. All Raman spectra were analyzed and compared to nitrogen weight percent and carbon to nitrogen ratios (C:N), which served as independent measures of bone quality. Samples were classified as excellent if C:N values were close to that of fresh bone (3.1 to 3.4), good if C:N values fell outside of that range but within an established range for well-preserved fossil bone (2.8 to 3.6), or poor if C:N values were below 2.8 or above 3.6. A calibration curve of a deprotienated bone standard mixed with increasing amounts of collagen was created to understand organic variation in spectra.

Both fossil sites showed signs of contamination, either exogenous organics (Buldir) or secondary carbonates (Last Canyon Cave); in both cases, contaminants were removed by sonication. Peak height ratio results created a positive regression with organic content, with an R^2 value of 0.71. However, peak height ratios weren't able to capture the entire variance seen in the fossil samples, which often had noisy or fluoresced spectra. A Principal Component Analysis was conducted to tease out organic variation from spectra fluorescence and other sources of noise (R^2 of 0.91). Overall, we found that the PCA was able to better quantify sample variance and organic content than traditional peak height ratio analysis, even without the step of baselining spectra. We tested the PCA effectiveness to predict organic content by comparing its score values to wt%N from EA.

Technical Session X (Friday, October 19, 2018, 9:15 AM)

EVALUATING SIZE CONSTRAINTS ON LOCOMOTION IN SAUROPOD DINOSAURS USING TRACKWAY DATA

LALLENSACK, Jens N., University of Bonn, Bonn, Germany; BUCHWITZ, Michael, Museum für Naturkunde Magdeburg, Magdeburg, Germany

Sauropod dinosaurs were the largest terrestrial animals that have ever existed, making them ideal models to study locomotion at extreme body sizes. Intriguingly, sauropods show an astonishing degree of variation in their locomotory apparatus despite their giant size. A recent biomechanical study proposed some of these variable features, including the trackway gauge and the difference between the manus and pes footprint areas (heteropody), to be correlated with both body size and the position of the center of mass. Thus, smaller and more basal sauropods with a center of mass close to the hips would have produced narrow-gauged trackways with manus footprints much smaller than the pes footprints. Conversely, the anterior shift of the center of mass seen in more derived sauropods would have allowed for larger body sizes while requiring wider gauges and larger manus areas. These hypotheses can be tested using fossil trackways, which represent direct evidence of movement. To analyze possible constraints on locomotion, we performed statistical analysis on a larger (n = 130) sample of trackways from around the world. Wider gauges are indeed strongly negatively correlated with proportionally larger manus footprints, confirming that both parameters are likely determined by the location of the center of mass. The suggested correlation of these parameters with body size, however, could not be confirmed, indicating that body size had less effect on locomotion than previously assumed.

The only trackway feature clearly constrained by body size is the manus rotation angle, which in small individuals can be larger than 90° on average. Multivariate linear regression analysis showed that a high angle is associated with both a lower relative locomotion speed and a narrower trackway gauge. We therefore hypothesize that the manus is anteriorly directed when actively involved in the propulsion of the animal, which would be the case at increased locomotion speeds, and when the center of mass is located more anteriorly. These data suggests that the contribution of the forelimb to the propulsion of the animal increases with size.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

IMPLICATIONS OF DISCOVERIES OF THE SHOVEL-TUSKED GOMPHOTHERE *KONOBELODON* (PROBOSCIDEA, GOMPHOTHERIIDAE) IN EURASIA FOR THE STATUS OF THE GENUS *AMEBELODON* AND THE SPECIES *A. FLORIDANUS*

LAMBERT, William D., Holy Innocents' Episcopal School, Atlanta, GA, United States of America

There is ambiguity about the relationship between the shovel-tusked gomphotheres *Amebelodon* and *Konobelodon*. Some authors consider these two taxa to be close relatives, even sister taxa, while others consider them to be only distantly related. Much of this ambiguity relates to a dispute about the phylogenetic significance of key morphological features that characterize these two taxa, as well as confusing biogeographical and chronological distributions.

Amebelodon consists of two morphotypes. One, typified by *A. floridanus*, is known from the early Hemphillian of North America and is characterized by a conservative chewing dentition reminiscent of typical gomphotheres and lower tusks that are narrow and only modestly flattened. The other morphotype, typified by the type species *A. fricki*, is known from the middle Hemphillian and is characterized by a more advanced chewing dentition and lower tusks that are both much broader and flatter than those found in *A. floridanus*. By comparison, *Konobelodon* resembles *A. fricki* in having both an advanced chewing dentition and a mandibular symphysis with lower tusks that are nearly identical in overall form. The most striking difference between the two genera is the presence of internal dentinal rods in the lower tusks of *Konobelodon*.

Konobelodon was first described from a middle Hemphillian locality in North America. It was originally proposed that it evolved from an advanced *Amebelodon* species, which then quickly dispersed into the Old World. However, new discoveries of older *Konobelodon* material in Europe and especially Asia have rendered this hypothesis implausible. A newly

described species of *Konobelodon* has been found in the Turolian (mid-Hemphillian) Pikermi region in Greece, while another new *Konobelodon* species has been found in older Vallesian (late Clarendonian) units in China. Complicating the situation, an undescribed gomphothere resembling *Konobelodon* except for lacking lower tusk dentinal rods has also recently been reported from the Vallesian ofChina.

This new *Konobelodon* material suggests that *Konobelodon* first appeared in Eurasia, rather than North America as first proposed. If indeed advanced *Amebelodon* is closely related to *Konobelodon*, then it too most likely represents a Eurasian, *Konobelodon*- affiliated immigrant. If this hypothesis is correct, then the status of the morphologically conservative species *A. floridanus* within *Amebelodon* becomes problematic, with the implication that it should be placed into a new genus that is informally described here.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

SCALING PATTERN OF EUARCHONTOGLIRES CEREBELLAR PETROSAL LOBULES: IMPACTS OF LOCOMOTION AND ACTIVITY PATTERN

LANG, Madlen M., University of Toronto Scarborough, Toronto, ON, Canada; BERTRAND, Ornella C., University of Toronto Scarborough, Toronto, ON, Canada; SILCOX, Mary T., University of Toronto Scarborough, Toronto, ON, Canada

The subarcuate fossa is a bony out-pocket of the petrosal bone that opens into the endocranial cavity. In several mammalian orders, the subarcuate fossa houses the petrosal lobules, which are comprised of one or more components of the floccular-paraflocular complex of the cerebellum. These lobules and associated neural tissues regulate functions associated with vision, including the stabilization of visual images on the retina and smooth pursuit and velocity control of eye movements. Due to their functional significance and the ability to isolate them in endocranial reconstructions, the petrosal lobules may be able to provide ecological information on fossil taxa. However, the study of a diverse comparative sample of living forms is required to actualize on this potential.

The scaling patterns of the petrosal lobules of 118 members of Euarchontoglires are examined to determine if ecological factors play a role in the volume of these structures. Virtual endocasts were produced for five mammalian orders including Rodentia (n = 70), Lagomorpha (n = 7), Dermoptera (n = 1), Scandentia (n = 10), and Primates (n = 30). Bivariate least squares regression analyses were performed in which $\log_{10}$ petrosal lobule volume (mm^3) was plotted against $\log_{10}$ endocranial volume (mm^3) according to one of three categories: suborder, activity pattern, or locomotor type. The effect of body mass was investigated by analyzing the volumes both with and without body mass standardization. Phylogeny is a major force driving petrosal lobule scaling, but some ecological signals are apparent. Diurnal taxa tend to have relatively larger lobules compared to nocturnal taxa, and gliders tend to have relatively larger lobules than arboreal rodents andprimates.

Fossorial rodents have significantly smaller lobules compared to all of the other locomotor categories. Importantly, there appear to be different scaling patterns between rodents and primates. While there are strong ecological signals in rodent petrosal lobule volumes, in primates they primarily scale according to phylogeny, with haplorhines having smaller lobules than strepsirrhines irrespective of ecology. The contrasting signals between rodents and primates may be related to different anatomical configurations of the petrosal lobules, as the rodent petrosal lobule is comprised of the entire paraflocculi while the primate is composed of only a portion of the paraflocculi. This illustrates the significance of phylogenetically constrained analysis when examining the petrosal lobules across different orders.

Grant Information

Supported by NSERC discovery grant to MTS, NSERC Canada Graduate Scholarships to MML, and additional support from the Office of Vice Principle/Dean, University of Toronto Scarborough to MTS

Technical Session I (Wednesday, October 17, 2018, 12:00 PM)

EXPLORING ELBOW KINEMATICS IN THE AMERICAN ALLIGATOR AND DOMESTIC TURKEY: IMPLICATIONS FOR PREDATORY DINOSAUR FORELIMBS

LANGEL, Christopher R., Stockton University, Galloway, NJ, United States of America; BONNAN, Matthew F., Stockton University, Galloway, NJ, United States of America

Non-avian theropod dinosaurs were bipeds that used their forelimbs in a variety of ways. Lack of modern analogs and missing soft tissues continue to present challenges for reconstructing non-avian theropod forelimb range of motion. Therefore, it is instructive to understand the range of motion in the forelimb of extant archosaurs (crocodylians and birds). We chose to investigate the range of radius and ulna movement relative to the humerus in the American alligator (*Alligator mississippiensis*) and the domestic turkey (*Meleagris gallopavo*). Forelimbs of intact, fresh alligator and turkey cadavers implanted with tracking markers were manually flexed and extended in a single plane. These movements were captured using high-speed cineradiography. Using XROMM (X-ray Reconstruction of Moving Morphology), we reconstructed the resulting three-dimensional forelimb bone orientation and range of motion. Our results show that during elbow flexion and extension, the radius and ulna of both alligators and turkeys follow a complex pattern of long axis rotation (pronation/supination) and abduction/adduction at the elbow joint.

Both long axis rotation and abduction/adduction were more pronounced in turkeys, motions which enhance wing folding. Moreover, for both alligators and turkeys the radius and ulna translate in parallel to one another during elbow flexion. Given the similarities in non-avian theropod forelimb bone morphology to those of alligators and turkeys, these data suggest that accurately reconstructing the range of movement in non-avian theropod elbows requires rigorous inferences of soft tissue morphology in addition to bone morphology. Moreover, our data suggest that long-axis rotation and abduction/adduction of both the radius and ulna at the elbow must have played a significant role in non-avian theropod forelimb use.

Technical Session III (Wednesday, October 17, 2018, 2:15 PM)

LOOKING AT FOSSILS IN A NEW LIGHT: TEETH TO BALEEN TRANSITION IN RELATION TO THE ONTOGENY AND PHYLOGENY OF BALEEN WHALES

LANZETTI, Agnese, San Diego State University, San Diego, CA, United States of America; BERTA, Annalisa, San Diego State University, San Diego, CA, United States of America; EKDALE, Eric G., San Diego State University/San Diego Natural History Museum, San Diego, CA, United States of America

Paleontological data are central to the investigation of tooth loss and relative skull shape adaptations for feeding, in combination with developmental evidence. Baleen whales (Mysticeti) represent a unique system to study this subject. Their extensive fossil record shows the transition from teeth to baleen and from raptorial to filter feeding. Fossil evidence suggests that tooth loss occurred during mysticete evolution after the first appearance of the keratinous baleen plates, although there is controversy on which extinct lineages retaining full dentition may have also possessed baleen-like structures. While developmental evidence shows that tooth buds develop in the upper and lower jaws in modern mysticetes before birth, present evidence is inadequate to determine whether tooth buds and baleen plates co-exist during the later stages of development. Understanding the transition between teeth and baleen in development and the related changes in skull morphology provides critical data bearing on the interpretation of this major macroevolutionary transition.

We acquired CT scans of nine fetal specimens of extant minke whales (*Balaenoptera acutorostrata* and *B. bonaerensis*) at different developmental stages and made qualitative observations on skull ontogeny. For the first time, we compiled a dataset, which includes 26 3D models of skulls representing a broad ontogenetic series (from embryo to adult) from seven of the 14 living mysticete species and six fossil specimens representing the major lineages of extinct mysticetes, to quantify shape changes during development using geometric morphometrics (GM) and explore how they relate to fossil morphologies and feeding modes.

We present new evidence on the ontogeny of the minke whale, which develops a dense tissue dorsal to the rostral canal where the tooth buds are either already absent or clearly undergoing resorption. The identity of this tissue should be confirmed by histological analysis, but it may be the first sign of baleen development, as posited by previous studies of these species. Overall, the GM analyses show that the fossils occupy a different morphospace than modern species, possibly indicating that they had specific feeding adaptations not shared by modern mysticetes. Both phylogeny and ontogenetic age are correlated with shape variation in the skull, while when only the rostrum is considered, only phylogeny has a significant impact on the result, indicating that feeding mode of the adults significantly shapes the development of modern species.

Grant Information

Grant-In-Aid of Research, Sigma Xi; Grant-in-Aid of Research, ASM; Gretchen L. Blechschmidt Award, GSA; MAPS Outstanding Student Research Award, Paleontological Society

Technical Session II (Wednesday, October 17, 2018, 10:30 AM)

A HIGH-LATITUDE ASSEMBLAGE OF FOSSIL TURTLES (TESTUDINES) FROM THE LATE CAMPANIAN OF ALBERTA, CANADA

LARSON, Derek W., Philip J. Currie Dinosaur Museum, Grande Prairie, AB, Canada; VAVREK, Matthew J., Grande Prairie, AB, Canada; BELL, Phil, University of New England, Armidale, Australia; CAMPIONE, Nicolas E., University of New England, Ottawa, ON, Canada; FANTI, Federico, Alma Mater Studiorum - Università di Bologna, Bologna, Italy; SISSONS, Robin, Edmonton, AB, Canada; SULLIVAN, Corwin, University of Alberta, Edmonton, AB, Canada

The diversity of present-day turtles is highest in tropical/subtropical latitudes, with a peak at approximately 25°N. Only six species extend their ranges north of the 50th parallel, and none are known to reach the 60thparallel. In comparison, Late Cretaceous terrestrial turtles are well-known above 50°N paleolatitude, but the northernmost limit of their range is thought to have been climatically restricted not far beyond the well-sampled assemblages of southern Alberta, with the exact biogeographic boundary depending on fluctuations in global temperature through time. To date, only a few shell fragments have been reported from northern Alberta during this time interval.

Here, we report on a diverse high-latitude turtle assemblage from the Late Campanian Wapiti Formation in northern Alberta. Remains represent at least five contemporaneous species across three families including the first high-latitude cranial material of a baenid and a trionychid, elements and shell fragments from at least two species within each of those families, and the northernmost remains of a chelydrid. Specimens can be referred to four specific taxa: *Plesiobaena antiqua*, *Aspideretoides foveatus*, cf. *Axestemys splendida*, and cf. *Boremys pulchra*. *Plesiobaena antiqua* and *B. pulchra* were previously identified as occurring only in more southerly localities within North America. Interestingly, all recovered specimens would have had carapace lengths less than 400 mm; even the recovered skull of cf. *Axestemys splendida* is approximately half the size of typical southern specimens. Other larger taxa are missing entirely, suggesting that the northern Alberta assemblage is indeed near the climatically-controlled biogeographic limit of these species' ranges.

This assemblage provides the first detailed examination of Campanian turtles at their northernmost limit with implications for their biogeography within North America. The relative diversity and abundance, but potentially small body size, of a climate-sensitive vertebrate group in a near paleo-Arctic (close to 66°N) setting also raises new questions about the reconstruction of the Campanian terrestrial latitudinal temperature gradient and its climate-driven limitations on diversity during the latest Cretaceous. These discoveries underscore the paleobiological importance of the Wapiti Formation for understanding the Cretaceous terrestrial vertebrate assemblages of northern Alberta as well as North America in general.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ANALYSIS OF UNUSUAL ABUNDANCE OCCURRENCES OF *HYOPSODUS* (CONDYLARTHRA) AND *HYRACOTHERIUM* (PERISSODACTYLA) IN THE LOWER EOCENE WILLWOOD FORMATION, BIGHORN BASIN, WYOMING, AND RESOLUTION FOR BIOHORIZON C

LARSON, Elizabeth B., Colorado State University, Fort Collins, CO, United States of America; CHEW, Amy E., Brown University, Providence, RI, United States of America; NICHOLS, Kimberly A., Fort Collins, CO, United States of America; BOWN, Thomas M., Westminster, CO, United States of America

The Willwood Formation of the central Bighorn Basin, Wyoming, yields fossil mammals from more than 1,800 localities, spanning most of the early Eocene (~56–52 Ma). Approximately 138 localities are used in this study, and those have been stratigraphically correlated by measured sections, allowing study of the distributions of the fossil mammals through time. Schankler's Biohorizon C does not represent a period of faunal turnover, rather a major change in relative abundances of certain taxa. Analysis of fossil assemblages of localities D-1204, D-1310, D-1536, D-1537, and D-1588 (438–450 meter levels) show abnormal abundance of the condylarthran genus *Hyopsodus*. Analyses of the percent distributions of fossil mammals situated in the 400–460 meter interval of the Willwood Formation demonstrate that species of *Hyopsodus*, normally making up 20%–30% of the mammal fauna at any one site, comprise up to ~50% of the fauna at certain localities. Although it is not unusual to find abnormal abundances of certain taxa at quarry sites, abnormalities of this scale are highly unusual in richly fossiliferous, well-sampled surface collections such as those yielding the *Hyopsodus* specimens of this study. These abundances, occurring in the 438–450 meter interval, closely correlate with the placement of Schankler's Biohorizon C. Other unusual occurrences within the 400–470 meter interval include major spikes and drops in the incidences of the earliest horse, *Hyracotherium*, and abnormal concentrations of the related tapirs *Homogalax* and *Cardiolophus*, and the short-lived appearances of the omomyid primates *Steinius* and *Arapahovius*. Abnormal changes in faunal abundances may be related to rapid environmental climate shifts that occurred at or near the abundance occurrences meter level range.

Technical Session VI (Thursday, October 18, 2018, 8:00 AM)

REVISITING ROMER'S ARMS RACE BETWEEN EURYPTERIDS AND EUVERTEBRATES

LASSITER, Linda S., Northern Arizona University, Flagstaff, AZ, United States of America

For over sixty million years, eurypterid (Arthropoda, Chelicerata) and early vertebrate (Chordata, Vertebrata, Agnatha) populations thrived in nearshore environments of extensive but shallow seas. Eurypterids, with their scorpion-like features, developed increasingly predatory appendages. Early vertebrates biomineralized calcium phosphate into increasingly complex exoskeletons of bony armor. From this, Alfred S. Romer hypothesized that armored defenses were developed in early vertebrates in an arms race with eurypterids. Testing any arms race hypothesis is difficult with extinct participants, a paucity of articulated fossils, and almost no predation proof. However, extant taxa like scorpions and crustaceans can, and do, provide testable evidence of capabilities in the use of chitinous appendages for feeding. Recent experimental work on eurypterid puncture force supports grasping and shredding capabilities against an armored prey. In addition, evidence of predation damage to armored euvertebrates by eurypterids has been reported. Also, extant taxa in shallow water or even terrestrial habitats can provide examples of behaviors that might be conceivable for eurypterids and early vertebrates with similar structures. A novel approach to find a pattern of an arms race is to combine and compare the phylogenies from eurypterids and euvertebrates to trace the appearance and loss of traits within each lineage over time. Changes are evident but inconclusive from the lack of a comprehensive phylogenetic analysis of the Heterostraci and their incomplete fossil record in the early Silurian. However, the present scope of evidence still supports Romer's hypothesis of an antagonistic relationship between eurypterids and euvertebrates.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

GATHERING BACULA TO BUILD A BACULUM MORPHOSPACE FOR THE CARNIVORA

LATORRE, Daniel V., UC Berkeley, Berkeley, CA, United States of America

The baculum displays tremendous morphological variation among mammals. This variation is frequently diagnostic for species level identification and can even be used to differentiate between cryptic species. However, the morphological variation of bacula has rarely been quantified. In the paleontological record, bacula are challenging to assign taxonomically when found dissociated from the rest of the skeleton. Here I describe a morphospace of bacula for extant species of mammals in the Order Carnivora to determine the extent to which clades within the order occupy distinct parts of that morphospace, which in turn will provide a framework for determining the taxonomic position of isolated fossil bacula. Once the fossil bacula are placed phylogenetically, their taxonomic position, shape, and stratigraphic age can be used to understand how bacula morphospace occupancy has changed with time. To develop the morphospace, I imaged the lateral view of all relevant bacula available in the Museum of Vertebrate Zoology at UC Berkeley. The sample includes species from the eight major families of caniforms, but there was less material available for feliforms. The lateral view of bacula captures the extent and direction of curvature, as well as thickness variation, variables commonly used as qualitative descriptions of bacula. I used a Fourier transform approach to quantify this 2D shape variation. Preliminary analyses show that the families sampled occupy largely different areas of the morphospace, although there is also substantial overlap among the families analyzed. However, this novel morphospace does not capture some important aspects of baculum shape. For example, modern Canidae and Ursidae overlap substantially in the 2D lateral morphospace generated here, but the canids can be distinguished from ursids by the presence of a urethral groove which is not visible in lateral view. Building the morphospace of bacula is the first step to investigate the tempo and mode of bacula evolution.

Grant Information
UCMP Graduate Student Research Grant

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A NEW HOLOMORPHIC SPECIMEN OF THE RARE HOLOCEPHALIAN FISH, *CHIMAEROPSIS PARADOXA*, FROM THE LATE JURASSIC PLATTENKALK OF GERMANY

LAUER, Bruce H.,Wheaton, IL, United States of America; POPOV, Evgeny V., Saratov State University, Saratov, Russia; DUFFIN, Christopher, Surrey, England; WARD, David J., Orpington, United Kingdom; LAUER, Rene L., Wheaton, IL, United States of America

Chimaeropsis paradoxa is a myriacanthoid chimaeriform fish (amily Chimaeropsidae) from the Late Jurassic Plattenkalk of Eichstätt in Bavaria, described from a single specimen by Karl Alfred von Zittel in 1887. The material was never adequately figured, and the unique holotype was destroyed in World War II. A holomorphic specimen of the fish, slightly smaller than the holotype, was recently obtained by the Lauer Foundation for Paleontology, Science and Education (LF 2317). The specimen, comprising part and counterpart, is a 730 mm long male with a short, bulky head lacking a long rostrum, with a dorsally curved trunk (postmortem position) containing representations of the musculature and valvular intestine, scapulocoracoid, ?homocercal tail, and poorly preserved pelvic fins with pelvic claspers. The head preserves the neurocranium and associated right mandible, a partially preserved lateral line system, four pairs of tuberculated dermal plates (only three pairs were described in the holotype) and a typically myriacanthoid dentition comprising paired anterior and posterior upper tooth plates, mandibular tooth plates and an unpaired lower symphyseal tooth plate exposed in right lateral view. The squamation consists of conical, star-like scales of various sizes, depending on their location on the body, with a series of enlarged scales in the region of the frontal midline. The dorsal fin spine (145 mm long) is of myriacanthid organisation with tuberculate walls and an anterior row of irregular, distally-directed denticles; no posterior denticle rows are visible. Details from the new specimen allow revised diagnoses to be given for the type species, the genus and the family.

Grant Information
RFBR 18-05-01045 (to EVP)

Podium Symposium (Friday, October 19, 2018, 11:30 AM)

FOSSIL REPLICANTS—INTEGRATING PRESERVED AND THEORETICAL MORPHOLOGIES IN BIOMECHANICAL ANALYSES

LAUTENSCHLAGER, Stephan, Univeristy of Birmingham, Birmingham, United Kingdom

New methods in digital visualisation, reconstruction, and computational biomechanical analysis have significantly transformed the way in which fossils can be studied in the past decade. Facilitated by the advent of new hard- and software tools, these techniques are now becoming routine techniques in vertebrate palaeontology. However, by their very nature vertebrate fossils are often incomplete, broken, or distorted when they are found. Furthermore, the comparatively small sample size of most vertebrate taxa makes it difficult to account for effects of intraspecific variation, sexual dimorphism, ontogeny, and allometry. This presents a significant problem for functional analysis of specific morphologies or anatomical structures and the respective comparability of biomechanical behaviour.

Here, a versatile solution to these problems is presented by integrating theoretical morphologies in biomechanical analyses and studies on form and function. Using digital modelling techniques a wide range of theoretical morphologies can be created, which can subsequently be subjected to biomechanical analyses to test the functional significance of morphological features. This approach not only permits the overcoming of limitations posed by the incompleteness of the fossil record and preservation, but can also increase sample size significantly. Comparing theoretical models with actually preserved vertebrate morphologies allows ground-truthing this approach and testing hypotheses on morphospace occupation and convergence.

Advantages, disadvantages, and possibilities of this approach are outlined, and different studies using this approach are presented, demonstrating: (1) how differences in mandibular morphology promoted niche partitioning in therizinosaur dinosaurs; (2) how efficiency in marine locomotion of ichthyosaurs increased through time and phylogeny; and (3) how convergent cranial characters provided functional advantages for herbivorous archosaurs.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A NEW AVIAN OOTAXON FROM THE BRULE FORMATION (OLIGOCENE) OF NORTH DAKOTA

LAWVER, Daniel R., Stony Brook University, Stony Brook, NY, United States of America; BOYD, Clint, North Dakota Geological Survey, Bismark, ND, United States of America

Avian remains are rare from Paleogene sediments in the Great Plains region of North America, especially those that can be identified taxonomically. Here, we describe an avian eggshell fragment from the Fitterer Ranch locality within the Oligocene Brule Formation of North Dakota, and compare it to previously described avian ootaxa and extant bird eggshell. The new specimen (NDGS 1934) exhibits low tubercles that form undulating surface ornamentation; 650–900 µm thick eggshell composed of three structural layers of calcite; an abrupt transition between the mammillary and continuous layers; prisms visible in continuous layer; squamatic texture primarily visible in lower half of continuous layer; and a mammillary-to-total shell thickness ratio of 1:2.70–2.75.

NDGS 1934 is most similar to *Metoolithus nebraskensis*; however, it is slightly thinner than this ootaxon. Additionally, the thickness ratio between structural layers (i.e., mammillary, continuous, and external layers) of NDGS 1934 is on average 1:1.49:0.26, whereas this ratio is 1:2.73:0.22 in *M. nebraskensis*. Other key differences between these ootaxa are prisms that fan outward to a lesser extent in NDGS 1934, more consistent distribution of squamatic texture in the continuous layer in NDGS 1934, and nodose surface ornamentation with a diameter approximately 50% smaller than *M. nebraskensis*. These smaller nodes likely correspond to the reduced expansion of the shell units towards the outer eggshell surface.

NDGS 1934 differs from *Microolithus wilsoni, Medioolithus geiseltalensis,* and *Incognitoolithus* by the presence of surface ornamentation consisting of nodes or tubercles.

Additionally, *Microolithus wilsoni* exhibits thinner eggshell, whereas *M. geiseltalensis, Incognitoolithus,* and *Ornitholithus* are thicker shelled than the new specimen. *Incognitoolithus* and *Ornitholithus* eggshell also consist of only two structural layers. Finally, the new specimen differs from all extant bird eggshells (with the except of emu eggshell) by the presence of surface ornamentation. Due to this unique combination of characters, we suggest that this specimen represents a new avian oospecies within the oogenus, *Metoolithus*. This new oospecies extends both the geographic and temporal ranges of *Metoolithus,* and demonstrates the importance of oological research in revealing the diversity of Oligocene avifauna in this region.
Grant Information
This research was funded by the North Dakota Geological Survey.

Technical Session V (Thursday, October 18, 2018, 11:30 AM)

EVOLUTION, TAXONOMY, AND PALEOECOLOGY OF THE SUIDAE (MAMMALIA, ARTIODACTYLA) FROM HADAR AND THE LEE ADOYTA SUB-BASIN, AFAR, ETHIOPIA

LAZAGABASTER, Ignacio A., Arizona State University, Tempe, AZ, United States of America

The Hadar Formation in the Hadar Research Area and the Lee Adoyta sub-basin in the Ledi-Geraru Research Area, in the Afar region of Ethiopia, sample a one-million-year, stratigraphically well-controlled, and almost continuous sequence between ~3.45 and <2.5 Ma. Here I review the taxonomy of more than 1600 suid (Artiodactyla, Suidae) specimens from these two sites, including unpublished material, and I provide paleodietary insights on the different suid species through stable isotope analysis ($\delta^{13}C$) of tooth enamel and three-dimensional dental microwear texture analyses.

The results show an increase in the length and height of the third molars and reduction of the premolars in *Notochoerus euilus*, a slight increase in the overall body size *Kolpochoerus afarensis*, and the disappearance of *Nyanzachoerus pattersoni* in the region ~3.2 Ma. Dental microwear texture analyses were performed on lower third molars of these three suid species and included a baseline of four extant African suid species (n = 50) for comparison. Non-parametric statistical analyses indicate significant differences in measures of complexity (Asfc), anisotropy (epLsar), and heterogeneity ($HAsfc_9$ and $HAsfc_{81}$) ($p < 0.05$). *Kolpochoerus afarensis* (n = 34) is characterized by higher levels of complexity like that of extant *Potamochoerus porcus*, indicating the consumption of tough foods like nuts and fruits. *Notochoerus euilus* (n = 61) has an unexpectedly wide range of microwear values but the high values of anisotropy suggest this suid was predominantly a grazer, like extant *Phacochoerus*. Finally, *Ny. pattersoni* (n = 14) has intermediate microwear values, suggesting a mixed and varied diet. These results add new information to the diet of Hadar suids, as $\delta^{13}C$ failed to support an evident dietary niche separation between the Hadar suids.

A turnover in suid species is detected between ~ 2.95 and 2.84 Ma, with the appearance of three species, *Notochoerus* cf. *No. capensis*, *K. phillipi*, and *Metridiochoerus andrewsi*. Suids comprise a significantly smaller proportion of the large mammal fauna at Lee Adoyta (3.1 ± 4.1%) than in Hadar (13.7 ± 0.7%). The $\delta^{13}C$ analyses reveal a weak trend towards a greater consumption of C_4 resources in *Kolpochoerus* through the Hadar sequence and into Lee Adoyta, whereas *Notochoerus* maintains a C_4-dominated diet during this time. Collectively, these findings suggest that the habitats in the lower Awash Valley after ~ 2.95 Ma were probably grassier and, therefore, less suitable for suids, most of which prefer mixed habitats of grassy and woody vegetation.

Grant Information
National Science Foundation (NSF BCS-1157351), John Templeton Foundation Grant, Obra Social La Caixa Graduate Fellowship

Technical Session XII (Friday, October 19, 2018, 2:45 PM)

A DIFFERENT LOOK AT PLEURODONTY: THE HISTOLOGICAL AND PHYLOGENETIC SIGNIFICANCE OF SQUAMATE TOOTH ATTACHMENT AND THE IMPORTANCE OF USING THE RIGHT PLANE OF SECTION

LEBLANC, Aaron R., University of Alberta, Edmonton, AB, Canada; PAPARELLA, Ilaria, University of Alberta, Edmonton, AB, Canada; DOSCHAK, Michael, University of Alberta, Edmonton, AB, Canada; CALDWELL, Michael W., University of Alberta, Edmonton, AB, Canada

Thecodonty, acrodonty, and pleurodonty are the classic divisions of tooth implantation. Thecodonty describes the socketed teeth of mammals and crocodilians, whereas the latter two forms describe implantation in extant lepidosaurs. Pleurodonty is found in many early reptiles and is the more common implantation mode across Squamata. It occurs when a tooth is fused to the labial wall of the jaw, with the calcified tooth attachment tissue being either explicitly homologized with mammalian root cementum, or given its own distinction as "bone of attachment". Furthermore, the amount of this tissue, and whether it fuses the teeth to a partial socket made from an interdental ridge, are key characters in the ongoing debates about squamate interrelationships and the origins of snakes. Given the significance of the evolutionary and developmental origins of these features, we re-examined squamate tooth development, pleurodonty, and attachment tissue histology. Using thin sections and micro-CT scans, we compared the teeth and jaws in representatives of nine squamate families with pleurodont dentitions and several snakes and mosasaurs in order to assess tissue homology and the origins of interdental ridges.

Our comparisons revealed a multi-tissue complex that unites a tooth to the jawbone in pleurodont squamates. This tissue complex consists of acellular and cellular cementum with Sharpey's fibers, and a surrounding bone layer we interpret as alveolar bone. Surprisingly, most of the attachment occurs between adjacent teeth, a feature that goes unnoticed in sections through individual teeth. These tissues are poorly developed along the labial surface of a pleurodont tooth and can be nearly absent from the lingual surface of a tooth if the dental lamina, the tooth-producing structure, contacts the root surface. Transverse and coronal sections also revealed that the interdental ridges in squamates, like those of other amniotes, are accumulations of old generations of tooth tissues, which track the migration of tooth positions through ontogeny. Interdental ridges are therefore not attachment tissues and their presence is ontogenetically variable. We conclude that using dental features in assessing squamate phylogeny first requires an understanding of their development. Moreover, we argue that pleurodonty represents a unique arrangement of ancestral tooth tissues found in all other amniotes and that the perceived simplicity of squamate tooth attachment is an artefact of the choice of sectioning plane through the jaws.

Grant Information
Killam Postdoctoral Fellowship to ARHL

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

NEW DATA ON DIAGNOSTIC AND APOMORPHIC MORPHOLOGY IN THE SKULLS OF GERRHONOTINE LIZARDS

LEDESMA, David T., University of Texas, Austin, TX, United States of America; SCARPETTA, Simon G., University of Texas, Austin, TX, United States of America

There are limited data on intra- and interspecific osteological variation for many squamate clades. These data are relevant for phylogenetic analyses that use osteological characters and for taxonomic placement of fossils in a phylogenetic context. We investigate whether morphological features in the skulls of extant gerrhonotine lizards can be used to distinguish taxa at the species level, and assess whether newly discovered intra- and interspecific osteological variation alters the utility of previously reported apomorphic characters. We examine skulls of species belonging to the gerrhonotine genera *Elgaria* and *Gerrhonotus*. These genera contain 15 extant species; however, the cranial osteology of relatively few species was previously examined. This is partly because there is little to no skeletal data available for most species. As a result, intra- and interspecific osteological variation within this group of lizards is poorly understood. We employed high-resolution x-ray computed tomography to scan alcohol-preserved specimens. We provide data on the skulls of all species of *Elgaria*, five for the first time, and three species of *Gerrhonotus*, two for the first time. We used 3-D reconstructed skulls of the scanned specimens as well as dry, traditionally prepared skeletons to report on intra- and interspecific variation found in previously reported morphology. We present previously undescribed morphology of the skulls of these lizards. Novel morphology includes the presence of a foramen on the prootic previously unknown in gerrhonotines and the presence of a ventral spur on the vomer previously reported only in *Diploglossus* and *Ophiodes*. Our results show that there exist morphological features that can readily diagnose different species. Several of these features are present on isolated cranial elements commonly recovered as fossils, including the premaxilla, frontal, parietal, and surangular. We found that the utility of many previously described morphological features is impacted because of previously unreported intra- and interspecific variation as well as bilateral asymmetry within single specimens. Our findings highlight the importance of documenting variation and using large sample sizes. Our results also demonstrate the utility of examining disarticulated cranial elements in the squamate skull for identifying morphology that can be used to distinguish taxa.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A NEW SMALL OVIRAPTORID DINOSAUR (DINOSAURIA, THEROPODA) FROM THE NEMEGT FORMATION (LATE CRETACEOUS) OF MONGOLIA

LEE, Sungjin, Seoul National University, Seoul, Korea, Republic of (South); LEE, Yuong-Nam, Seoul National University, Seoul, Korea, Republic of (South); CHINSAMY-TURAN, Anusuya, University of Cape Town, Cape Town, South Africa; LÜ, Junchang, Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China; BARSBOLD, Rinchen, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; TSOGTBAATAR, Khishigjav, Institute of Paleontology and Geology, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

Oviraptorosaurs are a bizarre group of theropod dinosaurs with distinctly short and deep skull and edentulous jaws in derived forms. Although they are known only in Asia and North America, they include more than 30 genera most of which are members of one of the two diverse families: Caenagnathidae and Oviraptoridae. While caenagnathids are found in both continents, oviraptorids have occurred exclusively in Asia, especially Mongolia and China. The Nemegt Basin in the Mongolian Gobi Desert has yielded numerous dinosaur taxa including several oviraptorids, reflecting their high diversity in this region. In 2008, the Korea-Mongolia International Dinosaur Expedition (KID) team found an oviraptorid specimen of a relatively small size associated with other theropod skeletons. The oviraptorid specimen consists mostly of crushed and disarticulated cranial and postcranial elements. It represents a new oviraptorid taxon and has a unique set of characters that distinguish it from other oviraptorids, such as the massive symphyseal shelf that is continuous with rudimentary lingual shelves, a strap-like coronoid bone, and proximal caudal vertebrae with more than one infraprezygapophyseal fossae. In particular, the unique dentary structure of this new oviraptorid is noteworthy. The symphyseal shelf is unusually thick without any ridge or groove. It extends caudally on the sides to become lingual shelves which are medially demarcated by shallow lingual ridges. The lingual shelves also bear a row of small occlusal grooves which must have met the ones on the ventral surface of the premaxilla when the beak is closed. None of these characters has been known in other oviraptorids, but many present in derived caenagnathids although their lingual shelves and ridges are more prominent. This could be, therefore, a case of convergence between them. The massive symphyseal shelf also provides a clue about the diet of the new oviraptorid, because it is suitable for crushing hard material rather than shearing. The phylogenetic analysis shows distant relationships among Nemegt oviraptorids and indicates that the new taxon is closer to three taxa from southern China than to any oviraptorid in the Nemegt Basin. Consequently, the new taxon increases oviraptorid diversity in the Nemegt Formation and confirms abundance of oviraptorids in a wet environment.

Grant Information
Funding for this project was granted by the National Research Foundation of Korea (grant number 2016R1A2B2015012) to Yuong-Nam Lee.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

SOFT-TISSUE IMPRESSIONS AND ORGANIC INCLUSIONS IN A LARGE THEROPOD COPROLITE DEPOSIT FROM THE LARAMIE FORMATION OF COLORADO

LEPORE, Taormina, The Webb Schools and Raymond M. Alf Museum of Paleontology, Claremont, CA, United States of America; CHIN, Karen, University of Colorado Boulder, Boulder, CO, United States of America; ROBINSON, Peter, University of Colorado

Boulder, Boulder, CO, United States of America; CULVER, Toni, University of Colorado Boulder, Boulder, CO, United States of America; FRAZIER, Frank, Deceased, Boulder, CO, United States of America

Coprolites provide an important window into paleoecological reconstruction and our understanding of the diets of ancient organisms. Here we analyze the presence of a variety of inclusions and tissue impressions within a large coprolite deposit from the Maastrichtian-aged Laramie Formation of eastern Colorado. The deposit is highly weathered, and includes 170 cream-colored fragments, with individual pieces ranging up to 40 centimeters in diameter. Examination of all fragment surfaces with a stereo microscope provided a non-destructive way to explore many views of the specimen that would not ordinarily be exposed in an intact coprolite. Select fragments were analyzed using low vacuum scanning electron microscopy (LVSEM) and optical emissions spectroscopy (OES) bulk chemical analysis of major elements. OES returned averages of 24.0 wt. % P_2O_5, 33.2 wt. % CaO, 2.61 wt. % SiO_2, and 2.75 wt. % Al_2O_3. This is consistent with mineralization by calcium phosphate and relatively small amounts of associated clay. The coprolite preserves a variety of refractory inclusions and soft tissue impressions; 324 examples of such features were documented. Common inclusions in the coprolite fragments include unidentified carbonaceous material (38%); wood (30%); and comminuted bone (21%). Striated, undulating impressions make up 4% of the inclusions/impressions and are inferred to be casts and molds of muscle cells, based upon size and morphology. Unidentified tissue impressions were present in 58% of fragments, including papillated and tube-like morphologies. The capacity of coprolites to preserve soft tissue impressions lends unique paleobiological perspectives—both in terms of diet and contemporaneous biota, as phosphatized feces can preserve impressions of the surrounding detritus. The large size of the deposit, phosphatic composition, comminuted bone, and apparent muscle tissue impressions point to a carnivorous producer, likely a tyrannosaurid dinosaur, the largest of the known Maastrichtian terrestrial predators. A morphotype road-map for coprolitic inclusions and impressions will facilitate description and identification of these features in future work.

Grant Information
Funding for this project was generously provided by the University of Colorado Museum Student Research award.

Podium Symposium (Wednesday, October 17, 2018, 3:45 PM)

OSTEOLOGICAL CORRELATES FOR CRANIAL SOMATOSENSATION IN PSEUDOSUCHIANS

LESSNER, Emily J., University of Missouri, Columbia, MO, United States of America; HOLLIDAY, Casey M., University of Missouri - Columbia, Columbia, MO, United States of America

The pseudosuchian and subsequent crocodylomorph radiation resulted in numerous lineages exhibiting a diversity of body forms and occupying multiple niches. Crocodylians, the surviving pseudosuchians, exhibit rostra housing a specialized somatosensory system suited to their semiaquatic lifestyle. Maxillary and mandibular divisions of the trigeminal nerve and associated vasculature course through bony canals in the maxillae and dentaries, exiting the bone through foramina where nervous branches terminate in numerous integumentary sensory receptors. Bony features of this system are often used to infer facial sensation in dinosaurs, crocodylomorphs, and other vertebrates though distribution of these features and their phylogenetic and physiological significance are unclear. To understand this system in extinct pseudosuchians, we investigated possible osteological correlates for integumentary innervation using standard and contrast CT, whole mount staining, histology, and dissection of of seven extant and six fossil species. Comparing dentary surface area and volume, tooth and foramina numbers, and neurovascular canal volume, we found differences between terrestrial and semiaquatic taxa. Dentary surface area is representative of the area of potential integumentary innervation and blood supply by neurovasculature in the mandibular neurovascular canal. We define a ratio (dentary surface area:dentary neurovascular volume) as the integumentary innervation index (I). A low I indicates each unit of canal contents is distributed across a smaller region of dentary surface, implying a more densely innervated surface. A less densely innervated surface is interpreted for a high I. Historically, a low rostral foramina count is interpreted to signify lack of sensitivity, though the terrestrial taxa tested have fewer foramina yet a lower I, whereas semiaquatic taxa have more foramina but a higher I. Also, semiaquatic taxa have smaller percentages of dentary volume occupied by neurovascular canal. The percentage of dentary occupied by neurovascular canal appears more closely correlated to tooth number than foramina number across all taxa investigated. Though these results suggest somatosensory ecology and evolution play a role in these patterns, additional data on allometry and proximal trigeminal morphology are necessary to better understand how facial sensation evolved in the lineage. These findings will help uncover patterns of somatosensory ecology and evolution in not only Pseudosuchia but also dinosaurs and sauropsids.

Grant Information
NSF EAR 163753, NSF IOS 1457319

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

STERNBERG EARTH AND LIFE SCIENCE ACADEMY: A MULTI-TIERED APPROACH TO YOUTH OPPORTUNITY ACCESS

LEVERING, David A., Sternberg Museum of Natural History, Hays, KS, United States of America

Kansas is dominated by small, underserved rural communities with few economic or structural resources for students interested in pursuing earth and/or life science fields in college, or as a career. Lack of resources, developmental experiences, and relevant resume-building opportunities can put students from economically stressed rural communities at a sharp disadvantage to their peers from urban/suburban settings with greater resource access. For these students, building credentials and capabilities that will make them more competitive with their more affluent peers is crucial to improving their chances of successful entry into the STEM job market. In 2014, the Fort Hays State University (FHSU) Sternberg Museum of Natural History started a series of outdoor science education camps aimed at youths and teens, instructed by Museum staff and specialist outside hires in an attempt to address these disparities in resource access.

This program is defined by five objectives: Objective 1: Offer robust, engaging, high-quality science camps with an affordable tuition; Objective 2: Balance academic rigor with hard and soft skill development; Objective 3: Provide built-in advancement opportunities for alumni, including paid positions during the school year and summer; Objective 4: Long-term mentorship and networking access available to student alumni; Objective 5: Continued program expansion to increase resource availability andreach.

Over the past five years, the program has grown from accepting a small handful of Kansas students, to students nation-wide. This expansion is a key component of our goal to provide an outdoor camp experience on par with or better than any other in the country, at lower tuition rates. This pulls students - and financial resources—from larger urban centers into Kansas. Tuition paid in full by students from higher income families subsidizes overall program costs, improving accessibility for students from low income families in Kansas and around the US. As the program expands, we increase our reach and availability of resources for all of our students, with special emphasis on those from high-need backgrounds. Our goal is to create a nationally visible, leading program in field science education that actively facilitates access for underrepresented groups in underserved communities. So far, our model is working as designed. Our biggest obstacle is broadening awareness outside the Central Plains. Thanks to five years of exceptional programs and fantastic students, we are well on our way to our programobjectives.

Grant Information
This project was funded through two crowdfunding campaigns, private donors from Kansas, a Paleontological Society grant, and ongoing donor support from our alumni families.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

OSTEOLOGY OF *MANCHUROCHELYS MANCHOUKUOENSIS* BASED ON A NEW SPECIMEN, AND PHYLOGENETIC RELATIONSHIPS OF EUCRYPTODIRAN TURTLES

LI, LAN, Beijing, China; GAO, KE-QIN, Peking University, Beijing, China; ZHOU, CHANG-FU, Shandong University of Science and Technology, Qingdao, China

Represented by more than 230 extant species, Cryptodira (sensu stricto) are the most diverse group of turtles, tripling the species number of their sister clade Pleurodira. Fossils of stem cryptodires have been reported mostly from the Jurassic and Cretaceous beds in Asia, with a few taxa known from the Lower Cretaceous in North America and Jurassic in Europe. These fossil forms are classified in a more inclusive clade Eucryptodira (Cryptodira plus their fossil relatives). However, conflicting phylogenetic hypotheses of the Cryptodira resulting from morphological versus molecular data impede our understanding of the evolution of cryptodires, and the situation is further deteriorated by the disputed relationships of basal eucryptodires.

Manchurochelys manchoukuoensis, known by fossils from Jehol Biota, is placed as one of stem eucryptodires by previous studies. However, the holotype (reportedly lost) lacks a skull with a large part of both carapace and plastron missing as well. All other specimens (two adults and a juvenile) known so far were preserved without a plastron. In this study, μCT scan of a nearly complete specimen of *M. manchoukuoensis* from the Lower Cretaceous Yixian Formation inwestern Liaoning Province provides previously unknown information on the skull and palate: lingual ridge absent, fenestra postotica opening ventrally and open incisura collumellae auris as primitive characters, internarial septum on the single vomer absent, quadrate process of the pterygoid without concavity. The well-preserved cruciform plastron presents a triangular anterior lobe and a greatly elongated, parallel-sided posterior lobe, and displays one median and two slit-like lateral plastral fontanelles with its entoplastron transversely extending to separate the epiplastra from the hyoplastra. The long first costal rib is a primitive carapace character.

To test the impact of molecular data on phylogenetic relationships of eucryptodires, this study conducts analyses of morphology data and morphology-molecular combined data with inclusion of both fossil and extant turtles. Both morphology and combined analyses recovered a monophyletic clade consisting of the Xinjiangchelidae and Sinemydidae as a stem lineage of Cryptodira. Within this clade, *M. manchoukuoensis* is grouped with *Sinemys* and *Dracochelys*. Our total evidence analysis improves the resolution of basal eucryptodires compared to morphology analysis, and implies the potential of integrating molecular data with morphological data to improve turtle phylogenetic analysis.

Grant Information
Funded by National Natural Science Foundation of China (grant 41672003)

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

CRANIAL OSTEOLOGY OF *BEIPIAOSAURUS INEXPECTUS* (THEROPODA, THERIZINOSAURIA)

LIAO, ChunChi, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

Beipiaosaurus inexpectus is an early-branching therizinosaurian theropod known from the Lower Cretaceous Yixian Formation of the Sihetun Locality near Beipiao, Liaoning, China. Despite being a key taxon for understanding the early evolution of therizinosaurians, it has never been fully described since the brief report naming the taxon that published in 1999. Here we present a detailed description of the cranial anatomy of the holotype specimen of *Beipiaosaurus inexpectus*, the only known specimen that can be definitively referred to the taxon. The newly acquired data is particularly important for understanding therizinosaurian cranial evolution, given that the cranial materials are rarely preserved in this clade or yet described in detail. The cranial features of *Beipiaosaurus inexpectus* are in general consistent with its proposed systematic position, an intermediate position between *Falcarius* and *Jianchangosaurus* and most other therizinosaurians, but some cranial features are apomorphic. We discuss the implications of the new data for understanding the cranial evolution of Therizinosauria and of the more inclusive Maniraptora.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE LATE CENOZOIC TURTLE *MEIOLANIA PLATYCEPS* WAS AQUATIC

LICHTIG, Asher J., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America; LUCAS`, Spencer G., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America

The Australian turtle *Meiolania* from the Pleistocene of Lord Howe Island has long been suggested to be terrestrial. This was largely based on general appearance and the assumption that limb osteoderms are a trait exclusive to terrestrial turtles. This assumes that other, similarly shaped spiny protrusions of the tail, such as those in *Chelydra serpentina,* which are made of keratin, are a separate issue, though these would function in the same manner if made of bone. The extant tortoises that bear the osteoderms this comparison is based on have armor on the limbs and, in rare cases, only on the dorsal side of the tail. This change in the distribution of osteoderms results from a change in their function. Tortoise limb armor is used to defend soft body parts pulled into the shell while immobilized. *Chelydra's* spines provide defense while fully mobile and allow the benefits of a long, hydrodynamically efficient tail while alleviating some of the predation risk this imposes. Analyzing the habitus of *Meiolania* based on limb proportions, shell shape, and femoral morphology suggests that it was an aquatic turtle similar in all these morphologies to *Chelydra*. The round shape of the femoral head indicates a walking mode of locomotion, as is seen in the bottom walking of *Chelydra*. Furthermore, the plastral fontanelle is not known in any turtle suggested to be terrestrial. A "tail club" has been suggested to indicate a terrestrial habitus, as swinging this as a weapon would be difficult to impossible in the water. This ignores the fact that the tail "clubs" of *Meiolania* and *Proganochelys* are too narrow to be used as a club. The body of the tail would contact a target before the "club's" impact, reducing the effect of any strike. In addition, no extant terrestrial turtle has such a large tail, but this is exactly what is seen in the bottom walking *Chelydra* and *Platysternon*. This is the first time quantitative measurements have been applied to this question, and there is no substitute for actual measurements and analysis. *Meolania platyceps* is an aquatic turtle, and this calls into question the presumed ecology of the Meiolaniidae, as this has largely been extrapolated from this one, most completely known species.

Technical Session IV (Wednesday, October 17, 2018, 4:00 PM)

REGIONAL EXTINCTIONS OF SOUTH AMERICAN PLEISTOCENE MEGAFAUNA: TAXONOMIC AND BIOGEOGRAPHIC PATTERNS AND INTERACTING EFFECTS OF HUMANS AND ENVIRONMENTAL CHANGES

LINDSEY, Emily, La Brea Tar Pits and Museum, Los Angeles, CA, United States of America; VILLAVICENCIO, Natalia, Universidad Católica de Chile, Santiago, Chile; MYCHAJLIW, Alexis, Stanford Univ, Los Angeles, CA, United States of America; DAVIS, Edward B., University of Oregon, Eugene, OR, United States of America; CAPRILES, Jose, The Pennsylvania State University, State College, PA, United States of America; GOLDBERG, Amy, University of California - Berkeley, Berkeley, CA, United States of America; MARSHALL, Charles, University of California - Berkeley, Berkeley, CA, United States of America; STAFFORD, JR., Thomas W., Stafford Research Labs, Inc., Lafayette, CO, United States of America; GUILDERSON, Tom, Lawrence Livermore National Laboratories, Livermore, CA, United States of America; BARNOSKY, Anthony D., University of California Berkeley, Berkeley, CA, United States of America

The late Quaternary megafaunal extinction event (LQE) represents the greatest faunal change that terrestrial ecosystems experienced during the Cenozoic, but the causes and dynamics of this event remain intensely debated. One obstacle to consensus, and to applying the lessons of this collapse to our current biodiversity crisis, is that most studies seek a single cause for the extinctions, and focus on either very broad or very local geographic scales. Here we present the first study to investigate the LQE from a regional perspective, integrating multiple regions across a continent. We focus the study on South America, where the LQE was latest, most severe, and coincided closely with both human migrations and end-Pleistocene climate changes.

We assembled a database of >230 vetted radiocarbon dates on extinct South American megafauna, including ~50 new, high-quality ultrafiltration and XAD dates. We statistically estimated 'true' extinction times for taxa, and compared taxonomic and geographic chronologies of extinctions with detailed regional and continental-scale records of human population dynamics and climate and vegetational change. We used a non-linear least squares analysis to determine whether human activities, climate change, or both correlated with these regional extinctions, and whether or not there was any synergistic interaction between the two.

Across taxa, inferred extinction times were earlier in Patagonia, southern Chile, and the Andes cordillera, and later in the Pampas region and coastal Brazil. On both regional and continental scales, Proboscideans and Meridiungulata disappeared first, while Xenarthrans persisted later than other extinct taxa.

Surprisingly, no region showed a close correlation between inferred local human population size and megafauna extinction rate. Inferred extinction times coincided closely with some climate proxies in Patagonia and the Andes, but not in other regions. We found evidence for both climate impacts and human-climate synergy in the Pampas region.

Taken together, these data suggest that high-altitude and high-latitude regions most sensitive to climate warming may have lost megafauna early, and in concert with late Quaternary climate changes. Meanwhile, other regions with more stable climate, like the Pampas, may have served as temporary refugia. While humans may have been the ultimate driver of continental extinctions, their direct impacts would have been drawn out, potentially driving megafauna populations to tipping points following thousands of years of coexistence.

Grant Information

This research was supported by National Science Foundation grant EAR-1148181 to Anthony D. Barnosky.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

DO EPIGENETICS AFFECT MORPHOLOGICAL CHARACTERS AND INFLUENCE PHYLOGENETIC RECONSTRUCTIONS IN BIRDS AND NON-AVIAN DINOSAURS?

LIPPINCOTT, Kaitlyn E., University of Pittsburgh at Johnstown, Johnstown, PA, United States of America; MCINTOSH, Logan E., University of Pittsburgh at Johnstown, Johnstown, PA, United States of America; LARSSON, Hans C., McGill Univ, Montreal, QC, Canada; DECECCHI, Alexander, University of Pittsburgh at Johnstown, Johnstown, PA, United States of America

Morphological data informs all aspects of our understanding of the paleobiology, paleoecology, and phylogenetic relationships among fossil organisms. Recently we have seen an increasing push to ever larger morphological character datasets, sometimes into the thousands of individual characters, which atomize an animal into smaller and smaller discrete, and theoretically independent, units. One underlying assumption to this is that all these distinct morphologies are suspected to be linked to be modification in the genotype, but recent work has shown that environmental factors can produce heritable changes in the phenotype without changing its underlying genetic makeup. Embryonic muscle activity is known to influence the retroversion of the hallux, a previously purported critical adaptation to arboreal life across the theropod to bird transition, from the plesiomorphic condition seen in basal theropods. Here we use pharmacological methods to paralyse chick embryos in early development to examine how epigenetic influences alter the expression of key anatomical characters. Findings include shifts in limb allometry, with the forelimbs being significantly reduced in length relative to the hindlimb, along with reduction of loss of ossification such as a decrease in the retroarticular process length and reduction in the level of uncinate processes development. The results of this study provide valuable insight into a potentially underappreciated method for producing morphological diversity seen among stem avians. They also suggest we should incorporate non-genetic factors into how we view the characters, their plasticity, and evolvability, and how to incorporate that information into the origins and early history of birds and flight.

Technical Session II (Wednesday, October 17, 2018, 8:45 AM)

THE EARLIEST ICHTHYOSAUR FROM THE MIDDLE LOWER TRIASSIC OF THAILAND

LIU, Jun, University of Bonn, Bonn, Germany; SANDER, P. M., University of Bonn, Bonn, Germany; SAMATHI, Adun, University of Bonn, Bonn, Germany; CHANTHASIT, Phornphen, Sirindhorn Museum, Sahatsakhan, Thailand

Biotic recovery from the Permian/Triassic mass extinction was accompanied by the invasion of the sea by several reptilian groups. Arguably the most important among these lineages is the ichthyosaurs. The ichthyosaur *Thaisaurus chonglakmanii* was discovered at a limestone hill in the southern peninsula of Thailand, of putative Triassic age. Since its first brief description, however, *T. chonglakmanii* has never been restudied in detail, and its exact stratigraphic and phylogenetic position remained elusive. Here we revisit the well prepared holotype specimen of *T. chonglakmanii*. The humerus of the holotype measures 21 mm long, suggesting a total body length of about 0.9 meter by extrapolation. This is even slightly smaller than the adult *Chaohusaurus* specimens from the Lower Triassic of South China, which was commonly taken as the smallest ichthyosaur before. Extensive cranial bone fusion and well-ossified limb bones, however, indicate an adult stage of the holotype specimen of *T. chonglakmanii*. Several characters suggest a much generalized morphology of *T. chonglakmanii* among ichthyosaurs, including notably the absence of the anterior terrace of upper temporal fenestra and an elongated humeral shaft without anterior flange. Parsimony analysis based on a published data matrix suggests the basal-most phylogenetic position of *T. chonglakmanii* among ichthyosaurs. Field reconnaissance combined with a published conodo nt study confirms a late Induan (Dienerian)–earliest Olenekian (early Smithian) age (*Sweetospathodus kummeli-Neospathodus waageni* zone) for the *Thaisaurus* locality, which corresponds well with the basal phylogenetic position of the taxon. This is the earliest record of Mesozoic marine reptiles, two million years earlier than the earliest previous record. Our result thus indicates that ichthyosaurs invaded the tropical waters at least as early as the Dienerian, when the sea surface temperature was relatively cool and the Refuge Zone was enlarged. The generally small body size of Early Triassic ichthyosaurs in the tropical oceans supports the inference of a stressed environment in the upper water column during most of the Early Triassic.

Grant Information

NSFC grants No. 41772003, 41402015; NIGPAS grant No. 173117; Humboldt Foundation

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE FIRST COMPLETE PAREIASAUR SKULL FROM CHINA AND ITS IMPLICATIONS FOR THE TAXONOMY OF CHINESE PAREIASAURS

LIU, Jun, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; YI, Jian, Shanxi Museum of Geology, Taiyuan, China; BEVER, Gabriel S., Johns Hopkins University School of Medicine, Baltimore, MD, United States of America

Pareiasaurs are a diverse group of large-bodied, herbivorous reptiles that were likely significant components of middle- and late-Permian terrestrial communities worldwide. The Asian record of these animals lags far behind those of the more intensively studied South African and Russian faunas, although recent discoveries reinforce the idea that the Permian of China holds great potential for informing broad-based patterns of pareiasaur phylogeny and biogeography. Realization of this potential will require the collection and description of better-preserved, articulated skulls. One such specimen was collected recently from the Ordos Basin, Sunjiagou Formation of Shanxi Province. The large, nearly complete skull with occluding lower jaw is characterized by a derived ornamentation that indicates an affinity with Elginiidae. This includes a cheek plate lined with prominent conical horns and a series of elongate horns extending from the cranial roof. The latter includes a posterolaterally projecting supratemporal horn. An elginiid diagnosis is further supported by a slender parabasisphenoid with a median, ventral groove, and enlarged tabulars (supernumerary bones) that contact each other medially and thereby exclude the postparietal from the caudal margin of the skull roof. The new specimen is significantly larger than *Arganceras* or *Elginia*, establishing a new size range for the clade. Referral to *Sanchuansaurus* is supported by a small maxillary boss posterior to the naris and a fan-

shaped crown on the maxillary teeth that includes 9 to 11 cusps. The morphology of the lower jaw, most notably the shape of the angular, suggests *Sanchuansaurus* and *Huanghesaurus* are closely related. This hypothesis is supported by our phylogenetic analysis.
Grant Information
National Natural Science Foundation of China (41572019)
State Key Laboratory of Palaeobiology and Stratigraphy (20161101)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

MODELING THE PHYLOGENETIC AND MORPHOLOGICAL DIVERSIFICATION OF MOSASAURINAE: INSIGHTS FROM TWO NEW GENERA FROM THE WESTERN INTERIOR SEAWAY

LIVELY, Joshua R., The University of Texas at Austin, Austin, TX, United States of America

I discuss the diversification of mosasaurine mosasaurs with a focus on two new genera from the Cretaceous Western Interior Seaway. Mosasaurs are marine lizards that traditionally are divided into four sub-familial clades, with the most diverse of those being the Mosasaurinae. Though the early history of the clade was represented by low taxonomic diversity, exemplified by taxa typically referred to *Clidastes*, mosasaurines diversified into numerous lineages during the Campanian and Maastrichtian, including the genera *Mosasaurus, Plotosaurus*, *Globidens*, *Prognathodon*, and *Plesiotylosaurus*. A new mosasaurine from the Campanian of Texas and Alabama and a redescription of '*Prognathodon' stadtmani* help to contextualize that diversification from both anatomical and phylogenetic perspectives.

To place these taxa into an evolutionary context, I scored a combination of published and novel discrete characters for Mosasaurinae and performed a phylogenetic analysis to form a hypothesis of relationships within the clade. To model occupancy of morphospace through time, I ran a principal coordinates analysis for temporally equivalent time bins throughout the Late Cretaceous using my matrix of discrete characters. I added variable and autapomorphic characters to the dataset to more completely model morphospace and morphological evolution.

Through the Coniacian and Santonian, mosasaurines occupied a narrow region of morphospace. Anatomical diversity increased dramatically in the early and middle Campanian, coinciding with an increase in taxonomic diversity and the co-occurrence of early-diverging mosasaurines, *'Prognathodon' stadtmani*, the new mosasaurine, and other highly-nested taxa including *Globidens* and *Mosasaurus*. In the late Campanian and Maastrichtian, continued high disparity coincided with high global taxonomic diversity, though the morphospace previously occupied by early-diverging mosasaurines was vacated by the clade. From a phylogenetic perspective, '*Prognathodon' stadtmani* and the new mosasaurine from Texas and Alabama help to contextualize the complex pattern of early Campanian diversification. Both taxa respectively possess a unique combination of plesiomorphic and derived character states and exemplify the homoplasy present in Mosasaurinae and mosasaurs broadly. Many of the characters previously optimized as synapomorphies for mosasaurine clades, including those related to the dentition and quadrate, are instead homoplastic and likely reflect similar paleoecology rather than shared ancestry.

Grant Information
Evolving Earth Foundation, Texas Academy of Science, Geological Society of America, Lundelius Award in Vert. Paleo., Jackson School of Geosciences, Christopher J. Bell

Technical Session IX (Friday, October 19, 2018, 12:00 PM)

DENTAL TOPOGRAPHIC CHANGE WITH WEAR IN THE EARLY MIOCENE STEM CERCOPITHECOID *NOROPITHECUS BULUKENSIS* (PRIMATES, VICTORIAPITHECIDAE) AND A COMPARISON WITH EXTANT CERCOPITHECIDAE

LOCKE, Ellis M., Arizona State University, Tempe, AZ, United States of America; NENGO, Isaiah, Turkana Basin Institute, Stony Brook, NY, United States of America; SCHWARTZ, Gary T., Arizona State University, Tempe, AZ, United States of America

As in all herbivorous mammals, primates face selective pressures to maintain function of their permanent dentition in the face of tooth wear from attrition, abrasion, and chemical erosion. Some folivorous primates maintain the three-dimensional (3D) length of molar shearing crests until extreme stages of wear are reached, while others maintain lifelong shearing capacity by forming compensatory shearing crests along regions of exposed dentine. Molar 'shear crest maintenance' may be an adaptation in folivorous primates for consuming high quantities of tough vegetation. No study, however, has determined whether this phenomenon is exclusive to folivorous primates or whether it also characterizes tooth wear in primates more generally.

Here we examine changes in relative 3D shearing crest lengths (3D SCL) and two additional topographic measurements associated with shearing, relief index (RFI) and slope, across a wear series of m2s of the stem cercopithecoid *Noropithecus bulukensis* from the early Miocene locality of Buluk, Kenya. Stem cercopithecoids are reconstructed as highly frugivorous, with shorter cusps and shear crests lengths than extant cercopithecids. Here, we examine how 3D SCL, RFI, and slope change with wear in *Noropithecus*, and compare this taxon with three extant cercopithecoids of varying diets: *Chlorocebus pygerythrus*, *Colobus guereza*, and *Macaca fascicularis*. Dental topographic parameters were measured in GRASS GIS (3D SCL and slope) and in R using the molaR package (RFI).

Our results show that RFI decreases with increasing percent dentine exposure (PDE) in all taxa, including *Noropithecus*, but the degree of this change is variable. Average slope also decreases steadily with wear in all taxa. 3D SCL differs from the other two variables in exhibiting differences with wear between taxa. *Noropithecus* exhibits a steady decrease in 3D SCL with wear, suggesting that dentine exposure in this taxon does not generate compensatory shearing crests. Shear crest maintenance was found in *Macaca* and *Colobus*, while 3D SCL decreases in the latest wear stages in *Chlorocebus*. In our preliminary study, we conclude that shear crest maintenance does not characterize all extant cercopithecoids, but the degree to which shear crest lengths are maintained with wear does not appear to be patterned by broad dietary differences between taxa. Further work is required to understand how food material properties and molar occlusal form covary in the context of selection on maintaining dental function in the face of wear.

Grant Information
The Institute of Human Origins Donald C. Johanson Endowment, The Leakey Foundation, The Turkana Basin Institute, National Geographic, and The Foothill De-Anza Foundation

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

THE THEROPOD ICHNOGENUS *SAUREXALLOPUS* BECOMES WIDELY KNOWN IN THE UPPER CRETACEOUS OF NORTH AMERICA

LOCKLEY, Martin, University of Colorado Denver, Denver, CO, United States of America

The theropod ichnogenus *Saurexallopus*, represented by three difficult-to-distinguish ichnospecies, is now known from seven Late Cretaceous (Campanian–Maastrichtian) localities in North America. Three named ichnospecies, *S. lovei* and *S. zerbsti* from Wyoming and *S. cordata* from British Columbia, all represent medium sized (foot length and width ~30 cm) slender toed trackmakers with wide digit divarication angles (II–IV) and a long variably oriented hallux (digit I). None are known from well-defined trackways. Three other reports, labelled *Saurexallopus* isp. indet. from Colorado include one assemblage of large well-preserved tracks in which hallux and metapodial traces are rarely preserved. The Colorado localities also yield relatively large tracks (foot length and width ~30 cm). Reinvestigation of a Late Cretaceous tracksite in Utah indicates that the tetradactyl tracks formerly labeled as "bird" footprints (i.e., avian theropod tracks) are morphologically indistinguishable from *Saurexallopus*, except for size (foot length and width ~ 10–20 cm). This site, regarded as the seventh known *Saurexallopus* occurrence, provides new information on the size range of the ichnogenus, and may help infer trends in trackmaker ontogeny. Since the ichnogenus was first reported in 1966, it has been found at seven sites, all in the Upper Cretaceous (Campanian–Maastrichtian) of North America. Thus it appears widespread and characteristic at this time. It has been proposed that the trackmakers were oviraptosaurids.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

THE PRESENCE OF MULTIPLE LINEAGES OF TYRANNOSAURS IN THE UPPER JURASSIC MORRISON FORMATION, U.S.A., DEMONSTRATES EARLY COSMOPOLITANISM IN TYRANNOSAUROIDEA

LOEWEN, Mark A., University of Utah and Natural History Museum of Utah, Salt Lake City, UT, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America; NORELL, Mark A., American Museum of Natural History, New York, NY, United States of America

The earliest documented members of Tyrannosauroidea appeared during the Middle to Late Jurassic in several sites across the northern hemisphere, with recent discoveries in Europe and Asia providing critical new information about the origins of this significant theropod clade. Recently recognized historic specimens from the Late Jurassic Morrison Formation Cleveland-Lloyd Dinosaur Quarry, including portions of the skull, can now be confidently referred to the enigmatic tyrannosauroid *Stokesosaurus clevelandi*. Analysis of these remains suggests a close relationship with the basal European tyrannosauroids *Juratyrant* and *Eotryannus*. Originally identified as a juvenile specimen of *Allosaurus*, new fossils recovered from the Morrison Formation of Wyoming instead likely represent a new tyrannosauroid taxon phylogenetically closer to the earliest representatives of the clade including *Kileskus, Proceratosaurus,* and *Guanlong*. The new taxon is represented by a partial left maxilla and dentary, both exhibiting adult surface texture in a skull that would have been approximately 35 cm long. The maxilla is characterized by a lancelate anterior ramus, a long intrafenestral strut twice as long as the anterior ramus, and a large antorbital fossa that extends ventrally to almost the ventral edge of the maxilla. In overall external morphology, the maxilla compares favorably with *Kileskus, Proceratosaurus,* and *Guanlong*. Medially, the maxilla exhibits a pronounced palatal process positioned opposite the ventral edge of the antorbital fossa similar to that of *Dilong* and *Kileskus*. The anterior end of the palatal process has 5 occlusal pits for accepting the dentary teeth. The dentary has a pattern of vascular foramina radiating from a lateral line anteriorly, similar to *Proceratosaurus* and *Guanlong*. This new specimen demonstrates that at least two distinct tyrannosauroid lineages, formerly considered to be present only in Europe and Asia, can now be documented in the Morrison Formation of North America, illustrating the widespread distribution of early tyrannosaurs in Laurasia. The new specimen further underscores the exceptional phylogenetic richness of the Morrison Formation theropod assemblage, with representatives now currently documented from nearly every major averostran clade. This richness appears to mirror other significant Upper Jurassic dinosaur radiations, setting the stage for later Cretaceous dinosaur faunas across Laurasia.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

A NEW PACHYRHIZODONTID FISH (ACTINOPTERYGII, TELEOSTEI) FROM THE UPPER CRETACEOUS EAGLE FORD GROUP OF TEXAS, U.S.A.

LONDON, Maxwell G., DePaul University, Chicago, IL, United States of America; POLCYN, Michael J., Southern Methodist University, Dallas, TX, United States of America; SHIMADA, Kenshu, DePaul University, Chicago, IL, United States of America

SMU 76938 is a fossil skeleton of a large, nearly complete actinopterygian bony fish housed in the Southern Methodist University in Dallas, Texas, U.S.A. It was collected in the late 1980s from Upper Cretaceous (middle Cenomanian, ~96 Ma) sediments in Tarrant County, Texas, an area near the western margin of the East Texas Embayment. Although parts of the skull and dorsal fin are damaged, the vertebral column is nearly complete with a total count of at least 54 (no more than 58) centra, and the caudal fin is well preserved, including its soft tissue outline. The fish has a fusiform body plan and measures about 93 cm, 109 cm, and 119 cm in standard length, fork length, and total length, respectively, and about 17 cm in maximum body depth. Several features of the caudal fin are reminiscent of Cretaceous pachyrhizodontids, including the presence of six or less uroneurals (the first being forked anteriorly), seven or less hypurals, and a hypurapophysis. In the skull, the posterior end of the infraorbital plate is expanded, reaching the anterior region of the opercle, and infraorbitals one and two are fused with possibly a second fusion between infraorbitals four and five. Each upper jaw contains an elongate supramaxilla, and the quadrate-mandibular articulation is placed posterior to the posterior margin of the orbit.

The dentition is villiform where each tooth is small, measuring no more than 1.5 mm in height, and is conical with a lingual curvature. The villiform configuration of the teeth is in striking contrast to typical pachyrhizodontids that have teeth generally aligned in a single row. The combination of these anatomical characters in SMU 76938 is unique, suggesting that the specimen likely belongs to a new taxon within the family Pachyrhizodontidae.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

NEW SPECIMENS OF THRYONOMYIDAE (RODENTIA) FROM THE EARLY MIOCENE OF KALODIRR (KENYA)

LÓPEZ-ANTOÑANZAS, Raquel, Institut des Sciences de l'Évolution-UMR 5554, Université de Montpellier, Montpellier, France; GROSSMAN, Aryeh, Midwestern University, Glendale, AZ, United States of America

The early Miocene site of Kalodirr, in the West Turkana Region of Kenya, yielded a number of thryonomyid remains, including two excellently preserved specimens, KNM-WK 29940 (complete cranium) and KNM-WK 17080 (cranium and articulated hemimandible). These specimens resemble *Paraphiomys pigotti* and *P. renelavoti*, except for some differences such as the morphologies of the jugal bone and the rostrum. They are very different from *Thryonomys*, not only in being much smaller, but also in the lesser diameter of the infraorbital foramen, the position of the zygomatic process, and the internal pterygoid processes that are less developed dorsoventrally, to mention but a few features. The upper cheek teeth have their lingual side higher crowned than the labial one, a well-developed anteroloph and protoloph, a short- to medium-length mesolophule, and a tiny metaloph that joins the posteroloph. The mesoflexus is deeper than the paraflexus and metaflexus. The posteriorly reduced third upper molars are slightly different in having a long mesolophule and a metaloph indistinguishable from the posteroloph. The lower cheek teeth have complete metalophid, hypolophid, and posterolophid, a tiny metalophulid II, and an isolated anterolabial cuspid, but lack the anterolabial cingulum. The new specimens are larger than all thryonomyid species except for the largest ones (*Paraphiomys pigotti*, *P. occidentalis*, *P. simonsi*, *Neosciuromys africanus, N. fracta*, *Paraulacodus johanesi, Thryonomys swinderianus, T. gregorianus*), being significantly smaller than a few of them (*Neosciuromys africanus, Paraphiomys occidentalis, Paraulacodus johanesi, Thryonomys swinderianus, T. gregorianus*). Morphologically, they differ from *Neosciuromys* and *Paraphiomys simonsi* in having less hypsodont cheek teeth and a tiny but distinct metalophulid II on the lower molars. The presence of this structure also allows us to distinguish the new specimens from species belonging to genera such as *Apodecter*, *Kochalia, Paraulacodus,* and *Thryonomys* as well as from smaller species of *Paraphiomys*, such as *P. shipmani*, *P. afarensis, P. roessneri*, and *P. australis*. The new specimens strongly recall *Paraphiomys pigotti*, but the smaller size of their teeth as well as the slight differences in cranial morphology suggest they may pertain to a different species. Therefore, pending an assessment of the variation in size and cranial morphology across *Paraphiomys pigotti*, we incline to regard the specimens from Kalodirr as a new, relatively large, species of *Paraphiomys*.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE FIRST RECORDS OF PROTOSTEGIDAE IN MEXICO (LATE CRETACEOUS)

LOPEZ-CONDE, Oliver A., UNAM, Mexico City, Mexico; STERLI, Juliana, Trelew, Argentina; CHAVARRIA-ARELLANO, Maria L., UNAM, Mexico City, Mexico; ALVARADO-ORTEGA, Jesus, UNAM, Mexico City, Mexico; PORRAS-MUZQUIZ, Hector, Saltillo, Mexico

The Cretaceous record of Pan-Chelonioidea in Mexico was restricted to the clade Cheloniidae and to Coahuila state, but recent discoveries in the same state of Coahuila, Mexico, have increased the diversity incorporating three specimens belonging to Protostegidae. One of the turtles (MUZ-562) was collected in the Austin Formation (Campanian), near of the city of Jiménez. The other two specimens (MUZ-646 and MUZ 678) were collected in the Eagle Ford Formation (Turonian), near of the city of Melchor Múzquiz. Both formations are composed of marly limestones, exhibiting fine parallel lamination. The presence of a micritical matrix in the fossiliferous layers, as well as the preservation of the fauna, suggests that these layers could be deposited in an open marine shelf with oxygen depleted environment, under low energy regimes and rapid burial, which allowed the excellent preservation of the soft parts and skeletons of the rescued specimens. The new specimens of Mexico share some features with Protostegidae like the reduction in ossification of the carapace, plastron with bony plates a little heavier, in the peripheral plates the zone of insertion of the ribs is visible, nine ribs are observed in the carapace with eight costal plates, moderately reduced or highly vestigial costal plates, intercostal fontanelles, presence of medial keels in neural plates, plastron with or without epiplastron, T-shaped entoplastron, the hyoplastron and the hypoplastron with star-shaped edges, anterior fins larger than the posterior ones, and a short tail. Furthermore, the new discoveries of Protostegidae in Mexico expands the distribution of this taxon along the interior seaway of North America. Possibly this interior seaway acted as an important corridor where this group of turtles were distributed during the Cretaceous. The preliminary study of these new specimens from Mexico suggests that one of them (MUZ-562) could be assigned to *Desmatochelys* cf. *D. lowi* and the others two (MUZ-646 and MUZ 678) could belong to a new genus and species of Protostegidae.

Grant Information
CONACyT 545282

Technical Session VIII (Thursday, October 18, 2018, 3:30 PM)

THE PHYLOGENETIC POSITION OF THE ANAGALIDAE WITHIN EUARCHONTOGLIRES AND ITS IMPLICATIONS FOR THE EVOLUTION OF GLIRES AND EUARCHONTA

LÓPEZ-TORRES, Sergi, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland; FOSTOWICZ-FRELIK, Łucja, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland

The family Anagalidae is an enigmatic and poorly studied group of primitive members of Euarchontoglires known from the Paleogene of China. Anagalids were originally suggested to be closely related to modern treeshrews, lagomorphs, some primitive eutherian groups such as zalambdalestids and pseudictopids, and Macroscelidae (within the broader concept of 'Anagalida'), but that idea was later rejected, especially with growing evidence of molecular relationships among major mammalian clades and the generally accepted monophyly of Glires. The broader mammalian phylogenies rarely include anagalids, but a few occasionally place the group relatively close to Glires. So far only one preliminary phylogenetic analysis (based on 28 characters) of Anagalidae has been performed, resulting in the group's monophyly.

Our study presents a new, more comprehensive phylogenetic analysis based on 190 dental characters. It includes all species of anagalids (n = 19), as well as representatives of primitive plesiadapiforms, primitive euprimates, scandentians, lagomorphs, rodents, a pseudictopid (*Pseudictops*) and zalambdalestids, putting the group in the broader context of Euarchontoglires. The resulting strict consensus tree (based on 76 equally-parsimonious trees) disagrees with the previous conception of anagalid monophyly. Instead, anagalids are heavily paraphyletic, appearing as several offshoots at the base of Glires, which suggests that anagalids could be considered stem Glires. *Pseudictops* clusters with one of the anagalid offshoots, implying that pseudictopids could have potentially radiated from a group of primitive anagalids. Only two anagalids, *Wanogale* and *Interogale* (of previously questioned status), appear as members of the euarchontan branch. *Wanogale* groups with plesiadapiforms, implying that this taxon might not be an anagalid, and indeed the broad molar talonid and the presence of a precingulid (among other characters) suggests its possible euarchontan affinities. Similarly, *Interogale* appears as sister group to Euarchonta, questioning its original ascription to Anagalidae as well.

The better resolution of anagalid phylogenetic relationships simultaneously helps consolidate our understanding of early evolution of rodents and lagomorphs. The fact that not all described anagalids fall on the Glires branch questions what is primitive for both Euarchonta and Glires. Therefore, a clear resolution of anagalid relationships is critical to broader questions of the evolution of Euarchontoglires.

Grant Information
This research was supported by National Science Centre (Poland) grant No. 2015/18/E/NZ8/00637 to LFF.

Romer Prize Session (Thursday, October 18, 2018, 10:30 AM)

PRESERVATION AND FAUNAL CHANGE OF MAMMALS IN THE BARSTOW FORMATION, SOUTHERN CALIFORNIA, AND THEIR IMPLICATIONS FOR TURNOVER AT THE HEMINGFORDIAN–BARSTOVIAN BOUNDARY

LOUGHNEY, Katharine M., University of Michigan, Ann Arbor, MI, United States of America

The Barstow Formation of southeastern California preserves rich middle Miocene mammalian assemblages that form the basis of the Barstovian North American Mammal Age. In the Barstow Formation, the Hemingfordian–Barstovian boundary is characterized by an increase in large-mammal (> 1 kg) diversity and the lowest stratigraphic occurrences of several taxa. This increase in diversity coincides with a change in facies and depositional environments, indicating that specific facies may have higher potential to preserve vertebrate remains than others. I examined the effects of facies and depositional environment on the preservation of large-mammal fossils in the Barstow Formation. Depositional environments in the Barstow Formation changed through time in relation to the tectonic and climatic history of the basin. I identified six major facies associations in the formation that represent the dominant environments at the time of deposition. Over time, environments transitioned from playa lakes and alluvial fans to floodplain settings with wooded grasslands and wetlands.

In order to characterize changes in faunal composition and turnover through the formation, I compiled species abundance and occurrence information from 148 vertebrate localities. I used abundance data to calculate evenness for faunal assemblages and presence-absence data to calculate turnover and 80% confidence intervals on the stratigraphic ranges of 54 large-mammal species. From confidence intervals, I calculated inferred turnover of large mammals through the formation. Species body size and facies were important determinants of preservation potential; these features contribute to observed patterns in richness and evenness among facies associations, as well as species ranges through the formation. Observed lowest and highest occurrences clustered at specific stratigraphic intervals and correspond with facies transitions, including high observed turnover at the Hemingfordian–Barstovian boundary. Spikes in observed turnover lie in stratigraphic intervals that have produced significant amounts of fossil material. In contrast, patterns of inferred turnover based on confidence intervals differ from the observed pattern and are stratigraphically dispersed. High turnover that marks the Hemingfordian–Barstovian boundary in the Barstow Formation is a product of favorable preservation in proximal-channel settings, and the increase in diversity is more likely due to a shift in depositional environments than to an influx of immigrant taxa.

Grant Information
University of Michigan Department of Earth & Environmental Sciences Scott Turner Grant

Technical Session V (Thursday, October 18, 2018, 11:00 AM)

NEW ORANGUTAN-BEARING FOSSIL DEPOSITS FROM WESTERN SUMATRA PROVIDE INSIGHTS INTO PLEISTOCENE ORANGUTAN TAXONOMY AND ECOLOGY

LOUYS, Julien, Griffith University, Nathan, Australia; PRICE, Gilbert, The University of Queensland, Redbank Plains, Australia; ZAIM, Jahdi, Institute Teknologi Bandung, Bandung, Indonesia; RIZAL, Yan, Institute Teknologi Bandung, Bandung, Indonesia; SANTOSO, Wahyu Dwijo, Institute Teknologi Bandung, Bandung, Indonesia; TRIHASCARYO, Agus, Institute Teknologi Bandung, Bandung, Indonesia

The Padang Highlands of western Sumatra host the only Pleistocene orangutan records from this island. Until now, sites excavated by Dubois in the late nineteenth century have been our only source of information on the ecological history and palaeobiology of Sumatran orangutans. Other than recent new research at Lida Ajer, these sites have been plagued by unreliable locality data and poor geochronological resolution. Here, we present two new orangutan-bearing deposits from caves in the region, and compare them to the Dubois sites. Ngalau Sampit is a breccia deposit consisting largely of isolated teeth, although unusually for Southeast Asia, a partial cranium of an ungulate is preserved.

U-series dating of a capping flowstone has produced an age of 91.2 ± 0.4 ka. This minimum age is supported by dates of 83.3 ± 4.9 ka for a calcite-filled vugh within the breccia. Ngalau Gupin preserves no datable flowstone; however, U-series dating of a *Tapirus* molar has produced a minimum age of ~42 ka. On the basis of ^{230}Th age and U-concentration profiling, the tooth appears to have taken up U rapidly following burial, with the resulting ages likely approximating the true age of the tooth. Ngalau Gupin hosts a diverse fauna including elephants, tigers, bovids, cervids, and rhinos. We explore the implications of these new data for taxonomy, ecology, and extinction of orangutans. Significantly, these sites, in conjunction with other data including Dubois' original excavations, suggest that rainforest conditions persisted in western Sumatra throughout the middle and late Pleistocene. Of particular interest, we demonstrate the continued presence of orangutans in the Padang Highlands from before and after the late Quaternary Toba super-eruption.
Grant Information
Australian Research Council Future Fellowship FT160100450

Technical Session I (Wednesday, October 17, 2018, 9:30 AM)

DEEP-TIME APPLICATION OF LINKED MICROCLIMATE AND BIOPHYSICAL MODELS CONSTRAIN THE THERMAL ECOLOGY OF TWO LATE TRIASSIC DINOSAURS (*COELOPHYSIS*, *PLATEOSAURUS*)
LOVELACE, David, UW-Madison Geology Museum, Madison, WI, United States of America; HARTMAN, Scott, University of Wisconsin Madison, Madison, WI, United States of America; LINZMEIER, Benjamin J., Northwestern University, Evanston, IL, United States of America; PORTER, Warren P., University of Wisconsin-Madison, Madison, WI, United States of America
The biophysiological modeling program Niche Mapper has been widely-tested using a diverse range of modern clades under a broad spectrum of environmental conditions. We used Niche Mapper to estimate the thermal ecology of two well-known Triassic dinosaurs, *Coelophysis* and *Plateosaurus*. These taxa were evaluated under six different microclimates that represent boundary conditions for Late Triassic paleoenvironments of the southwestern U.S.A. at 12 degrees paleolatitude. We chose a small and large bodied saurischian to: (1) test the role of mass and shape in mediating heat and mass transfer between organisms and their environment, and (2) minimize confounding factors due to phylogenetic differences in life history, locomotion, or metabolism. We evaluated heat and water stress, as well as changes in daily activity under a broad range of physiological interpretations. Additionally, we simulated a 'metabolic chamber' to analyse shifts in active thermoneutral zones with changing air temperature, diet, shape, size, internal body temperature, insulation, and metabolic rate.
Our results support elevated metabolic rates similar to modern ratites with an intermediate core temperature range. Differences in paleogeographic distribution of large prosauropods (restricted to higher latitudes) and smaller coelophysoids (present in both low and high latitudes) can be explained by the rostrocaudally and dorsoventrally elongate coelophysoid bauplan; this may have enabled their survival in hot low latitude environments and colder higher latitude environments (or higher elevation) with small body size and variable degrees of epidermal insulation. The paucity of large sauropodomorph body fossils in low latitude Triassic strata contrasts with a notable presence of prosauropod ichnotaxa in those facies along the boundaries of regional structural highs. This suggests that at low latitudes prosauropods were restricted to cooler microclimates such as dense forests or higher elevations; habitats with notably lower preservation potential. This is in agreement with the Late Triassic fossil record and may help to explain the latitudinal gap in the Triassic prosauropod record.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

TAPHONOMIC ANALYSIS OF AVIFAUNAL REMAINS FROM THE PLEISTOCENE TAR PITS OF TALARA, PERU
LOWI-MERRI, Talia, University of Toronto, Royal Ontario Museum, Toronto, ON, Canada; SIMON, Jade, University of Toronto, Toronto, ON, Canada; REYNOLDS, Ashley R., University of Toronto, Toronto, ON, Canada; SEYMOUR, Kevin L., Royal Ontario Museum, Toronto, ON, Canada; EVANS, David, Royal Ontario Museum, Toronto, ON, Canada
The late Pleistocene tar pits at Talara, Peru, hold one of the largest known tar seep assemblages of fossil vertebrates. From this assemblage, 34.5% of the specimens represent birds. Unlike the penecontemporaneous Rancho La Brea tar pits, where predatory birds dominate the avifauna, the Talara collections are dominated by Anseriformes, even though there are several similarities in the reconstructed palaeoenvironment for these two sites. In order to better understand the preservational differences between these two sites, we undertook a detailed taphonomic analysis of the Talara avifauna.
Using the collection at the Royal Ontario Museum, consisting of more than 10,000 individual avian elements, we tallied basic taphonomic information, including element size, breakage, weathering, and abrasion, as well as minimum number of individuals and number of identifiable elements. We found that limb bones such as humeri and tibiotarsi are far more abundant than sterna or skulls and show greater quality of preservation. Elements exhibit very low degrees of abrasion and weathering, with stages typically from 0 to 1. Importantly, there is no evidence of pit wear in any fossil from the pits. We found an approximately proportionate forelimb to hindlimb ratio (55:45), however so far, no hindlimb elements from Passeriformes have been identified. Additionally, ~70% of all coracoids are completely preserved, which is significantly greater than for any other avian bone from this assemblage. Finally, there is a greater proportion of individuals in larger size classes than smaller.
The lack of pit wear at Talara is likely due to the shallowness of the Talara pits relative to La Brea, and thus there was limited movement of elements. The inconsistency in bone completeness is surprising for this type of preservational environment. A compound of biases from taphonomic effects and collection procedures likely contribute to both inconsistency in completeness and the underrepresentation of smaller skeletal elements. Small, thin bones are more prone to destruction when dissolving and screening bulk samples. This pattern of preservation has implications for how we reconstruct biodiversity at Talara, and should be considered when drawing conclusions of species composition from tar pit assemblages.
Grant Information
NSERC Discovery Grant to DCE (RGPIN 355849)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

MORPHOMETRIC ANALYSIS OF CRANIOFACIAL VARIATION IN AN *EDMONTOSAURUS* BONEBED FROM THE LANCE FORMATION, WYOMING
LOWNSDALE, Ashley, Denver Museum of Nature and Science, Denver, CO, United States of America; FREEMAN, Fox, Denver Museum of Nature and Science, Lafayette, CO, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America; MACKENZIE, Kristen, Denver Museum of Nature & Science, Eugene, OR, United States of America
Monotaxic bonebeds offer unique opportunities to examine intraspecific and ontogenetic variation in vertebrate taxa usually restricted to isolated, stratigraphically disparate occurrences. An exceptionally large sample of *Edmontosaurus annectens* from a single bonebed located in the Maastrichtian Lance Creek Formation of eastern Wyoming, including individuals ranging from juvenile to large adult, permits direct quantitative analysis of craniofacial variation in a hadrosaurid taxon. Two-dimensional morphometric analysis of isolated but undistorted cranial elements was conducted to quantify variation within the sample. Skull elements were photographed in lateral, medial, and ventral views and landmarks were chosen at significant points on each element on the basis of their presence in at least 90% of the sample size and the ability to place them consistently. A generalized Procrustes analysis (GPA) followed by principal components analysis (PCA) accounted for roughly 60 to 80% of variance in the specimens. PCA of isolated frontals reveals that the anteroposteriorly short and rounded morphology of small specimens first, elongates in animals of medium size, then becomes dorsoventrally thickened in the largest specimens, ultimately resulting in a sub-rectangular overall morphology. The postorbital varies widely between specimens, with the smallest individuals generally showing a straight ventral process, and large individuals with a shorter, anteriorly curved process. The postorbital also broadens anteroposteriorly and thickens around the orbital fenestra, indicating a narrowing of the orbital fenestra posteriorly during growth. Generally, the squamosal suture on the posterior process shifts anteriorly and broadens in large specimens. In contrast, the jugal changes isometrically with size, showing little change in shape between differently sized individuals. Based on these results, ontogenetic change in the skull of *E. annectens* occurs primarily in the dorsal orbital region as expected during normal allometric growth. However, the surprisingly conservative morphology of other cranial elements, regardless of size, has implications for the identification and diagnosis of hadrosaurid taxa from isolated or incomplete elements.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW MORPHOLOGY OF *CHINLECHELYS*, A LATE TRIASSIC TURTLE FROM NEW MEXICO, U.S.A.
LUCAS, Spencer G., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America; LICHTIG, Asher J., New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America
New details of *Chinlechelys* morphology have been revealed by reexamination of the type specimen and recollecting the type locality, which uncovered a significant portion of the carapace. This new material includes thoracic vertebrae 1–3 and 5–8 as well as the isolated axillary notch and a small carapace fragment. A fragment originally described as cervical armor on further inspection is found to be a portion of the posterior carapace margin. This fragment shows a distinct radial sculpture like that of the posterior marginals of *Proganochelys*. The new fragments include the anterior three and posterior four thoracic vertebrae, which articulate with the other vertebrae. These have a narrow proximal end laterally that broadens into a T shape, and the base has a distinct anterior process approaching the midline. The dorsal side of the carapace has two distinct longitudinal ridges crossing the midline. The neural-costal sutures outline an extremely broad neural series as much as 3 times as wide as long. A costal fragment in the medial portion of the costal's width shows the costals do not parallel the ribs; instead, the costal-costal suture crosses the rib at a 45° angle. This suggests that the peripheral previously published is not from the posterior of the carapace, but rather from its lateral margin. This peripheral has been matched to two additional fragments, giving a more complete picture of its morphology. This also shows a suture well short proximally of where the neurals would start, suggesting that there was an additional row of costal ossifications. Four bones concreted together tentatively considered the posterior left corner of a skull are unusual in their morphology relative to other turtles. The long quadratojugal is similar to that of dwarf pareiasaurs in its long length and the presence of a ventral ridge parallel to the lateral margin. The squamosal has a distinct ventral conch similar to *Anthodon* and more anterior and ventral than the otic notch of *Proganochelys*. Overall, this makes a very unusual turtle, but some of this may not be as odd as it seems as many of these features are unclear in other Triassic turtles like *Proganochelys*. The preserved ribs and overlying neurals and costals support the idea that the costals and ribs were originally two separate ossifications that were fused latter in evolution.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

CONTEXTUALIZING THE MAMMALIAN FAUNA OF THE BRIDGERIAN FANTASIA FOSSIL LOCALITY FROM CARTER MOUNTAIN, WYOMING
LUNDEEN, Ingrid K., University of Texas at Austin, Austin, TX, United States of America
Fantasia is a high-elevation (3140 m) Bridgerian fossil locality located on the north face of Carter Mountain in northwestern Wyoming. Carter Mountain is found within the Absaroka Volcanic Province (AVP) on the western edge of the Bighorn Basin. The AVP was one of the major eruptive zones during the Eocene, depositing tuffs and volcaniclastic sediments throughout the Absaroka Range and in adjacent sedimentary basins. Fantasia preserves a fauna that lived in the AVP when the Thorofare Volcanic group became active, marked by the ~48 Ma Blue Point ash bed, which directly overlies the site. Fantasia was initially collected in the late 1970s by J. Eaton, yielding a sample of 446 vertebrate fossils. This

assemblage is of particular interest because Fantasia is found at a higher modern elevation than better-known basin center Bridgerian sites in the greater Green River Basin and the Bighorn Basin. The timing of eruptive events in the AVP, as well as ongoing oxygen isotope paleoaltimetry studies in the region, suggest that this site documents a faunal community that lived at a relatively high elevation, with modern elevation not significantly altered by local Laramide uplift. Modern biogeographic patterns suggest that high elevations should document substantially different faunas than lowland basins and sampling such sites should provide new insight into regional diversity patterns.

Here I report the preliminary results of renewed collecting at Fantasia in 2017, which approximately doubled the number of fossil specimens known from the site. Microvertebrate fauna are extremely common at this site and erode out of the fossiliferous matrix and accumulate along a broad deflation surface. The most common taxa in the sample reported here are rodents (36%), euarchontans (28%), including particularly abundant *Microsyops* species, *Hyopsodus* (7%), and *Orohippus* (6%). Additionally, a crocodylian vertebra was collected, which is the first archosaur recorded from this site. This finding suggests that during the early middle Eocene, crocodylians may have been able to occupy a broader range of elevations than seen in modern representatives of the clade. Increased sampling of high-elevation sites such as Fantasia provides an opportunity to critically examine sampling biases favoring lowland depositional environments in the North American Eocene. The degree to which this bias has impacted our understanding of faunal community change over time is explored here in light of new data from Fantasia.

Grant Information
Evolving Earth Foundation, Geological Society of America, Paleontological Society, and American Museum of Natural History Theodore Roosevelt Memorial Fund

Technical Session VIII (Thursday, October 18, 2018, 2:45 PM)

MORPHOLOGICAL DISPARITY ACROSS THE SYNAPSID FORELIMB: SUBORDER-LEVEL PATTERNS ACROSS 80 MILLION YEARS OF SYNAPSID EVOLUTION

LUNGMUS, Jacqueline K., University of Chicago, Chicago, IL, United States of America; ANGIELCZYK, Kenneth D., Chicago, IL, United States of America

Synapsid evolution can be characterized by three successive radiations: the Permo–Carboniferous pelycosaurs, the Permo–Triassic Therapsida, and the Triassic Eucynodontia. Previous geometric morphometric research at the clade level revealed a continuous increase in humeral morphological disparity in Therapsida, in contrast to their pelycosaur forebearers. Here we present associated data on ulnar morphological disparity, as well an an overall taxonomic expansion of the analyses. This increase in sample size brings the dataset to 765 specimens from which functional units across the forelimb were analyzed. Further, it allows for a more detailed discussion of variance within nearly every major group of early Synapsida, as well as across 80 million years of geologic history.

Groups were analyzed for Procrustes variance in 5 million year time bins from 305–225 Mya (Carboniferous–Triassic). In all analyzed functional units—the proximal humerus, distal humerus, and proximal elbow—within group disparity is higher in therapsid families than in pelycosaur families. In addition, therapsid family level disparity is much more variable between groups and across time. Ulnar variance values are higher than humeral values for the entire study period. Procrustes variance for the forelimb decreases across the End Permian Mass Extinction Event in the major therapsid groups that survived it—Anomodontia and Cynodontia.

Macroevolutionary changes observed in Synapsida have historically been associated with ecological diversification. Cynodontia and Anomodontia have the highest variance in Therapsida, while Gorgonopsia has the lowest. The high values in Anomodontia, as one of the most taxonomically and ecological diverse clades of Therapsida, suggests that forelimb variance is linked to aspects of ecological diversification. Further, within pelycosaurs Sphenacodontidae has the lowest variance through time, while Ophiacodontidae has the highest. The finding of uniquely high variance levels in Ophiacodontidae, hypothesized by some to be semi-acquatic, is suggestive of a potentially unique forelimb ecomorphology. This research provides evidence that along with major shifts in forelimb morphology, within-family disparity dynamics may have been critical to the evolutionary success of individual synapsid sub-orders.

Grant Information
Field Museum Women in Science Fellowship
National Science Foundation EAR-1337569, EAR-1337291, and EAR-1336986.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

WHEN ECOLOGY AND PHYLOGENY ARE AT ODDS: EXTRAPOLATING RESTING AND STANDARD METABOLIC RATES OF AETOSAURS (ARCHOSAURIA, AETOSAURIA) FROM EXTANT SAURIANS

LUSTRI, LORENZO, Bologna University, AVEZZANO, Italy; HECKERT, Andrew B., Appalachian State Univ, Boone, NC, United States of America

Although much of what we know of the biology of extinct organisms can be inferred directly from the fossils themselves, other characteristics must be extrapolated from comparisons with living animals. This is especially true of metabolic rate (MR) in fossil vertebrates. Previously many workers have attempted to understand the metabolism of dinosaurs, but there has been little to no work on more basal archosaurs, in spite of the fact that it was the diversification of archosauromorphs over the first 30 million years of the Triassic that set the stage for dinosaur dominance during the latter Mesozoic.

Here we report our estimates of the MR of several well preserved aetosaur specimens. Our method relies on the fossil record for body mass estimates, but otherwise extrapolates aetosaurian MR from an array of empirical measurements of extant saurians pulled from the literature. We subdivide our approach in two different analyses, one performed on a dataset emphasizing ecological role, the second emphasizing phylogenetic position, and running two different multiple linear regressions to obtain resting metabolic rate (RMR) and standard metabolic rate (SMR) for each. For example, we find for a 120 kg (live weight mass estimate) specimen of Typothorax coccinarum an RMR of 1871 mL O2h−1, and an SMR of 973 mL O2h−1 utilizing the ecological analysis. On the other hand, the saurian-based estimation for the same specimen we find substantially higher values, with an RMR of 2253 mL O2h−1 and an SMR of 1619 mL O2h−1. In both analyses metabolic rate is most strongly influenced by body mass, but, from a relative weight analysis we obtained estimates of the relative weights of other dependent variables involved in MR prediction, as well as a corroboration of the importance of phylogeny (6.6%), feeding mode (2.2%) and environmental adaptation (8.6%) of the total variance in the analysis based on the saurian dataset.

As we expected from the literature, the ecology-based equation yields the lower MR. We attribute this difference to the presence of armor, emphasized in this analysis, in comparison to the saurian based estimation. However, our extant saurian based estimation could be a useful tool to estimate MR of extinct ectothermic saurians that are not as heavily armored.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

Podium Symposium (Wednesday, October 17, 2018, 10:45 AM)

THE ROLE OF CLIMATE IN SHAPING MAMMALIAN BODY SIZE DISTRIBUTIONS OVER THE CENOZOIC

LYONS, S. Kathleen, University of Nebraska Lincoln, Lincoln, NE, United States of America; SMITH, Felisa A., University of New Mexico, Albuquerque, NM, United States of America; ERNEST, S. K. Morgan, University of Florida, Gainsville, FL, United States of America

Understanding how ecological communities are organized and how they change through time is critical to predicting the effects of climate change. Studies on modern communities find that the shapes of body size distributions are weakly related to climatic variables and more strongly to habitat type, with flat distributions common in temperate habitats and peaked distributions common in tropical ones. In essence, increased habitat structure and productivity lead to more peaked body size distributions presumably because a greater number of 'medium' sized mammals can be supported. Because there have been major changes in mammalian community composition, body size, and global climate over the last 65 million years, we ask how these patterns play out over geologic time. We created a database of Cenozoic mammal communities that spans multiple continents and habitats using the Paleobiology database augmented with additional literature sources. Species level body sizes were collected from the literature and estimated from measurements on fossil teeth. Our database contains 226 communities with 6713 species occurrences. For 103 communities, we were able to classify them into general habitat types. Global climate data were taken from the Zachos curve. We analyzed the shapes of community body size distributions and their relationships to habitat type and global climate. We find that 1) local body size distributions of Cenozoic mammals are weakly correlated with climate and more strongly with habitat type, 2) archaic and modern mammals show similar patterns in their body size distributions, and 3) maximum body size of local communities increases as mammals evolve larger body sizes and is correlated with climate change. The remarkable similarity in these patterns and their relationship to climate over the last 65 million years suggest a fundamental role of body size in community assembly, and that modern and archaic mammal faunas respond in similar ways to the environmental template.

Grant Information
This work was supported by NSF-DEB 0541625, 1257625, and 1744223.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

THE SKULL ANATOMY AND FUNCTIONAL DISPARITY OF OVIRAPTOROSAURS

MA, Waisum, University of Edinburgh, Edinburgh, United Kingdom; BRUSATTE, Stephen, University of Edinburgh, Edinburgh, United Kingdom; LÜ, Junchang, Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China; SAKAMOTO, Manabu, University of Reading, Reading, United Kingdom

Theropod dinosaurs had diverse skull morphologies and attained a wide variety of diets. Oviraptorosaurs are a group of bird-like theropods which have a general skull shape that diverged from that of most other theropods – their skulls are anteroposteriorly short but dorsoventrally deep, edentulous, and possess a rhamphotheca beak in crownward forms. Over the last decade, the known diversity of oviraptorosaur has greatly increased thanks to new fossil discoveries, particularly in Ganzhou, Jiangxi province of southern China. Despite this, little is known about how skull shape and function vary among oviraptorosaurs.

This is the first comprehensive investigation into the anatomy and functional disparity of oviraptorosaur skulls using quantitative techniques. First, we use two-dimensional geometric morphometrics to quantify skull shape. Homologous landmarks were plotted on images of oviraptorosaur crania, mandibles and beaks (premaxillae and dentaries) obtained from published literatures and first-hand photographs. These data sets were then subjected to principal component analysis (PCA) to generate a morphological morphospace for each data set. The PCA results show that the crania of oviraptorosaurs (excluding caenagnathids) mostly vary in the anteroposterior length of the external naris and the depth of the premaxilla-maxilla region. The mandibles of oviraptorosaurs differ primarily in the size of the external mandibular fenestra, the height of the coronoid process region and the depth of the dentary. We find significant correlations between mandible/beak shape and phylogeny. Second, we developed a list of mandibular characters likely to have functional relevance in oviraptorosaurs, based on studies of other extant and extinct animals. After the measurements were standardised, they were subjected to principal coordinate analysis (PCoA) to obtain a functional morphospace. The Ganzhou oviraptorosaurs are relatively spread out in the functional morphospace, indicating that dietary-related niche partitioning might have facilitated their coexistence. Skull function shows significant and moderate correlations with mandible and beak shape. The results show that both phylogeny and function may have been important factors in influencing oviraptorosaur skull morphologies. This study clarifies the skull shape and function variation patterns in oviraptorosaurs, which is important for understanding the complex dietary evolution in oviraptorosaurs, and theropods in general.

Grant Information
JL: National Natural Science Foundation of China (grant no. 41672019 and 41688103)
MS: Leverhulme Trust

Romer Prize Session (Thursday, October 18, 2018, 8:15 AM)

THE EVOLUTION OF BODY PROPORTIONS AND LOCOMOTION IN BIRDS

MACAULAY, Sophie, University of Liverpool, Liverpool, England

Mass properties (e.g., body mass and center of mass) are key biomechanical properties that correlate closely with various features of organismal biology, including posture and locomotion. Birds occupy a large range of ecological niches in which they utilize a diverse range of locomotor behaviours, and their body plans have adapted to these varied demands. Although the links between center of mass and terrestrial locomotion have been well investigated in birds, little work has been done to assess correlations with aerial locomotor behaviors. Such information would enable center of mass position to predict flight style in transitional fossils such as *Microraptor*. In addition to this lack of understanding, current mass property estimates in fossils are hindered by substantial error margins, undermining our ability to draw any meaningful conclusions from these data. Here, I present new relationships for estimating center of mass in extinct archosaurs using volumetric modelling. These relationships are grounded in data comparing skeletal and skin volume for individual body segments in over 40 closely related extant taxa (birds, crocodylians and lizards). The resulting predictions have significantly reduced error compared to that inherent in previous studies, and show marked differences to previous relationships established in mammals. These new relationships are applied to volumetric models of a selection of theropod dinosaurs representing the transition from the 'conservative' body plan of an obligate terrestrial biped, to species with body plans specialized for flight. The resulting centre of mass estimates are interpreted in the context of new data linking body plan with flight ability in birds. Results from 27 unique families within Aves, show that locomotor style correlates closely with centre of mass position along the cranio-caudal and dorso-ventral axes; birds whose locomotion is 'forelimb dominated' have a more dorso-cranial whole body center of mass. By combining improved estimates of key mass properties in fossil taxa, with novel data on the links between centre of mass and volant behaviors, new insights are gained into the evolution of flight in birds.

Grant Information
NERC PhD studentship, through the ACCE doctoral training program.

Technical Session II (Wednesday, October 17, 2018, 11:00 AM)

THE MORPHOLOGICAL DISPARITY AND PHYLOGENETIC DIVERSITY OF PARAREPTILIA THROUGHOUT THEIR EVOLUTIONARY HISTORY

MACDOUGALL, Mark J., Museum für Naturkunde, Berlin, Germany; BROCKLEHURST, Neil, Museum für Naturkunde, Berlin, Germany; FRÖBISCH, Jörg, Museum für Naturkunde, Berlin, Germany

The clade Parareptilia, the sister taxon of Eureptilia, is a group of sauropsids that thrived during the Late Palaeozoic and Early Mesozoic. The earliest known parareptile appeared in the Late Carboniferous, and from there the clade began to diversify, achieving considerable diversity and a cosmopolitan distribution by the end of the Permian, as well as becoming an important component of Permian terrestrial ecosystems. However, most major parareptilian clades go extinct during or before the end-Permian mass extinction event, with only one clade, the Procolophonoidea, surviving into the Mesozoic, before eventually going extinct at the end of the Triassic. Parareptilia is notable in that members of the clade exhibit a wide range of morphologies. Examples include: small, predatory superficially lizard-like taxa, secondarily aquatic taxa, and large, armoured herbivorous taxa. The wide array of morphologies present in the clade allowed parareptiles to occupy and be successful in a variety of ecological niches. In order to better understand parareptilian evolution and the numerous morphologies that appeared within the clade we investigated both the morphological disparity and phylogenetic diversity of parareptiles over the course of their evolution. To accomplish this our study uses phylogenetic data and statistical techniques to quantify the morphological disparity of parareptiles during the Palaeozoic and Mesozoic, as well as comparing it with their phylogenetic diversity. The results of our study indicate that there is an overall increase in parareptilian disparity during the Permian with the highest peak occurring in the Early Permian. From there parareptilian disparity fluctuates slightly, before it eventually declines sharply towards the end of the Permian and into the Triassic, corresponding with the end-Permian extinction event. Interestingly, this is a different trend to what is observed regarding parareptile phylogenetic diversity during this same time frame. As the diversity of the clade does not experience the same sharp drop at the end of the Permian, not being as heavily affected by the extinction event. This is likely in part due to the fact that, despite the extinction of several morphologically distinct parareptile clades, the procolophonoids, one of the largest parareptilian clades, were diversifying at the same time, resulting in the evolutionary patterns that are observed here.

Grant Information
Research funded by:
Deutscher Akademischer Austauschdienst
Deutsche Forschungsgemeinschaft

Technical Session V (Thursday, October 18, 2018, 8:30 AM)

THREE'S A CROWD: SPATIAL ANALYSIS OF MULTI-TAXA SLOTH LOCALITIES

MACIAS, Melissa K., Psomas, Santa Ana, CA, United States of America

The first giant ground sloths (Xenarthra, Pilosa) arrived in North America during the late Hemphillian, and members of the four families of North American sloths (Megatheriidae, Megalonychidae, Mylodontidae, and Nothrotheriidae) subsequently expanded their geographic range to inhabit areas throughout the continent, with each filling individual niches and habitats. Although the overall geographic ranges overlap, the majority of these localities are single taxon occurrences, and in many cases, individual specimens. Sloths are considered to be primarily solitary animals, with social interaction limited to parenting and mating, which may contribute to the presence of isolated fossil specimens in most localities. While rare, multi-sloth localities occur on both the east and west coasts.

This study uses ArcGIS to spatially analyze the localities with three or more sloth taxa present to determine the contributing factors of the relative abundance compared to 1) potentially competing taxa and 2) sloth localities in the surrounding area. Of the 721 unique localities analyzed in this study, 108 contain remains of two sloth taxa, and only 15 contain three or more. Localities with three or more sloth taxa have been recorded in California, Mexico, Florida, and South Carolina, with one locality in the Blancan, four in the Irvingtonian, and 10 in the Rancholabrean. In each of the three-taxa localities, the number of identified specimens (NISP) per sloth taxon represents 0.4–45% of the total large mammal NISP of that locality. The California sites are primarily *Paramylodon*-dominated by a ratio of 10:1, while the East Coast sites are more evenly split between the taxa present. The three-taxa localities were also compared to the NISPs for all sloth localities within a 100 km radius. Based on spatial distribution, each of the multi-sloth localities deviate from the general patterns seen in the region. The results of this study indicate that the environments of the multi-sloth localities were more suitable for higher-density sloth populations than the surrounding area, and were primarily suitable for the dominant taxon, although the lesser-represented taxa were able to inhabit the area as well.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

AN OCCURRENCE OF THE LATE CRETACEOUS HYBODONTIFORM SHARK *PTYCHODUS WHIPPLEI* FROM THE MANCOS SHALE IN THE HOLY GHOST QUADRANT ON RESERVATION LANDS BELONGING TO THE PUEBLO OF JEMEZ, NORTH-CENTRAL NEW MEXICO, U.S.A.

MADALENA, Kevin M., Utah Dine Bikeyah, Jemez Pueblo, NM, United States of America; SUMIDA, Stuart S., California State University San Bernardino, San Bernardino, CA, United States of America

Teeth belonging to the extinct shark and index taxon *Ptychodus whipplei* have been discovered in abundance in the Late Cretaceous age Mancos Shale (Juana Lopez Member) of the Cenomanian age on reservation lands belonging to The Pueblo of Jemez. *Ptychodus* teeth are massive, round and blunt. Individual teeth form a pavement of closely packed teeth within a single jaw. These teeth were ideally used and suited to crushing shells of ammonites and large bivalves that made up its main diet. The *Ptychodus* teeth from the Holy Ghost Quadrant originate from a low diversity area, which makes it the most abundant shark fossil in this particular region in the Mancos Shale.

Ptychodus teeth were discovered weathering out of a large road cut in the Holy Ghost Quadrant in the eastern edge of the San Juan Basin, in the lands belonging to the Pueblo of Jemez. *Ptychodus* is a common index fossil in the biochron fauna typically associated with the Juana Lopez Member of the Mancos Shale (Cenomanian Age) in the Late Cretaceous. The strata and sections of The Juana Lopez Member of The Mancos Shale form distinctive deposits of the Upper/Late Cretaceous stratigraphic marine deposits.

These rocks and marine deposits are well exposed along the State of New Mexico, ranging from the south-central, west-central and north central New Mexico. The Mancos Shales and rocks were deposited during the transgression of the Western Interior Seaway, bisecting North America, during the Upper/Late Cretaceous, 100 million years ago. In the Holy Ghost Quadrant, the Mancos Shale is more then 25 meters thick. The shale is downward sloping, and dips to the south. It is pale yellowish, sandy in color, dense and it is interbedded with light olive-gray fissile shales. The Mancos Shale is further underlined and split by a light grey and very fossil rich limestones. The fauna known from these shales are, *Ptychodus* itself, five different species of predatory and the triangular shaped, bladed teeth of lamniform sharks, large marine reptiles, rays, bony fish, bivalves, nautilus shaped ammonites, and small coral communities. The marine environments for this Late Cretaceous fauna is pelagic to neritic.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

POSTNATAL LIMB ALLOMETRY IN THE LA BREA GROUND SLOTH *PARAMYLODON HARLANI*

MADAN, Meena A., University of Bristol, Bristol, United Kingdom; LONG, Katherine, Cal Poly Pomona, Pomona, CA, United States of America; PROTHERO, Donald R., Pierce College, Los Angeles, CA, United States of America

Many mammals undergo dramatic changes in limb proportions during ontogeny, but it is usually difficult to study this phenomenon in extinct taxa because large samples of juvenile bones are rarely preserved in most fossil localities. However, the tar pits at Rancho La Brea not only preserve large numbers of rarely fossilized taxa, but also many juvenile bones in all stages of growth. We measured the diaphysis length and midshaft circumference of all the unbroken limb bones of the larger La Brea ground sloth, *Paramylodon harlani* in the La Brea Tar Pits Museum. Since ground sloths are graviportal animals with heavy, robust limbs, and not adapted to fast walking or running, we might expect their limbs to get more robust as they grew into adulthood and their body mass increased (i.e., slopes much less than 1.0 on a plot of circumference vs. length). Fitting reduced major axes on our data from all four major weight-bearing limb bones (humerus, radius, femur, tibia), we found that the slopes of growth are statistically indistinguishable from isometric growth (0.91–1.4) or even slightly gracile or cursorial, with very high r-squared values (0.76 or higher). The only living xenarthran whose ontogenetic growth trends have been studied so far is the giant anteater, *Mymecophaga tridactyla*, which has slopes that range from robust (0.66) to isometric (1.03). Even though giant ground sloths would be expected to grow morerobust as they matured, the data from the La Brea ground sloth *Paramylodon harlani* show that they have no clear trend toward robustness with ontogeny.

Technical Session VI (Thursday, October 18, 2018, 9:30 AM)

A NEW PERMIAN-LIKE FAUNA PRESERVED WITHIN A SINGLE FOSSILIZED STUMP FROM THE CARBONIFEROUS OF NOVA SCOTIA

MADDIN, Hillary C., Carleton University, Ottawa, ON, Canada; MANN, Arjan, Carleton University, Ottawa, ON, Canada; HEBERT, Brian, Joggins, NS, Canada

The fossil record of tetrapods from the Carboniferous of Nova Scotia has been central to understanding some of the earliest phases of tetrapod evolution, including the earliest records of the major groups of tetrapods alive today. Here we report on the discovery of a fossiliferous lycopsid 'tree' stump from the Sydney Mines Formation, Upper Pennsylvanian, Cape Breton Island, that remarkably contains the remains of at least six taxa, both non-amniote and amniote, in various states of preservation and articulation. Significantly, most of the preserved taxa are otherwise only known by representation in the later, Permian ecosystems of North America. Most notable among these is a virtually complete skull of a large, pantylid recumbirostran, as well as four partial,

articulated skeletons of a varanopid synapsid. As such, the material provides new, earliest records of these taxa and reveals several evolutionary events vastly predate currently known occurrences. For example, CT scanning of the pantylid reveals a highly specialized dental apparatus composed of opposing dental fields on the palate and coronoids. The low, conical teeth of these fields is suggestive of complex oral processing of a diet consistent with high-fibre herbivory, well advanced to that of any known tetrapod of equivalent age. Additionally, the presence of at least three partial, articulated varanopid specimens of equal, subadult size, and an associated very small fourth, alludes to the possibility of a social aggregation—a behavior otherwise known from this clade in the late Permian. These skeletons are consistent in many regards with mycterosaurines, except for the presence of tall, broad neural spines, suggesting they may represent a new taxon. Furthermore, a fragment of a large proximal femur is also attributable to a varanopid, and approaches the size and morphology of much later occurring varanodontines, such as the Permian-aged *Varanops*. This latter specimen reveals that this early amniote clade had already become much larger, possibly taking on a role of apex predator, well before the start of the Permian. Together, the implications of this discovery are numerous and include revisions to the tempo of evolution of major tetrapod clades and several new additions to the Upper Carboniferous faunal record. Further detailed analyses of this material will contribute to revising our understanding of the ecosystem composition and dynamics of Upper Carboniferous tetrapod communities.

Grant Information
NSERC DG RGPIN-2015-04633

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

THE FIRST CAMELID MATERIAL FROM THE EARLY PLIOCENE GRAY FOSSIL SITE, EASTERN TENNESSEE

MADEN, Shayleigh, East Tennessee State University, Johnson City, TN, United States of America; SAMUELS, Joshua X., East Tennessee State University, Johnson City, TN, United States of America

Prior to their decline in the late Pleistocene, the Camelidae were a successful family of herbivorous megafauna with an expansive North American range. Despite being some of the most common large herbivores recovered from Cenozoic fossil sites in North America, camelids are primarily known from sites in the western and central United States, most of which preserve open grass-dominated environments. Camelid material recovered from the Gray Fossil Site (GFS) is notable both for its geographic location in upper East Tennessee and its early Pliocene age. As no pre-Pleistocene camelid remains have been recovered from Appalachia, the GFS camelid represents the oldest camelid remains recovered from the region so far. Additionally, multiple lines of evidence, including floral and faunal composition as well as isotopic analysis, suggest the GFS records a closed forested environment, markedly different from the open environments from which camelids are usually recovered. For these reasons, the GFS camelid is important to the understanding of the ecology and biogeography of camelids as a group.

Camelid remains recovered at the Gray Fossil Site are primarily postcranial, including a metacarpus, carpals, vertebrae, and fragmentary dental remains. The paucity of GFS camelid material, especially cranial, means that comparison with other previously described taxa is difficult. However, a number of characters present in the metacarpus and carpals suggest a closer affinity with lamines than modern camelines: 1) pronounced tubercle on the posterior surface of the cuneiform, 2) metacarpal facet extending up the posteroventral process of the unciform, 3) long posterolateral process of the magnum, and 4) posterior face of metacarpus deeply excavated. These similarities suggest that the GFS camelid is a lamine, though its taxonomic identity is currently uncertain.

While camelid remains were first recovered from the Gray Fossil Site early in its history, no excavations have specifically targeted areas of the deposit that produce multiple, closely-associated camelid skeletal elements. Targeted excavations are underway for the 2018 field season in an 8 m^2 section of the deposit that has produced a camelid metacarpus, rib, and thoracic vertebra, which represent the largest and most complete camelid elements recovered so far. Ongoing work will also involve the application of morphometric techniques previously used with success in classifying artiodactyl postcrania.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

STABLE CARBON AND OXYGEN ISOTOPES PROVIDE NEW INSIGHTS ON CLIMATE AND PALEOECOLOGY DURING THE MIOCENE OF NORTHERN NEW MEXICO

MAGALLANES, Isaac, University of Florida, Gainesville, FL, United States of America; MACFADDEN, Bruce J., University of Florida, Gainesville, FL, United States of America; MORGAN, Gary S., New Mexico Museum of Natural History, Albuquerque, NM, United States of America

The integration of stable isotope geochemistry and paleontology is crucial to understanding ancient ecosystems. Previous studies on carbon and oxygen isotope ratios in the marine record offer an extensive view of changing climatic conditions and shifting paleoecology throughout the Cenozoic. In contrast, however, notably less evidence has been presented for the terrestrial record of carbon and oxygen isotope data that might be used to compare to the marine record, and of relevance here, the Mid-Miocene Climatic Optimum (MMCO) and the onset of C4 grasses in southwestern North America.

Stable carbon and oxygen isotope ratios from 61 terrestrial fossil mammal teeth of the Miocene Tesuque and Chamita formations of the Santa Fe Group in northern New Mexico provide new insights into herbivore paleodiets, ecology, and past climatic conditions. Temporally, the Santa Fe Group is significant because the age range of deposition (~18–6 Ma) occurs during two major climate-driven events. One would expect terrestrial mammals feeding on vegetation during this period to incorporate carbon and oxygen isotopes into their tooth enamel that reflect these events. Preliminary results however do not wholly replicate this pattern. With regard to grasses, stable carbon isotopes from the older Tesuque Formation (~18–13 Ma) show $\delta^{13}C$ values (mean = -6.00 ‰) likely indicating C_3 plants. In contrast, $\delta^{13}C$ values (mean = -8.06 ‰) from the younger Chamita Formation (~7–6 Ma) likely indicate the presence of purely C_3 plants. The latter results presented are in contrast to other evidence demonstrating a global shift to C_4-dominated ecosystems during the late Miocene. Regional uplift and climatic conditions in southwestern North America potentially serve as contributing factors to a C_3 plant dominated environment. The stable oxygen data from the Tesuque (mean = -5.66 ‰) and Chamita (mean= -6.66 ‰) formations allow for analysis of the magnitude of these influences, however, their interpretation is more complex. In summary, stable isotope data from the Santa Fe Group provide an opportunity to interpret distinct climatic and ecological conditions during the Miocene of southwestern North America. Spatially these data coincide with important events including the MMCO and onset of late Miocene grassland evolution.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

BIOEROSION OF MEGATOOTHED SHARK TEETH: IMPLICATIONS FOR TIMING VERTEBRATE FOSSIL LAG DEPOSIT FORMATION IN ONSLOW BAY, NORTH CAROLINA, U.S.A.

MAISCH IV, Harry M., The Graduate Center, City University of New York, New York, NY, United States of America; BECKER, Martin A., William Paterson University, Wayne, NJ, United States of America; CHAMBERLAIN JR., John A., Brooklyn College, Brooklyn, NY, United States of America

The continental shelf in the Cape Fear Region of southwestern Onslow Bay, North Carolina contains lag deposits with an abundance of megatoothed shark teeth, including those of *Otodus megalodon* and *Otodus chubutensis* from the Pliocene Yorktown and Miocene Pungo River formations. These teeth exhibit different degrees of bioerosion and contain ichnofossils identified as: *Gastrochaenolites torpedo*, *Gastrochaenolites lapidicus*, *Entobia* isp., and *Maeandropolydora* isp. that are attributed to endolithic bivalves, clionid sponges, and serpulid worms. Differences in bioerosion in these megatoothed shark teeth can be separated into three categories: (1) taphonomically worn shark teeth and borings; (2) taphonomically worn shark teeth with borings that contain the shells of endolithic bivalves; or (3) shark teeth with little to no taphonomic wear and bioerosion as a result of recent exhumation. Many shark teeth in category one contain multiple borings at various angles and on opposing tooth surfaces indicating numerous episodes of bioerosion and reworking have occurred since their initial burial. Radiocarbon dating of endolithic bivalves found directly in bored teeth in category two indicates that some of the observed bioerosion is recent and only dates back several hundred years. Similarly, radiocarbon age dates for corals encrusting teeth in category three support their recent exhumation. Consequently, the three categories of bioerosion observed on megatoothed shark teeth provide a means to interpret and time processes of lag deposit formation since the Miocene in Onslow Bay.

Technical Session XVI (Saturday, October 20, 2018, 10:30 AM)

A NEW SPECIMEN OF THE LARGE-BODIED DROMAEOSAURID *TIUANYURAPTOR* PROVIDES NEW INSIGHTS ON MICRORAPTORINE ANATOMY, TAXONOMY, AND PLUMAGE EVOLUTION.

MAKOVICKY, Peter, Field Museum of Natural History, Chicago, IL, United States of America; GORSCAK, Eric, Field Museum of Natural History, Chicago, IL, United States of America; ZHOU, Cheng-Fu, Shandong University of Science and Technology, Qingdao, China

Tianyuraptor, and the similar *Zhenyuanlong*, differ from other Jehol dromaeosaurids in their large body size and proportionately short forelimbs. Both of these dromaeosaurids have been recovered as potentially outside of the microraptorine radiation, to which all other Jehol dromaeosaurids belong, according to a recent phylogenetic analysis. A new, articulated specimen of *Tianyuraptor* acquired by the Paleontological Museum of Liaoning is nearly complete except for the reconstructed right foot and provides new anatomical information that bears on the taxonomy and systematics of Jehol dromaeosaurids and also on plumage evolution in this clade.

The new specimen exhibits a combination of traits that were previously used to distinguish *Tianyuraptor* from *Zhenyuanlong*. For example, the antorbital fenestra has a sharp lower border as reported in *Zhenyuanlong*, but a lobate brevis shelf on the ilium as in *Tianyuraptor*, whereas other traits, such as the length of MCII relative to MCI+I-1, are indeterminate due to preservation. Study of the new specimen prompted a re-evaluation of the traits used to differentiate *Tianyuraptor* from *Zhenyuanlong,* revealing that several suffer from poor or variable preservation in the holotype of one or the other taxon, or represent ontogenetically variable traits. Taken together, all three specimens likely represent the same taxon, which by seniority is *Tianyuraptor*. Although differing in size and limb proportions, the new *Tianyuraptor* specimen exhibits several proposed synapomorphies with the Jehol microraptorines such as accessory pneumatic pits within the antorbital fossa. A revised phylogenetic analysis supports the inclusion of *Tianyuraptor* within Microraptorinae when all traits are treated as unordered in parsimony analysis.

The new *Tianyuraptor* specimen preserves feather impressions behind the skull, along the neck, right forelimb and parts of the tail, with superior preservation along the dorsum compared to areas ventral to the vertebral column. Long primaries (~35 cm) are present on the right arm but the rectrices are comparatively much shorter, differing from plumage patterns in smaller microraptorine species. Long coverts in the neck region exhibit a dense distribution of melanosomes, whereas melanosomes are less abundant and more patchy elsewhere. However, the asymmetric distribution of feather and melanosome preservation between dorsal and ventral regions of the skeleton sound a note of caution regarding the reconstruction of plumage color patterns in stem Avialans.

Grant Information
PJM was supported by NSF PLR1341645 during the time this research was performed.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

PALEOBIOGEOGRAPHIC ANALYSIS OF LATE MAASTRICHTIAN LARAMIDIA AND TESTING HYPOTHESES RELATED TO FAUNAL PROVINCIALITY

MALINZAK, D. Edward, South Dakota School of Mines and Technology, Rapid City, SD, United States of America

The late Maastrichtian terrestrial vertebrate paleobiogeography of Laramidia has attracted considerable interest due to its implications for the structure of faunas inhabiting this landmass at the close of the Mesozoic. Various workers have argued either for or against the possibility of faunal provinciality, with proponents citing observed paleobiogeographic patterns, and opponents claiming that supposed trends are artifacts of temporal, sampling,

and/or preservational incongruences. To test hypotheses of late Maastrichtian Laramidian faunal provinciality, a large-scale dataset of turtle, crocodilian, and non-avian dinosaur records was constructed and analyzed using an array of common statistical methods (NMDS, PERMANOVA, UPGMA clustering, and SIMPER). Turtle and crocodilian faunas showed little to no support for provinciality, whereas the results of the non-avian dinosaur analyses varied depending on the taxonomic resolution employed. Analyses under coarse taxonomic resolution supported the existence of distinct faunal regions at the extreme north and south of Laramidia separated by a sizable gradational zone, whereas analyses that employed finer taxonomic resolution provided support for three distinct zones. The finest-scale analyses supported even more pronounced zonation. Specifically, these latter analyses suggested the existence of distinct northern and southern zones, a sizable central zone with a weak longitudinal influence that was likely linked to the regression of the Western Interior Seaway, and a region with a fauna gradational between those of the central and southern regions.

Comparison of these results against historical paleobiogeographic trends suggests that variation in dinosaurian faunal composition in late Maastrichtian Laramidia was strongly influenced by environmental/ecological preferences and niche partitioning of ancestral taxa, with climatic variation exerting less impact. This indicates that climatic differences alone were not sufficient to produce the observed paleobiogeographic patterns, and suggests that faunal patterns observed in late Maastrichtian dinosaurs may be linked to changing environmental conditions and niche membership. These results highlight the need for fine taxonomic resolution in paleobiogeographic analyses, as well as the advantages of comprehensive approaches to deciphering the influences and pressures that affect biotic distributions, thus facilitating better understanding of the interactions between faunas and their environments.

Podium Symposium (Friday, October 19, 2018, 8:00 AM)

QUICK, CHEAP, AND NOT DIRTY AT ALL: EXTREMELY RAPID PHOTOGRAMMETRY TECHNIQUES FOR MASS DIGITIZING IN VERTEBRATE COLLECTIONS

MALLISON, Heinrich, Palaeo3D, Pöttmes, Germany; BELVEDERE, Matteo, Office de la culture, Paléontologie A16, Porrentruy, Switzerland

Many vertebrate paleontology studies are based on morphological data, both surface and internal. The latter is usually acquired via CT scans, the former via direct inspection of the original fossils. For this reason, surface-level data acquisition often requires extensive, expensive travel, thus many studies rely on published images and illustrations of fossils. Using high resolution, high accuracy 3D surface scans (virtual specimens) helps reduce or eliminate travel cost and time demands. Underfunded researchers especially from economically developing countries can gain access through virtual collections they can otherwise never get. Also, these advantages help avoid repeat visits to collections and limit the handling of fragile specimens.

Nevertheless, 3-D surface scanners that are used for creating 3-D models of specimens are prohibitively expensive for many research groups. Here, I present a simple photography protocol allows the speedy creation of highly accurate and highly detailed models at low cost: (1) specimen is placed on four different backgrounds on flat surfaces; (2) specialized scale bars are placed around it in the first position; (3) digital high resolution photographs are captured from all around the specimen in each position; (4) the resulting data set is processed in one of many available commercial or free photogrammetry softwares; (5) the resulting 3D models are carefully scaled and checked for accuracy; and (6) deposited as virtual specimens, with detailed documentation of their creation process, in public collections (ideally with the institution holding the physical specimen). The use of certain support materials and certain workflows for the software typically allows the process to be completed in less than five minutes for data capture and five minutes of program interaction per specimens.

Resulting files are highly accurate—the average deviation of the surface from the specimen is less than the measuring accuracy of digital calipers, the resolution equivalent to optimal full-specimen high resolution digital imagery, far above that of color figures in typical publications. This digitizing regime allows a much more efficient use of science funding for the benefit of all, especially those with limited funding.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A PROBLEMATIC TYRANNOSAURID (DINOSAURIA, THEROPODA) SKELETON AND ITS IMPLICATIONS FOR TYRANNOSAURID DIVERSITY IN THE HORSESHOE CANYON FORMATION (UPPER CRETACEOUS) OF ALBERTA

MALLON, Jordan C., Canadian Museum of Nature, Ottawa, ON, Canada; BURA, Jonathan R., University of Ottawa, Ottawa, ON, Canada; SCHUMANN, Dirk, Fibics Incoporated, Ottawa, ON, Canada

Several published censuses have noted the presence of two tyrannosaurids, *Albertosaurus sarcophagus* and *Daspletosaurus* sp., within the Upper Cretaceous Horseshoe Canyon Formation of Alberta. Although *Albertosaurus* is known from more than a dozen major discoveries in these strata, *Daspletosaurus* is known from just a single problematic skeleton (lacking most of the skull) of a young individual at the Canadian Museum of Nature. The significance of the taxonomic status of this skeleton is not trivial, for if it is *Daspletosaurus*, it would provide evidence for the presence of two co-occurring large apex-predators within the Horseshoe Canyon Formation, which introduces a suite of palaeoecological complications. Further, it would extend the range of *Daspletosaurus* from the middle Campanian into the lower Maastrichtian, a corresponding temporal increase of ~3.5 million years. In this study, we describe and figure this immature skeleton, and marshal a variety of osteohistologic, morphometric, and phylogenetic methods to accurately determine its taxonomic status. Although none of these methods individually provides convincing evidence regarding the affinities of the specimen, together (and including other historical and biostratigraphic considerations) they strongly imply that the skeleton instead pertains to a young *Albertosaurus sarcophagus*. In this way, we show that only a single species of tyrannosaurid is definitively present in the Horseshoe Canyon Formation, greatly simplifying interpretations of tyrannosaurid evolution and ecology in this setting.

Grant Information
Funding for this project was provided by an NSERC Discovery Grant awarded to JCM.

Technical Session VII (Thursday, October 18, 2018, 2:15 PM)

COULD PTEROSAURS AND BASAL MANIRAPTORANS ADOPT A BAT-LIKE HIP POSE? AN ANALYSIS USING "ROM MAPPING," A NEW METHOD FOR COMPARING JOINT MOBILITIES

MANAFZADEH, Armita R., Brown University, Providence, RI, United States of America; PADIAN, Kevin, University of California Berkeley, Berkeley, CA, United States of America

Studies of soft tissue effects on joint mobility in extant animals can help to constrain reconstructions of joint range of motion (ROM) in extinct animals. These studies generally compare maxima in each of a joint's degrees of freedom (e.g., flexion–extension) as measured from different preparations (e.g., all tissues intact vs. dry bones only). However, measuring ROMs in this way suggests the viability of joint poses that are not actually achieved. To combat this misrepresentation, we developed a new approach for comparing joint mobilities called "ROM mapping," which involves plotting 3-D points representing each joint pose and then wrapping the resulting point cloud to create a polygonal ROM envelope representing a joint's mobility. Several ROM envelopes can then be compared. We used ROM mapping to compare the common quail's hip mobility based on "osteological" poses (measured from CT-derived bone models) and "ligamentous" poses (measured from a biplanar fluoroscopic analysis of cadavers with hip joint capsules/ligaments intact). We found that nearly 95% of the hip joint poses that appear possible from the manipulation of bones alone are rendered impossible by ligamentous constraints, a much more drastic reduction than is evident from comparisons of individual degrees of freedom (e.g., flexion–extension = 56% loss). Among these poses was the severely abducted, batlike hip pose often proposed for extinct ornithodirans. We simulated ligament fibers and found that in order to reach this pose, the ventral fibers of the quail ischiofemoral ligament, which limits hip abduction, would have had to stretch to 2/3 beyond their maximum experimental length.

These findings raise the question of whether manipulations of fossil bones have been misleading, and whether ligamentous constraints would have also prevented a bat-like pose in pterosaurs and basal maniraptorans. Because all extant diapsids have a ventral ligamentous thickening of the hip joint capsule, it is most reasonable to infer that these taxa also did, and that their hip abduction would have been similarly limited by ligaments as the common quail's. Although it could be argued that variation in ligament properties may have allowed increased abduction in extinct forms, the results of our ligament simulation indicate that these differences would have had to be extraordinary. In light of our analyses, and considering that other soft tissues (e.g., muscles) further restrict ROM, we suggest that the bat-like hip pose was, in all probability, inviable for pterosaurs and basal maniraptorans.

Grant Information
Supported by a Sigma Xi Grant-in-Aid of Research, the Bushnell Research and Education Fund, the Uplands Foundation, and the Sakana Foundation.

Technical Session VI (Thursday, October 18, 2018, 10:30 AM)

A NEW LONG-BODIED RECUMBIROSTRAN FROM MAZON CREEK WITHA FULL PELAGE OF SCALES REVEALS AMNIOTE-LIKE ULTRASTRUCTURAL INTEGUMENTARY PATTERNS

MANN, Arjan, Carleton University, Ottawa, ON, Canada; MADDIN, Hillary C., Carleton University, Ottawa, ON, Canada

The Carboniferous Pennsylvanian-aged (309–307 Ma) Mazon Creek lagerstatte produces some of the earliest tetrapod fossils of major Paleozoic lineages. Recently, several new tetrapod specimens collected from Mazon Creek have come to light, including some of the earliest recumbirostrans. Here we describe a new long-bodied recumbirostran, known from a single concretion, FMNH 1309, bearing a virtually complete skeleton. We utilized both parsimony and Bayesian phylogenetic methods to conduct phylogenetic analyses using the most recent tetrapod matrix, run in the programs PAUP (parsimony) and MrBayes (Bayesian). Both analyses recover the new taxon within the Cocytinoidea clade, as the sister taxon to *Brachydectes*. Our new taxon represents an important early record of an elongate recumbirostran bauplan, bearing several features linked to fossoriality, including a characteristicly recumbent snout. Uniquely, FMNH 1309 also preserves a full pelage of body scales and lacks any trace of gastralia. Investigation of these scales using Scanning Electron Microscopy (SEM) reveals ultrastructural components and confirms that these structures are composed of small 'fractally-arranged' fibres and not bone. We compare the ultrastructure of these scales to SEM images of extant reptile and amphibian scales compiled from the existing literature. The scales of FMNH 1309 bear remarkable resemblance to the scale ultrastructure of extant snakes and fossorial reptiles, which have scales modified for body-based propulsion. On the basis of these data, we identify the integumentary structures preserved in FMNH 1309 as keratinous scales. We synthesize integumentary patterns of Recumbirostra, noting losses of gastralia and osteoderms associated with body elongation and increased fossoriality. Our new specimen provides the oldest record of keratinous scales in the tetrapod fossil record and provides an important data point when considering terrestrial adaptations and amniote origins, particularly given the recent hypothesis that recumbirostrans are eureptiles.

Podium Symposium (Wednesday, October 17, 2018, 9:45 AM)

SAMPLING-DRIVEN CONSTRAINTS ON TETRAPOD DIVERSITY DYNAMICS ACROSS THE CRETACEOUS/PALEOGENE BOUNDARY

MANNION, Philip, Imperial College London, London, England; BENSON, Roger B., University of Oxford, Oxford, United Kingdom; BUTLER, Richard J., University of Birmingham, Birmingham, United Kingdom; CARRANO, Matthew T., Smithsonian Institution National Museum of Natural History, Washington, DC, United States of America; CLEARY, Terri, Natural History Museum, London, United Kingdom

The Cretaceous/Paleogene (K/Pg) boundary, 66 Ma, marks the most recent Phanerozoic mass extinction. Although biotic patterns during the boundary interval have been the focus of numerous studies, most have focused on the North American record. Whilst this is understandable in terms of the abundance and stratigraphic resolution of North American data, if patterns there are not globally representative this will cloud any understanding of diversity dynamics elsewhere. Furthermore, until recently, these studies did not explicitly consider biases in our sampling of the fossil record that can obfuscate genuine macroevolutionary patterns. The advent of large databases, coupled with the development of statistical methods to ameliorate sampling biases, has revolutionised our approach to reconstructing past diversity. Using the Paleobiology Database, we have contributed to a near-comprehensive data set on published tetrapod fossil occurrences, spanning the Campanian through Paleocene. This comprises >22,000 occurrences, representing >2000 genera, from >5000 localities. Although still dominated by the North American record, >25% of these data come from other regions. Working at stage level (the stratigraphic resolution of most tetrapod fossils), we applied shareholder quorum subsampling to reconstruct diversity for major clades within paleocontinental regions, as well as globally for marine taxa. We also quantified the quality of sampling using Good's *u*, a measure of sampling coverage. Although North America still provides the only well-sampled, continuous K/Pg record, data from Asia and Europe suggest a modest decrease in dinosaur and crocodylomorph diversity from the Campanian to Maastrichtian. However, there is no evidence that this indicates the onset of a terminal 'decline' in diversity, rather than normal background fluctuations. In contrast to North America, we find evidence for a slight decline in South American crocodylomorph diversity across the K/Pg boundary. Although the Maastrichtian record is too sparse to reconstruct a continuous record in Asia, Paleocene mammalian diversity appears to greatly exceed that of Campanian mammals and dinosaurs combined, mirroring the North American pattern. Hypotheses of extinction selectivity have primarily been based on the persistence of crocodylomorph and turtle lineages in North America, but it remains unclear whether the same processes occurred on other continents. An improving record outside of North America is critical to developing a global understanding of the K/Pg event.

Grant Information
Royal Society University Research Fellowship (UF160216); European Union's Horizon 2020 research and innovation programme 2014–2018 (ERC starting grant 637483)

Technical Session VI (Thursday, October 18, 2018, 8:15 AM)

YES, WE CAN HOMOLOGIZE SKULL (AND OTHER) BONES OF ACTINOPTERYGIANS AND TETRAPODS

MARJANOVIĆ, David, Museum für Naturkunde, Berlin, Germany

It is difficult to tease apart the homologies of bones across Osteichthyes, often even within Actinopterygii. For a long time, it seems, anatomists gave up the attempt; numerous separate—sometimes contradictory—nomenclatures were used in different decades for different taxa or by different authors. However, a flood of recent discoveries provides grounds for optimism.

The tetrapod stem is much more densely sampled than 25 years ago, confirming unambiguously that the large bones of the actinopterygian skull table—which lie in roughly the same places as the frontal and parietal of crown-group tetrapods—are homologous to the parietal (the "preorbital" of "placoderms") and the postparietal. This affects the next more lateral series as well: as recently proposed, the "dermosphenotic"/"infraorbital 5" is the intertemporal (which participates in the orbit margin in a few early tetrapods), the "dermopterotic"/"intertemporal" is the supratemporal and the "supratemporal" is the tabular.

Further, the base of the tetrapod stem clarifies the original spatial relationships of other bones: the bone dorsal of the (anterior) naris is plesiomorphically not the nasal, but the so-called anterior tectal, and the one ventral to it is the so-called lateral rostral (apparently homologous to the septomaxilla of crown-group tetrapods), making it likely that these are the homologs of the actinopterygian "nasal" and "antorbital" respectively. Unlike in tetrapods, the squamosal of many other sarcopterygians has a long contact with the maxilla and could be homologous to the (second) "supramaxilla".

Outside the tetrapod stem, the placoderm-grade animal *Entelognathus* has shown that some homologies can be traced beyond Osteichthyes; I further propose that the unpaired "vomer" of various actinopterygians is the "prerostral plate" seen in "placoderms" and the Silurian osteichthyan *Guiyu*, the actual paired vomers being represented by the "vomerine toothplates".

The braincase remains underresearched even within crown-group tetrapods, and neomorphic bones seem more common there than in the dermal skeleton; still, it seems clear that the best candidates for homologs of the opisthotic are the "autopterotic" and/or perhaps the "epiotic"/"epioccipital" of actinopterygians, not the "intercalary" sesamoid.

I propose further homologies throughout the skeleton based on ontogenetic data and the rich fossil record, and hope to start a discussion on this promising field. Confidently identified homologs would give a boost to phylogenetics and evolutionary biology.

Technical Session XIII (Friday, October 19, 2018, 2:15 PM)

NEW SPECIMENS OF *ACAENASUCHUS GEOFFREYI* (ARCHOSAURIA: PSEUDOSUCHIA) SUPPORT THE PRESENCE OF A NEW TRIASSIC CLADE OF ARMORED PSEUDOSUCHIANS IN NORTH AMERICA

MARSH, Adam D., Petrified Forest National Park, Petrified Forest National Park, AZ, United States of America; SMITH, Matthew E., Petrified Forest National Park, Holbrook, AZ, United States of America; PARKER, William, Petrified Forest National Park, Petrified Forest National Park, AZ, United States of America; IRMIS, Randall, University of Utah, Salt Lake City, UT, United States of America; KLIGMAN, Ben T., Petrified Forest National Park, Petrified Forest National Park, AZ, United States of America

The Upper Triassic strata of North America have produced an incredible diversity of morphologically disparate vertebrate taxa that were adorned with a variable amount of dermal bones. These ossifications range from dorsal rows of osteoderms in taxa such as phytosaurs, rauisuchids, and crocodylomorphs, to partial or full carapaces, such as those found in *Vancleavea*, *Revueltosaurus*, *Euscolosuchus*, and aetosaurs. One such taxon, *Acaenasuchus geoffreyi*, was originally named as a new aetosaur genus only from small (~2-4 cm mediolateral width) paramedian and lateral osteoderms from the Chinle Formation near St. Johns, Arizona. *Acaenasuchus* has since been considered a juvenile *Desmatosuchus*, the sister taxon of *Desmatosuchus*, or a non-aetosaur pseudosuchian. We introduce new specimens of *Acaenasuchus* from Petrified Forest National Park and the holotype locality near St. Johns, including ornamented skull bones, novel osteoderm morphotypes, trunk vertebrae and ribs, and appendicular bones such as the humerus, ilium, pubis, ischium, femur, and tibia. Differences in the shape and articular surfaces of the osteoderms of *Acaenasuchus* indicate regional variation in osteoderm morphology depending on placement over the body. The paramedian osteoderms are serially coossified to one another over the pectoral girdle but not over the trunk, and coossified osteoderms form rings around the tail, much like those of glypodonts. A phylogenetic analysis performed using these new specimens supports the hypothesis that *Acaenasuchus geoffreyi* is closely related to *Euscolosuchus olseni* from the Upper Triassic Vinita Formation of Virginia; both taxa share features on the osteoderms such as the presence of a large lateral spine on trunk lateral osteoderms and dorsal ornamentation consisting of narrow, anastomosing ridges. *Acaenasuchus* represents a clade of stem-aetosaurs, and histological data indicate that the diminutive osteoderms from the type locality of *Acaenasuchus* are not skeletally immature, further supporting the argument against it being a juvenile aetosaur. Our results emphasize the importance of osteohistology as an independent line of evidence for estimating skeletal maturity and suggest that even fragmentary fossils can shed light on previously unknown diversity in the Late Triassic vertebrate assemblages in North America.

Grant Information
Petrified Forest Museum Association

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A REVIEW OF MIDDLE TO LATE MIOCENE CRICETID RODENTS FROM FLORIDA

MARTIN, Robert A., Murray State Univ, Erie, PA, United States of America; HULBERT, Richard C., University of Florida, Gainesville, FL, United States of America

The pre-Pleistocene fossil record of cricetid rodents in Florida is sparse, especially in contrast to their abundance and diversity in Blancan and younger localities in the state. In this study, we summarize cricetid fossils from the middle to late Miocene of Florida. Four new records are documented: *Copemys russelli* from the early Barstovian Gunn Farm Mine, either a new genus and species or a new species of *Jacobsmys* from the early Hemphillian Tyner Farm site, and *Bensonomys arizonae* and *Baiomys* sp. from the late Hemphillian Montbrook locality. The new taxon, known from a single first lower molar, is characterized by tubercular hypsodonty, a symmetrically bifid and recurved anteroconid, a centrally located anterostylid at the base of the anteroconid, vertically and horizontally deep flexids separating slightly alternating metaconid-protoconid and entoconid-hypoconid cusp pairs, and a short mesolophid. Adaptively similar (ecomorphic) dental features are present in extant insectivorous and piscivorous cricetids such as *Onychomys* and the ichthyomyinin sigmodontines. The new taxon resembles *Abelomoschomys simpsoni* from Florida and *Jacobsmys dailyi* from western North America, and the three are considered part of a North American Neogene clade with possible ties to South American sigmodontines. The low diversity of sigmodontine dentitions from late Neogene Florida deposits suggests the full radiation of this speciose subfamily was mostly confined to Central and South America.

Technical Session II (Wednesday, October 17, 2018, 8:00 AM)

SALT GLAND STRUCTURES IN *ICHTHYOSAURUS*?

MASSARE, Judy A., SUNY Brockport, Brockport, NY, United States of America; WAHL, William R., Wyoming Dinosaur Center, Thermopolis, WY, United States of America; LOMAX, Dean R., The University of Manchester, Manchester, United Kingdom

Salt-secreting glands allow marine reptiles to remove salts that accumulate from ingesting seawater and prey that is isosmotic with seawater. Salt glands have been considered a primitive feature for diapsid reptiles. Their anatomical position varies among extant reptiles, from orbital glands in sea turtles to oral glands in marine crocodiles and snakes, to nasal glands in lizards and birds. Because of the difference in position, salt glands are thought to have originated independently multiple times. The presence of salt glands in extinct marine reptiles have been inferred from structures in the antorbital region of metriorhynchid crocodiles and narial region of mesosaurs. Additionally, paired casts of lobate structures in the internal nasal region of the Cretaceous polycotylid plesiosaur *Pahasapasaurus haasi* and the Late Jurassic ichthyosaur *Ophthalmosaurus natans* have been interpreted as evidence of nasal salt glands. Here we report the occurrence of structures in the external nares that might indicate the presence of salt gland ducts. In several specimens of the Early Jurassic ichthyosaur *Ichthyosaurus* (including the holotype of *I. larkini*), a small triangular process on the lacrimal protrudes into the external naris, defining a circular region at the posterior end of the naris. On two specimens of *I. somersetensis*, a ring of bone occurs in a similar position. These features might mark the position of a duct for excreting a concentrated salt solution from nasal salt glands. This is an ideal position for such a duct because the flow of water across the skull during swimming would efficiently carry away the salt solution.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

USING FIELD PALEONTOLOGY AS A MEANS TO INSPIRE STEM INTEREST AND CROSS-CURRICULAR EXPERIENTIAL LEARNING IN AN ALL-GIRLS HIGH SCHOOL.

MASTERS, Simon L., Beaumont School, Brecksvilee, OH, United States of America

Fossils spark the imagination of learners of all ages. They can also spark interest in STEM. Women are underrepresented in the physical (non-life) sciences in the United States. The Summer Dig Program at Beaumont School aims to help change this statistic. Students engage in an eleven day cross-country road trip. The trip is designed to incorporate not only STEM but as many subjects as possible: art, history, social studies, and English. Students visit the Burpee Museum of Natural History and the Carter County Museum to gain an appreciation for public institutions and their civic value. The eleven days consist of three days from Cleveland to Montana, five days in Montana, and three days back to Cleveland. Many students have never been west of Chicago, creating a greater understanding of America.

We work with the Burpee Museum of Natural History on one or more active fossil resource locations. By working on active sites, students are contributing to active, on-going research projects. During the five days on-location, the students learn basic field techniques that are used in paleontology but can be applied to many other field science disciplines. To break up the week of field work, we take a day to visit the first national monument, Devil's Tower, in Wyoming. This provides students with yet another opportunity to look at government, sustainability, ecology, and tourism as complex dynamic components of the human experience. On the way back to camp, there is a historical marker describing a short lived military camp in the area and the effect it had on the local peoples. The end of the field portion is devoted to the Dino Shindig, hosted by Carter County Museum. The event brings in researchers from all over the globe to discuss research in the latest Cretaceous. Students get to experience a mini-conference of technical talks and community interactions. Even more importantly, they get to see women scientists who can and do serve as positive role models. Throughout the trip, students use technology to document their experiences through social media, digital photography, blogs, and emails to the school community. The students will reflect on their experience in the fall. Students have the opportunity to put their reflection into whatever medium they wish; so far the choices have been video with music, poem, speech, and picture book. The program uses field paleontology and the thrill of discovery to build cross-curricular experiences and an inspiration for STEM.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

TEN YEARS OF EXCAVATION AT THE LATE JURASSIC (TITHONIAN) HANKSVILLE-BURPEE DINOSAUR QUARRY, (MORRISON FORMATION, BRUSHY BASIN MEMBER) AND A POSSIBLE NEW SPECIMEN OF *TORVOSAURUS TANNERI*

MATHEWS, Joshua C., Burpee Museum of Natural History, Rockford, IL, United States of America; LARGE, Daniel S., Burpee Museum of Natural History, Rockford, IL, United States of America; WILLIAMS, Scott A., Museum of the Rockies, Bozeman, MT, United States of America; TREMAINE, Katie, Museum of the Rockies, Bozeman, MT, United States of America

The Hanksville-Burpee Dinosaur Quarry is a sauropod dominated multi-taxonomic bonebed in the Brushy Basin member of the Morrison Formation in south central Utah, located on land administered by the Bureau of Land Management. Field crews from the Burpee Museum of Natural History located the site in 2007 and have been excavating the site for 10 consecutive summers since its discovery. The bone-bearing unit extends for more than 1 kilometer to the northeast and is interpreted as a mass accumulation of fossils deposited within a braided-river system. The enclosing sediments are a series of fine to coarse-grained sandstones with occasional green mudclasts present.

Over 1,000 fossils have been recovered from the site to date. The most abundant dinosaurs in the quarry belong to the sauropod dinosaurs and include *Diplodocus*, *Apatosaurus*, *Camarasaurus*, and possibly *Barosaurus*. The vast majority of the material is postcranial, however a partial *Camarasaurus* braincase has been recovered along with a near complete right dentary. Surprisingly, none of the recovered sauropod material appears to be of adult size and ranges from very young animals to subadult. This is not unique, however, as other localities have shown a similar occurrence of younger animals buried together. While the quarry is rich with sauropod material, there is a considerable amount of non-sauropod material present at the site. Theropod material from the quarry includes a partial *Allosaurus* skull, dentary, vertebrae and ribs, a small, unidentified theropod femur, and a large thumb claw and tibia tentatively referred to *Torvosaurus tanneri*. To date, the only known thumb claw of *Torvosaurus* is only provisionally referred to the species and was found nearly 200 km from the type specimen at Dry Mesa Quarry in Colorado. This would mark the first occurrence of the thumb claw in a deposit with other *Torvosaurus* material. Additional theropod fossils from the quarry that were assumed to belong to *Allosaurus* are currently being reexamined and may represent additional *Torvosaurus* material. The rare nodosaurid ankylosaur, *Mymoorapelta maysi* has also been found in the Hanksville-Burpee Dinosaur Quarry. This specimen is represented my numerous osteoderms, ribs, vertebrae, and a femur, and represents the eighth known specimen. Ornithopods are uncommon in the quarry and the only known occurrence at the site is *Dryosaurus*. It is represented by an ilium, scapula, and femur. Excavation of the Hanksville-Burpee Dinosaur Quarry has been ongoing for over a decade and continues to produce new finds every year.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE SLEEPING BEAUTY: A DESMOSTYLIAN FOSSIL RE-DISCOVERED FROM THE GEOLOGICAL COLLECTIONS AT THE UNIVERSITY OF TSUKUBA

MATSUI, Kumiko, Kyushu Universiyty, Fukuoka, Japan; KIMURA, Yuri, National Museum of Nature and Science, Tsukuba, Japan; NAGATA, Mitsuhiro, Toyama University, Toyama, Japan; INOSE, Hiroaki, Fukushima Museum, Fukushima, Japan; IKEDA, Kazuya, Tsuchiyu-Onsen Tourism Association, Fukushima, Japan; BEATTY, Brian L., NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America; HIRATA, Takafumi, The University of Tokyo, Tokyo, Japan; SHINMURA, Tatsuya, Ashoro Museum of Paleontology, Ashoro, Japan; AGEMATSU, Sachiko, University of Tsukuba, Tsukuba, Japan; SASHIDA, Katsuo, University of Tsukuba, Tsukuba, Japan

Unexpected discoveries can be made from museum cabinets when specialists come across uncatalogued or even cataloged specimens. Here, we report a new 'discovery' of a desmostylian fossil from geological collections of the University of Tsukuba, Japan. This fossil was unearthed over 60 years ago and donated to the university for an unknown reason. Owing to the original hand-written note kept with the fossil in combination with interview investigation, we were able to reach two equally possible fossil sites in the town of Tsuchiyu Onsen, Fukushima, Japan. Through the interviews, we learned that the fossil was discovered during the construction of a debris flow barrier and that it was recognized as a 'dinosaur' bone by the locals and displayed in the Village Hall until the town experienced a fire disaster in 1954.

This 'dinosaur' specimen is a femur with a flattened, straight shaft and a well-developed third trochanter with well-preserved muscle scars on the surface. These features are characteristic of Desmostylia. We compared this specimen with other desmostylian femora (*Ashoroa*, *Behemotops*, cf. *Cornwallius*, *Desmostylus*, *Paleoparadoxia*, *Neoparadoxia*) and identified it as a right femur of *Paleoparadoxia*. Femoral characteristics only present in *Paleoparadoxia*, such as a lesser trochanter that is bulging to the inside and a lesser trochanter that is close to the femoral head, correspond to our specimen. This specimen is thought to be an adult individual based on the fused femoral head. Previously, desmostylian femoral characters were not explicitly included in their diagnoses, and there were few comparative analyses of the desmotylian femur. This study revealed femoral traits diagnostic for *Paleoparadoxia*. We further utilized the host rock that remains intact on the specimen for the age determination. The rock sample was analyzed for U-Pb dating of zircons with a Nu Plasma II multiple collector-ICP- mass spectrometer combined with the IFRIT 260 nm femtosecond laser system at the Geochemical Research Center at the University of Tokyo. The age was estimated to be 15.9 Ma or younger in zircon-dating, which is consistent with a biostratigraphically inferred age.

This study is an excellent example of how historical and scientific significances can be extracted from long-forgotten uncatalogued specimens as long as the original information is retained with the specimens.

Grant Information
JSPS 16J00546, Chemostratigraphy Project: N10N03-2003

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

THE IMPACT OF EXCAVATION AND DOCUMENTATION ON ANALYSIS AND INTERPRETATION: A LOOK AT THE ICHNOLOGICAL INTERPRETATIONS AT THE MILL CANYON DINOSAUR TRACKSITE, UTAH

MATTHEWS, Neffra A., US Bureau of Land Management, Denver, CO, United States of America; HUNT-FOSTER, ReBecca K., Bureau of Land Management, Moab, UT, United States of America; BREITHAUPT, Brent H., Bureau of Land Management, Cheyenne, WY, United States of America; LOCKLEY, Martin, University of Colorado Denver, Denver, CO, United States of America

The Mill Canyon Dinosaur Tracksite (MCDT) was discovered in 2009 approximately 14 miles north of Moab, Utah, on land managed by the Bureau of Land Management's Moab Field Office. Initial investigation of this Early Cretaceous tracksite yielded a unique vertebrate ichnofauna, including dinosaurian, crocodilian and avian tracks. Didactyl trackways of *Dromaeosauripus* represent the first trackways of this ichnotaxon reported from North America. Due to the scientific importance of the site and its proximity to outdoor recreation opportunities, a resource management approach was developed that emphasized scientific research, public visitation, and education. Between 2013 and 2015, overlying sediment was removed from the site for ichnological research, resulting in the discovery of at least 10 named ichnotaxa. Included in the census were an additional *Dromaeosauripus* trackway, as well as large-, medium- and small-sized tridactyl theropod tracks and trackways. Also present are *Caririchnium*-like ornithopod trackways and sauropod trackways. Between 2015 and 2017, ADA compliant footpaths, boardwalks, interpretative signs, a shade structure, an expanded parking area, and a pit toilet were installed.

Traditional ichnological documentation began at the site in 2009, and hand-held, close-range photogrammetric documentation was conducted in the isolated exposed areas in 2010. In 2014, after spring excavation and prior to the construction of the boardwalk, systematic photogrammetric documentation of the main track surface was conducted using a high resolution digital camera with remote trigger mounted on a monopod to acquire nadir, overlapping photographs. In May 2017, after completion of the boardwalk and facilities, the entire developed area was photogrammetrically documented using a 3DR Solo equipped with a Ricoh GR II camera. The MCDT was photographed at a variety of heights ranging from 7.5 meters above the main track surface to 76 meters over the developed area. Due to the approach utilized to capture photogrammetric imagery of the site, all three episodes of photography were processed together in Agisoft PhotoScan in a unified coordinate system. The resulting digital data set provides a unique look at the evolution of a tracksite from a documentation and interpretation perspective; both in terms of the impact of exposure to the elements on potential morphological changes to the tracks themselves, as well as how limiting the window to the track surface may impact current and future interpretations.

Technical Session V (Thursday, October 18, 2018, 12:00 PM)

THE COMPLETENESS OF THE EARLY HOMININ FOSSIL RECORD: IMPLICATIONS FOR DIVERSITY PATTERNS AND THE ORIGIN OF HOMININI

MAXWELL, Simon J., Birkbeck, University of London, London, United Kingdom; HOPLEY, Philip J., Birkbeck, University of London, London, United Kingdom; UPCHURCH, Paul, University College London, London, United Kingdom

The early African hominin fossil record is notoriously poor, particularly during the period molecular clock studies date the *Pan-Homo* last common ancestor, and there is much scope for a quantitative analysis of the biological, geological, and anthropogenic factors controlling specimen and taxon completeness. Here, we assess the completeness of the early African hominin fossil record using the Character Completeness Metric 2 (CCM2), which calculates the percentage of phylogenetic characters that can be scored, and the Skeletal Completeness Metric 2 (SCM2), which calculates the percentage of the skeleton preserved. The average completeness score is plotted through geological time and compared to taxic diversity, rock availability, collection effort, abundance of hominin specimens, the ratio of hominin-bearing collections to formations (a proxy for the bonanza effect), and a record of continental-scale aridity. Time-series were de-trended and corrected for autocorrelation prior to regression, and evaluated using Spearman's rho, Kendall's tau, and significance values corrected for multiple tests. Multiple regressions were also applied to explore the possibility of multiple explanatory variables. CCM2 is remarkably poor during the first half of hominin evolution (less than 8% between 7.0 and 5.3 Ma), while the second half is exceptionally complete (approximately 80% between 3.4 and 1.0 Ma). The SCM2, on the other hand, shows multiple peaks separated by major troughs and, unsurprisingly, CCM2 and SCM2 show little relation to one another (a consequence of hominin phylogenetic analyses including only cranio-dental characters). Both CCM2 and SCM2 show no relation to taxic diversity, suggesting that specimen completeness has no significant effect on the ability of palaeoanthropologists to recognise species. However,

both are influenced by sampling: CCM2 by collection effort and SCM2 by the bonanza effect. In combination, these findings demonstrate that neither character nor skeletal completeness is an adequate continental-scale proxy for sampling, and that the fossil record during the period most pertinent to human origins is frustratingly incomplete.
Grant Information
SJM is supported in full by the Natural Environment Research Council [NE/L002485/1].

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

DENTAL MICROWEAR ANALYSIS OF THREE TAXA OF LATE CRETACEOUS LIZARDS (SQUAMATA, BORIOTEIIOIDEA)

MAYBERRY, Aaron L., Midwestern University, Glendale, AZ, United States of America; NYDAM, Randall L., Midwestern Univ, Glendale, AZ, United States of America; TOWNSEND, K.E. Beth, Midwestern University, Glendale, AZ, United States of America; MITCHELL, John, Midwestern University, Glendale, AZ, United States of America; COOPER, Kimbal, Midwestern University, Glendale, AZ, United States of America; MANFREDI, Kevin, Midwestern University, Glendale, AZ, United States of America

Dental microwear analysis is commonly used in the study of bite cycle and diet in mammals and has recently been applied to dinosaurs. In a first of its kind study, we analyzed dental microwear of a group of fossil squamates: borioteiioid lizards (Cenomanian–Maastrichtian, North America). These lizards are distinguished by the presence of transversely-oriented, interdigitating teeth; a rare morphology in squamates. Additionally, most taxa, except *Bicuspidon,* appear to have arrested tooth replacement. These features have led to hypotheses of feeding specialization dependent upon maintenance of precise occlusion of the upper and lower marginal dentitions. Dental microwear analysis of *Bicuspidon* (four teeth), *Dicothodon* (five teeth), and *Polyglyphanodon* (three teeth) was used to assess if this hypothesis can be applied to these specimens. 400X SEM images were systematically captured and analyzed to identify, label, and determine the angle of observed scratches. Angle values were further analyzed using circular statistics (for data measured on a radial rather than linear scale).

For both *Bicuspidon* and *Dicothodon,* the teeth examined were a small sample of numerous specimens recovered from bulk sampling of lag deposits making it unlikely that they were from the same individuals. This was further supported by the significant difference in mean scratch angles of each tooth within each taxon. For *Polyglyphanodon* the three teeth are occlusal neighbors (two maxillary teeth on either side of one dentary tooth) from the same skull. The mean scratch angles of these teeth were not significantlydifferent.

As a general comparison, the mean scratch angle (when corrected to 0–90°) for the examined teeth of *Bicuspidon* (80.1°) indicates less overall vertical occlusal precision than for those of *Dicothodon* (82.2°), but the heavily worn teeth of *Dicothodon* indicate a much more abrasive diet. The mean scratch angle of *Polyglyphanodon* (85.5°) suggests it possessed the most precise dorsoventral bite precision of the three taxa. Interestingly, apical wear in *Polyglyphanodon* is minimal raising new questions about previous hypotheses regarding tooth replacement and diet in *Polyglyphanodon*.

Our study shows that dental microwear analysis can be a useful tool for analyzing fossil lizard teeth. It is best applied to specimens with known occlusal relationships, but in the absence of such specimens, these analyses remain useful for determining general occlusal patterns, but appropriate circumspection should be applied to interpretations.
Grant Information
MWU Biomedical Sciences Research Funds (ALM) and MWU Intramural Research Funds (RLN)

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

INTRASPECIFIC VARIATION IN *ACRATOCNUS* (MAMMALIA, PILOSA, MEGALONYCHIDAE) ACROSS THE GREATER ANTILLES

MCAFEE, Robert K., GA-PCOM, Suwanee, GA, United States of America; BEERY, Sophia M., Findlay, OH, United States of America

Of the various megalonychid sloth genera inhabiting the Greater Antilles during the Neogene and Quaternary, only the genus *Acratocnus* has been found on all three sloth-bearing islands (Jamaica has no known sloth fossils). Based on island isolation and morphological differences, species for *Acratocnus* are specific to each island and there is no more than one species to an island: *A. antilliensis* from Cuba, *A. ye* from Hispaniola, and *A. odontrigonus* from Puerto Rico. Diverse cave samples from Hispaniola and Puerto Rico permitted exploration of intraspecific variation within each island, as well comparison of patterns across islands. Linear measurements of upper limb elements (humerus, radius, ulna) were utilized in this study, with total length serving as a proxy for body mass, as that variable has not been reliably calculated from xenarthran limb bones. Coefficients of variance (CV), regressions, and box plots of geographic localities were also used to evaluate patterns and parameters for intraspecific variation. CVs of *A. odontrigonus* are consistent for each element (6.15–6.38%), while those of *A. ye* vary a little (5.70–7.36%); such values and range are not unreasonable for a single species. Between species, there is almost no difference in size dimension, except for the radius which is larger in *A. odontrigonus*. For the humerus, each *Acratocnus* species exhibits size separation that forms two groups or morphs when the data is plotted without regard to locality. When plotted by locality to assess any geographical effects, similar ranges are evident and the two size groups are mostly present within each locality; a few only exhibit one size morph, likely attributed to smaller sample sizes ($n \leq 3$). Patterns for the ulna and radius are not as clear as the humerus, which may be due to the bowed nature of those forelimb elements in *Acratocnus*. Although temporal variance is not able to be accounted for, the overall implications are that each *Acratocnus* species exhibits two distinct size morphs that, given the CV values, are suggestive of sexual dimorphism rather than speciation. At least as it applies to the upper limb, there would be little to distinguish these *Acratocnus* species from one another if not for their separate island existences. Similar results and patterning is expected for *A. antilliensis* from Cuba, should adequate samples be obtained.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

***EOSAUROPUS* (SAUROPODOMORPH) TRACKWAY FROM THE CHINLE INTERVAL (UPPER TRIASSIC) OF THE PURGATOIRE RIVER VALLEY, SOUTHEASTERN COLORADO**

MCCLURE, Warren, Otero Junior College, La Junta, CO, United States of America; KORBITZ, Mark, Otero Junior College, La Junta, CO, United States of America; SCHUMACHER, Bruce A., USDA Forest Service, La Junta, CO, United States of America

A tetrapod trackway recently recorded in 'red rocks' (Upper Triassic) geology of the Purgatoire Valley (southeastern Colorado, property of The Nature Conservancy) is attributable to *Eosauropus*. The trackway (Alejandro Site) occurs along the banks of the Purgatoire River, roughly ten miles upstream from the "Dinosaur Lake" tracksite of the Morrison Formation.

Until recently, stratigraphic subdivision of the 'red rocks' interval in this region was poorly understood. The geologic map of Colorado depicts this area the 'Entrada Sandstone' overlying 'Dockum Group'. Fossils from the 'red rocks' interval are rare, and is largely the cause of historical stratigraphic ambiguity. Recent stratigraphic work on adjacent U.

S. Forest Service land led to discovery of Late Triassic tetrapods, including scutes, teeth, and bone fragments of metoposaurs, aetosaurs, and phytosaurs. The tetrapod fossils occur in discontinuous channels of limestone-pebble conglomerate deposited in a high-energy fluvial environment near the top of the 'red rocks interval. The trackway occurs within a thinly laminate sandstone bed, roughly one meter above the conglomerate, and just a few meters below a major unconformity (~J-0–J-2) marking contact with overlying Jurassic evaporate deposits (Ralston Creek equivalent).

The new trackway ('Alejandro Site') represents one of only about five reported occurrences of Late Triassic *Eosauropus* tracks in North America. Shape and orientation of pes tracks are strikingly similar to those of well documented post-Triassic sauropod ichnos such as *Parabrontopodus*, reinforcing the logical presumption that *Eosauropus* tracks represent basal sauropodomorph dinosaurs ('prosauropod').

Twelve pes prints were naturally exposed, and five more were quickly revealed from beneath a minimal amount of overburden (continues in subsurface). Manus prints are subtly present at a few locations within the series. The track series extends over 7 meters, with seventeen successive pes footfalls so far. Pes prints average 25 cm in length, with pace angulation values averaging 155°. Tracks excavated during recording are filled with sandstone casts, and preservation of fine details such as digital indications are lacking. Based upon initial literature review, this is the longest successive series of *Eosauropus* tracks known in North America. Also noteworthy are new locations containing tetrapod bone fragments, and extensive, cylindrical burrow structures (m-scale) which we continue to investigate as possible rhizoliths or invertebrate activity.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A NEW SPECIES OF *BOREALOSUCHUS* AND ITS IMPLICATIONS FOR THE EVOLUTION OF CROCODYLIA

MCCORMACK, Larkin, University of Iowa, Iowa City, IA, United States of America; BROCHU, Christopher A., University of Iowa, Iowa City, IA, United States of America

Crocodylian fossils first appear during the Campanian (Late Cretaceous). The genus *Borealosuchus* is critical to understanding early crocodylian evolutionary history, as it could be close to the ancestry of all modern groups, but the phylogenetic relationships with respect to other crocodylians and eusuchians are not well resolved. In recent analyses, *Borealosuchus* has been recovered as most closely related to Gavialoidea, Brevirostres, or Crocodylia as a whole. Previously described *Borealosuchus* span the Maastrichtian to the Eocene, are mostly from the North American Western Interior, and represent a eusuchian clade that survived the K/Pg mass extinction. We identified a new species of *Borealosuchus* that represents the oldest occurrence of this genus, extending its chronologic range by 15 million years. The specimen is from the Harrell Station locality, an early Campanian (~82 Ma) site in the Mooreville Chalk of Alabama. The specimen preserves the posterior end of the skull including the quadrates, quadratojugals, exoccipitals, basioccipital, postorbitals, and squamosals, as well as a disarticulated maxilla, lacrimal, frontal, parietal, and a partial mandible. Preserved postcranial remains include an ilium, trunk vertebrae, dorsal osteoderms, and ventral osteoderms. Additionally, fragmentary mandibular material from the late Santonian Eutaw Formation of Alabama may be referable to the same species, which would further increase its range. Although fragmentary, this specimen possesses a unique combination of characters not found in any other species of *Borealosuchus*. These include bipartite ventral osteoderms, a splenial that participates in the mandibular symphysis, a short mandibular symphysis, and a small external mandibular fenestra. This combination of characters is unexpected given its stratigraphic age.

Phylogenetically the new species is more closely related to the other eastern species, *B. threeensis*, and the younger, more derived *B. wilsoni*, rather than the older Late Cretaceous/Paleocene species *B. sternbergii* and *B. formidabilis* as would be expected. This new taxon is among the oldest known crocodylians or crocodylian relatives, and sheds critical light on morphological conditions and the biogeographic distribution of the earliest members of the crown group. This study suggests that there are likely unsampled stratigraphic and geographic extensions for other eusuchian clades.
Grant Information
GSA Graduate Student Research Grant
University of Iowa, Department of Earth and Environmental Sciences

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

NEW DISCOVERIES OF TYRANNOSAURID, ORNITHOMIMID, AND NODOSAURID DINOSAURS FROM THE UPPER CRETACEOUS (LOWER CAMPANIAN) ALLISON MEMBER, MENEFEE FORMATION OF NEW MEXICO

MCDONALD, Andrew T., Western Science Center, Hemet, CA, United States of America; WOLFE, Douglas G., Zuni Dinosaur Institute for Geosciences, Springerville, AZ, United States of America

In 2011, we began surveying unexplored outcrops of the Menefee Formation in the San Juan Basin of northwestern New Mexico, under permits from the U.S. Bureau of Land Management and assisted by volunteers from the Southwest Paleontological Society and University of Pennsylvania. Historically, the vertebrate fauna of the Menefee Formation

has been poorly known, with only two associated vertebrate specimens: a skull of the alligatoroid *Brachychampsa* and an indeterminate centrosaurine dinosaur. Our discoveries so far include partial shells of baenid and trionychid turtles, osteoderms and other elements of a large neosuchian similar to *Denazinosuchus*, and several associated dinosaur skeletons. All of these specimens were collected in the upper part of the Allison Member (lower Campanian, ~81–80 Ma).

A new tyrannosaurid is represented by an associated skeleton that includes both frontals, manual and pedal elements, and many axial and appendicular fragments. The frontals are most similar to those of *Teratophoneus* from the middle Campanian Kaiparowits Formation of Utah, but exhibit three autapomorphies that distinguish the Allison Member specimen from all other tyrannosaurids. The frontals are similar in dimensions to those of the subadult *Tyrannosaurus* specimen previously considered the holotype of "*Dinotyrannus*".

An indeterminate ornithomimid is known from an extremely fragmentary appendicular skeleton that includes a non-raptorial manual ungual with a reduced flexor tubercle. Although too incomplete to diagnose to genus or species, this specimen is the first ornithomimid reported from the Allison Member.

A new nodosaurid is represented by three associated skeletons that consist mostly of cervical/pectoral, thoracic, and pelvic osteoderms; one of the skeletons also includes vertebrae and forelimb elements. The Allison Member nodosaurid specimens all share a unique osteoderm surface texture, and two of the specimens preserve an additional autapomorphy, a 'split keel' on some thoracic osteoderms. The new nodosaurid is closely related to *Glyptodontopelta* from the Maastrichtian Naashoibito Member, Ojo Alamo Formation of New Mexico.

Lower Campanian dinosaurs are rare in western North America. Along with recent discoveries in the Wahweap Formation of Utah, and units in Montana and Alberta, the new dinosaurs from the Allison Member will help elucidate this mysterious chapter in the evolution of North America's dinosaurs.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

PROTEROTHERIIDS (MAMMALIA, LITOPTERNA) FROM THE EARLY MIOCENE (SANTACRUCIAN SALMA) OF PAMPA CASTILLO, CHILE, ANDA PHYLOGENETIC ANALYSIS OF THE GROUP

MCGRATH, Andrew J., University of California-Santa Barbara, Santa Barbara, CA, United States of America; FLYNN, John J., American Museum of Natural History, New York, NY, United States of America; WYSS, Andre, University of California-Santa Barbara, Santa Barbara, CA, United States of America

The early middle Miocene (Santacrucian South American land mammal age) Pampa Castillo fauna, the westernmost fossil mammal assemblage in Patagonia, records at least two proterotheriids, small to mid-sized native ungulates. The first, *Thoatherium*, represents the northernmost occurrence of this taxon and its first outside Santa Cruz Province, Argentina. The other, *Picturotherium* was previously restricted to the upper Pinturas River valley, also in Santa Cruz. An m3 referred to *Picturotherium* (SGO PV 2158) is ~50% larger than that of *P. migueli*, the only known species. Even if this size difference is too large to be ascribed to intraspecific variation, a single tooth provides an inadequate basis for recognizing a new species. A third, indeterminate proterotheriid, larger than *Thoatherium* and *Picturotherium*, is represented by a mandibular fragment bearing two fragmentary molars. Hypsodonty appears to vary with longitude among Santacrucian proterotheriids. Eastern localities produce exclusively hypsodont forms, whereas western localities also produce brachyodont taxa. This pattern suggests that western localities sample wetter, more closed habitats than eastern ones, or that the former are slightly older.

The phylogenetic relationships of proterotheriids, which range from the late Oligocene through late Pleistocene, have not previously been addressed comprehensively. Our analysis scored 35 taxa, including four from La Venta, and five outgroups, for 84 discrete and eight continuous characters.

Results indicate that one taxon from La Venta, *Megadolodus molariformis*, falls outside of Proterotheriidae. The four La Venta species represent three early-diverging lineages, implying some degree of biogeographic separation between northern and southern proterotheriids during the Miocene. The phylogenetic position of the La Venta proterotheriids implies the existence of several currently unknown species linking early and late Miocene Argentine proterotheriid assemblages. Many proterotheriid genera were found to be paraphyletic. Three anisolambdids (included in the analysis as presumptive outgroups) fell within Proterotheriidae, highlighting the uncertainty regarding basal litoptern relationships. The small, gracile *Thoatherium* and the large, robust *Diadiaphorus* are identified as close relatives, suggesting considerable evolutionary plasticity of proterotheriids in these regards.

Grant Information
AMNH Collections Study Grant, Tanya Atwater Global Field Travel Fund, UCSB Regents Fellowship

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

HEAD MECHANICAL PROPERTIES IN EXTANT PRIMATES WITH IMPLICATIONS FOR FOSSIL TAXA

MCGROSKY, Amanda, Arizona State University, Tempe, AZ, United States of America; GRIDER-POTTER, Neysa, Arizona State University, Tempe, AZ, United States of America; KEMP, Addison, University of Texas-Austin, Austin, TX, United States of America; MCGECHIE, Faye, University of Missouri, Columbia, MO, United States of America

Efficient head balance is a vital component of animal locomotion and posture because the head houses the visual and vestibular systems, the sensory inputs of which can lose resolution or utility during uncontrolled head movements. The head can be modeled as a first-class lever with the atlanto-occipital joint as its fulcrum. Within this model, the load of the anterior cranium is balanced by the downward force of the nuchal musculature. The shape of the cranium should affect how it is balanced. There is a striking diversity of cranial forms within the primate order. Apes, on one end, possess orthognathic faces, large brain sizes, and more anteriorly positioned foramina magna. Lemurs, on the other end, have prognathic faces, small brain sizes, and more posteriorly positioned foramina magna. These morphological differences should affect the head's mechanical properties, and thus, the extent to which the nuchal musculature must act to balance the head and reduce head movement during locomotion.

The head's center of mass (COM) is of particular interest in understanding the evolution of head balance. However, reconstructing head COM in fossil species can be difficult due to the lack of soft tissue preservation. The goal of this project is to reconstruct head COM using only hard tissue remains. To do this, cadaveric primate heads (n = 18) were measured and photographed while suspended from their apex and ear. These photos were used to calculate the relative location of the COM in ImageJ. The heads were also iodine stained and micro-CT scanned, allowing both the bony and soft tissues to be reconstructed. In Amira, the centroids of the brain, bony skull, skin, and muscle were calculated and averaged to obtain a virtual estimate of COM. Paired t-tests demonstrate limited significant differences between the cadaveric and the virtual measures of center of mass. However, the sagittal position of the COM was the least-reliably reconstructed. Additionally, eliminating the skin and other soft tissue from the calculation produced little significant error. Further eliminating the brain from these calculations additionally increases error. These error rates demonstrate that one can estimate center of mass from minimally deformed fossil crania.

Technical Session XVI (Saturday, October 20, 2018, 11:15 AM)

AN ALTERED ASSEMBLAGE: BONE SURFACE MODIFICATIONS ON VERTEBRATE MATERIAL FROM THE UPPER JURASSIC MYGATT-MOORE QUARRY IN RABBIT VALLEY, COLORADO

MCHUGH, Julia B., Museums of Western Colorado, Grand Junction, CO, United States of America; DRUMHELLER-HORTON, Stephanie K., University of Tennessee, Knoxville, Knoxville, TN, United States of America; RIEDEL, Anja, Colorado Mesa University, Grand Junction, CO, United States of America; KANE, Miriam, Colorado Mesa University, Grand Junction, CO, United States of America

Species interactions (e.g., predation, insect borings) and environmental conditions can be preserved as bone surface modifications on fossils, providing key sources of paleoecological data. However, collection protocols that favor more complete or aesthetically pleasing fossil specimens may bias research collections against these informative traces. Here, we present a survey of bone surface modifications on Upper Jurassic fossils collected from a single site under different protocols. All specimens are from the Mygatt-Moore Quarry, within the Brushy Basin Member of the Morrison Formation. Historically, fossils from this quarry were collected based on completeness and quality of preservation. However, in 2016, excavations shifted to a bulk collection protocol. This allowed direct comparison of bone surface modification types and frequencies across specimens collected using both protocols. Collection surveys revealed that bone surface modifications are prevalent in this assemblage. Vertebrate bite marks, including punctures, scores, and serrations, are common, as is evidence of insect damage and abiotic alterations, including abrasion and weathering. Approximately 10–12% of examined specimens preserve biologically mediated bone surface modifications, which require prolonged exposure times, indicating an assemblage that was not quickly buried. Slow burial and a lack of in-flow into the assemblage is additionally supported by the sedimentology of the quarry. Numerous axial skeletal elements preserve feeding traces on low-economy anatomical regions, indicating that carcass scavenging may have been common at the site as these skeletal elements are preferentially scavenged last in modern ecosystems. Analysis of the 2016–2017 bone material that would have not been collected under previous protocols reveals that fragments bearing BSMs were prevalent in subsample. These collections were further subdivided by bone weathering stages. In the 2016 subsample, 68 bones passed weathering stage sorting as preserving enough surface material to examine for BSM and 14.71% of them had BSM. In the 2017 subsample, 109 bones passed the weathering stage sorting and 11.93% of them preserved BSM. Based on these findings, a new collection protocol, based on bone fragment size and weathering stage was proposed for the 2018 field season. Additionally, field crews (including students, volunteers, and the public) received training on identifying bone surface modifications to maximize the precision of data recovery during field collection.

Grant Information
Funding for this project was provided by the David B. Jones Foundation.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

UGLY AMBASSADORS: TURNING OVERLOOKED BONE FRAGMENTS INTO EFFECTIVE EMISSARIES OF STEM EDUCATION, MENTORSHIP, AND PUBLIC ENGAGEMENT

MCHUGH, Julia B., Museums of Western Colorado, Grand Junction, CO, United States of America; DRUMHELLER-HORTON, Stephanie K., University of Tennessee, Knoxville, Knoxville, TN, United States of America; KANE, Miriam, Colorado Mesa University, Grand Junction, CO, United States of America; RIEDEL, Anja, Colorado Mesa University, Grand Junction, CO, United States of America

All too often due to research priorities, available collections space, or even aesthetics, the total collection of fossil material at a site is avoided. Logistics and protocol biases frequently work against collection of incomplete and/or taxonomically unidentifiable bone fragments, which are seen as less informative and cumbersome to collect. However, interactions between species (e.g., feeding, trampling) and environments at the time of death and burial (e.g., abrasion, dissolution) can be preserved as bone surface modifications (BSM) on fossils. This provides important sources of paleoecological data, but often detracts from their aesthetic value, leading to a bias against their collection. Furthermore, these "ugly" bones can provide a suite of education enrichment and outreach opportunities. Here, we demonstrate the utility of these fossils to foster STEM mentorship, education, and outreach, while working to help facilitate better data collection and collection protocols. Training of field crews, volunteers, students, and citizen scientists (in the form of public excavation participants) is critical for the collection of scientifically important data, particularly easily overlooked BSM data. Working with the vertebrate fossil material from the Upper Jurassic Mygatt-Moore Quarry (MMQ) in western Colorado, we demonstrate the effectiveness of training on the collection and preservation of BSM data, as well as the use of these data in revising collection protocols, enhancing volunteer preparatory training, and success of education enrichment for students and the public on Jurassic ecosystems.

Education of those involved with field collection resulted in the recovery of dozens of additional specimens bearing BSM in 2016–2017. Data recovery and education efforts also resulted in the mentorship of two undergraduate research interns, two summer field crew, ten volunteers, and hundreds of citizen scientists. Furthermore, data from these marked bones educated the public on taphonomy and Jurassic ecology through new permanent museum exhibits, online digital exhibits, outreach events, and social media. K–12 STEM education was also touched by these unlikely ambassadors, resulting in teaching modules and K–12 educator workshops. Together, these programs established an integrated network of mentorship and education to promote conservation of scientific data from the most "ugly" fossils, and that all fossil material has the potential to inform on research questions, excavation logistics, and scientific literacy among the public.

Grant Information
Funding for this project was provided by the David B. Jones Foundation.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

DENTAL VARIATION IN A NEONATE GREAT WHITE SHARK (*CARCHARODON CARCHARIAS*) WITH IMPLICATIONS FOR THE SHARK FOSSIL RECORD

MCKEEBY, Ryan L., Michigan State University, East Lansing, MI, United States of America; GOTTFRIED, Michael D., Michigan State Univ, East Lansing, MI, United States of America

The morphology of isolated fossil shark teeth is often used to make identifications at the level of genus or species. Some Recent sharks, however, exhibit such a high degree of ontogenetic variation in their tooth morphology that it impacts how confidently we can make taxonomic assignments based on isolated fossil teeth. The degree of variation can be considerable in even a single individual. In this context, we examined a complete set of jaws from a neonate (1521mm total body length) Great White Shark (*Carcharodon carcharias*). The variation exhibited in its teeth is in several respects incongruent with generalizations previously applied to juvenile white shark teeth. Lateral cusplets are inconsistently developed, and serrations vary considerably in both the lower and upper teeth. Both the upper and lower teeth range, depending on position, from fully serrated, to partially serrated, to unserrated. The size of serrations and presence of lateral cusplets also varies among teeth within the same series, and this variation is not always reflective of the relative position of a tooth in the series. It is clear that not all juvenile white shark teeth possess characters that have been previously ascribed to juvenile teeth of this species. As a consequence, isolated fossil juvenile white shark teeth that vary from the "expected" juvenile morphology could easily be misinterpreted and misidentified. Juvenile white shark teeth in some cases closely resemble the teeth of the Neogene lamnid *Lamna novus,* and even some isolated carcharhinid (reef shark) teeth. This example further highlights the potential challenges and pitfalls of over-reliance on isolated teeth in fossil sharkstudies.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

THE ENDOCRANIAL ANATOMY OF *BISTAHIEVERSOR SEALEYI* (DINOSAURIA, THEROPODA) AND NEUROSENSORY EVOLUTION IN TYRANNOSAUROIDS

MCKEOWN, Matthew, University of Edinburgh, Edinburgh, United Kingdom; BRUSATTE, Stephen, University of Edinburgh, Edinburgh, United Kingdom; WILLIAMSON, Thomas E., New Mexico Museum of Natural History, Albuquerque, NM, United States of America; SCHROEDER, Katlin, University of New Mexico, Albuquerque, NM, United States of America; ESPY, Michelle, Los Alamos National Labs, Los Alamos, NM, United States of America; GAUTIER, Cort, Los Alamos National Labs, Los Alamos, NM, United States of America; HUNTER, James, Los Alamos National Labs, Los Alamos, NM, United States of America; LOSKO, Adrian, Los Alamos National Labs, Los Alamos, NM, United States of America; NELSON, Ronald, Los Alamos National Labs, Los Alamos, NM, United States of America; VOGEL, Sven, Los Alamos National Labs, Los Alamos, NM, United States of America

Over the course of their 100+ million year evolutionary history, tyrannosauroid theropods transitioned from fleet-footed, small-bodied taxa into colossal apex predators that dominated ecosystems in North America and Asia during the Late Cretaceous (Tyrannosauridae). It has been hypothesized that development of large brains and keen senses (particularly smell and hearing) at small-to-medium body size in the Jurassic-middle Cretaceous may have helped underpin the acquisition of giant body sizes and ecological dominance in the last-surviving tyrannosaurids like *Tyrannosaurus rex*. However, this hypothesis is based on limited fossil evidence, because few non-tyrannosaurid tyrannosauroids have well-preserved skulls that provide evidence on neurosensory systems. We here use computed tomography (CT) scanning to describe the endocranial anatomy and reconstruct the brain endocast, sinuses, and neurosensory systems of *Bistahieversor sealeyi* from the Kirtland Formation (Campanian) of New Mexico. This taxon is of interest because it is one of the first giant tyrannosauroids to appear in the Late Cretaceous fossil record (ca. >8 m in body length and 1 ton in mass), and is one of the immediate outgroups of Tyrannosauridae. The brain endocast of *Bistahieversor* has an elongate, cylindrical shape and an extensive dural venous peak (which housed blood sinuses), as in intermediate-grade mid-sized tyrannosauroids like *Timurlengia* and derived large-bodied tyrannosaurids. The olfactory bulbs are enormous, as is the case in tyrannosaurids, indicating that a strong sense of smell developed before the origin of Tyrannosauridae itself. *Bistahieversor* possesses the tyrannosaurid condition of larger and more numerous sinuses surrounding the brain, particularly huge subcondylar recesses and an enlarged anterior tympanic recess that invades much of the prootic near the ear and is manifested as a distinct 'prootic fossa' on the lateral surface of the braincase. These features are not present in intermediate-grade taxa like *Timurlengia*, but seemingly evolved prior to Tyrannosauridae as immediate outgroups like *Bistahieversor* began to develop enormous body sizes, possibly as a means to lighten the skull or play a role in thermoregulation or enhanced hearing. In general, *Bistahieversor* demonstrates that most of the signature neurosensory features of the largest, last-surviving tyrannosaurids evolved earlier in earlier in tyrannosauroid evolution, and some (but not all) of these features were associated with the development of large size.

Grant Information
New Mexico Consortium, NSF (EAR 0207750 to TEW, EAR 1325544 and DEB- 1654952 to TEW and SLB), BLM grant to TEW and SLB, NNSA Science Campaign from LANL.

Technical Session IX (Friday, October 19, 2018, 8:45 AM)

INSIGHT INTO THE DISPERSAL AND PHYLOGENY OF NEOGENE RHINOCEROTIDS FROM A NEW KYRGYZ CHILOTHERE

MCLAUGHLIN, Win N., Oberlin College, Bend, OR, United States of America

The late Miocene is characterized by abundant and diverse rhinocerotids across North America and Eurasia. Rhinocerotids are proposed to have significant intercontinental dispersal events, but current phylogenetic assessments of the family concentrate on continent level organization. While rhinocerotids initially evolved in North America, their biogeography is complicated as many later Cenozoic rhinocerotids in North America are inferred to be of Asian origin. I herein present a new species of rhinocerotid from the Neogene of Kyrgyzstan and examine the novel taxon's placement temporally and biogeographically. I present a cladistic analysis that not only places this new Kyrgyz taxon but also establishes the position of the North American taxa *Teleoceras* and *Aphelops* as most closely related to Asian taxa.

Chilotherium is the most common Neogene Asian genus, and phylogenetic analysis and morphological comparisons place the new Kyrgyz taxon within the genus. The new taxon is a medium-to-large, barrel-bodied rhinocerotid, although with more gracile limb proportions than other members of the genus. It is hornless, with an enlarged mandibular symphysis with anterolateral projecting tusks. Adding this new taxon to my cladistic phylogenetic analysis does not support "Chilotherinii" as an independent tribe, as the close relationship between both *Acerorhinus* and *Chilotherium* renders the tribe paraphyletic, and suggests both genera should be part of Aceratherinii. I retain the attribution of the North American *Aphelops* to Aceratheriini in my analysis, and I find that *Teleoceras* also nests between *Chilotherium* and *Acerorhinus*, and therefore does not fit with any of the European genera attributed to the tribe Teleoceratini.

Geochronology of the Kyrgyz taxon is established via paleomagnetostratigraphy and sequence stratigraphy, placing the species' occurrence around 8.5 million years ago. The close affinities between the new Kyrgyz *Chilotherium* species and North American rhinocerotids support previous indications of significant biotic interchange in the Oligocene to Miocene and highlight the need to address phylogenetic relationships in the greater context of biogeography.

Grant Information
Fulbright Student Researcher 2014–2015, American Alpine Club Research Grant

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

REASSESSMENT OF *UNAYSAURUS TOLENTINOI* (DINOSAURIA, SAUROPODOMORPHA) FROM THE LATE TRIASSIC (EARLY NORIAN) OF BRAZIL

MCPHEE, Blair W., Universidade de Sao Paulo (USP), Ribeirao Preto, Brazil; BITTENCOURT, Jonathas, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil; LANGER, Max C., Universidade de Sao Paulo (USP), Ribeirao Preto, Brazil; APALDETTI, Cecilia, Instituto y Museo de Ciencias Naturales, San Juan, Argentina; DA-ROSA, Atila A., Universidade Federal de Santa Maria, Santa Maria, Brazil

We present a systematic revision of the Brazilian 'prosauropod' dinosaur *Unaysaurus tolentinoi*. Most recent phylogenetic treatments of this taxon have presented it as a key constituent of the Plateosauridae. This clade, along with the Massospondylidae, is currently regarded as a relatively non-controversial example of monophyly among non- sauropodan sauropodomorphs—an otherwise pectinate grade of animals from which the apically nested Sauropoda is derived. The inclusion of *Unaysaurus* within the Plateosauridae is primarily dependent on similarities shared with the Norian-aged northern 'prosauropod' *Plateosaurus*, and in many topologies the clade is restricted to these two genera. The presumed relatedness of these taxa is thus suggestive of an initial instance of Pangaean cosmopolitanism among early sauropodomorphs. However, an in-depth exploration of the character-states that in the past have supported this relationship shows that many either present a more complex distribution throughout early Sauropodomorpha, or are subject to inter-worker subjectivity and/or ambiguities in the formulation and scoring of primary homologies. An updated cladistic analysis finds weak continued support for a sister taxon relationship between *Unaysaurus* and *Plateosaurus*, but this result only is obtained in scenarios in which the 'core prosauropod' array is found to be non-polytomous—an outcome highly sensitive to both character and taxon inclusion. These uncertainties aside, the validity of *Unaysaurus tolentinoi* remains supported by several relatively robust autapomorphies. Although strong anatomical evidence for monophyletic divergences among early sauropodomorphs remains complicated by a combination of missing data and the morphological conservativeness of the group in general, the relatively low stratigraphic occurrence of *Unaysaurus* demonstrates that the typical 'prosauropod' bauplan—and hence habitual herbivory— had evolved by the early Norian.

Grant Information
FAPESP: Sao Paulo Research Foundation

Technical Session V (Thursday, October 18, 2018, 9:00 AM)

THE POSTCRANIAL MORPHOLOGY OF THE BERINGIAN WOLF REVEALS TWO PULSES OF ECOLOGICAL DISAPPEARANCE

MEACHEN, Julie, Des Moines University, Des Moines, IA, United States of America; TOMIYA, Susumu, Des Moines University, Des Moines, I A, United States of America

With the recent discovery of the extinct Beringian wolf (*Canis lupus* ssp.) at the Natural Trap Cave (NTC) f ossil site in northern Wyoming, we wanted to explore the postcranial ecomorphology of this extinct wolf and u nderstand the differences between Beringian wolves a nd other g roups of wolves. We took l inear measurements of the postcrania of Beringian wolves from NTC, and for comparison we also measured multiple different groups of wolves, including dire wolves (*Canis dirus*), Beringian wolves from Alaska,

early Holocene wolves from Idaho, and multiple gray wolves from both historic and modern North American populations. We analyzed the data first using linear discriminant analysis to identify morphometric distinctions among the groups, then we used MANOVA to assess statistical significance of across-group differences. We also used ANCOVA to examine differences in limb-bone lengths while controlling for midshaft width (as a proxy for body size).

Our findings indicate Beringian wolves were characterized by short-leggedness on both sides of the Cordilleran–Laurentide ice sheets, and this trait survived well into the Holocene despite the extinction of Pleistocene megafauna and the disappearance of the Beringian wolf from Alaska. By comparison, extant populations in the Midwestern U.S.A. and northwestern North America are distinguished by elongated limbs with long distal segments, which likely evolved during the Holocene, perhaps in response to a new level or type of prey depletion. We also found that historic populations (circa 1800s) of Plains wolves (*C. l. nubilis*) and modern Mexican wolves (*C. l. baileyi*) show a similar short-legged morphology. This discovery reveals that there was a large loss of wolf ecological variation at the end of the Pleistocene with the extinction of the Beringian wolf, and another loss of variation in the late 1800s/early 1900s, with the depletion of the historical short-legged morphotypes. Since modern short-legged subspecies are severely threatened, we should make every effort to conserve them to avoid any further loss of wolf postcranial, as well as genetic, diversity.

Grant Information
This study was funded by NSF EAR/SGP grant number 1425059.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

EXTINCT CAPYBARA, *NEOCHOERUS PINCHNEYI* (HYDROCHOERIDAE) FROM THE RANCHOLABREAN OF TÈRAPA, SONORA, MEXICO

MEAD, Jim I., Mammoth Site, Hot Springs, SD, United States of America; WHITE, Richard S., Tucson, AZ, United States of America; SWIFT, Sandra L., Hot Springs, SD, United States of America; BAEZ, Arturo, University of Arizona, Tucson, AZ, United States of America

Precisely dated vertebrate localities that provide late Pleistocene (Rancholabrean LMA) paleoenvironmental information for Sonora, northwestern Mexico are rare. Sonora provides only 2% of all known fossil sites in Mexico. The Terapa fossil site, located in northcentral Sonora (Rio Moctezuma valley), contains an exceptional and extensive array of aquatic and terrestrial faunal remains within the 11 m of marsh and fluvial sediments impounded by the Tonibabi basalt flow. Infrared Stimulated Luminescence (IRSL), amino acid racemization (AAR), and radiocarbon (AMS) analyses indicate a depositional age of 43–40 ka for the sediments and fossils, Oxygen Isotope Stage (OIS) 3. Detailed descriptions on remains to date include: ostracodes, avian, crocodilian, select carnivorans, shrews, bats, glyptodont, and pampathere, along with isotopic analyses on enamel and stable isotopes on ostracodes. Mollusks, rodents, proboscideans, carnivorans, perissodactyls, and artiodactyls are currently in line to be studied. Here we present the analysis of the extinct, large capybara rodent *Neochoerus pinchneyi* (Hydrochoeridae). The extant capybara, *Hydrochoerus*, lives no farther north than the Isthmus of Panama.

Fossil capybara are an unusual occurrence in all of Mexico and exceedingly rare in the northern part of the country. For the Rancholabrean in Sonora, *Neochoerus* is recorded from only Terapa (presented here); for the Irvingtonian LMA the capybara is reported only from El Golfo (at the confluence of the Colorado River and the Gulf of California). Capybara are not known from the Rancholabrean in the adjacent states of Arizona or New Mexico. The taxon is exceptionally rare in the latest Blancan and Irvingtonian LMAs of southeastern-most Arizona, yet not known from New Mexico for this time. The occurrence at Terapa seems to relate to the subtropical marsh habitat along the Río Moctezuma, which flows into the Río Yaqui and on into the Gulf. With headwaters in southeastern Arizona, the Río Yaqui drainage likely was the avenue for capybara and glyptodonts, among other southern species, to move north into Arizona. The drainage and subsequent more subtropical habitat apparently did not extend elsewhere in Arizona or into New Mexico. The Río Yaqui is the largest, most-northern river on the west side of the Sierra Madre Occidental flowing into the Gulf until the Colorado River confluence. This likely explains why subtropical species are not found throughout most of interior Sonora until the El Golfo locality.

Romer Prize Session (Thursday, October 18, 2018, 11:45 AM)

LIMBS INTO FINS: CONVERGENT EVOLUTION AND THE POLYPHYLY OF THE MOSASAURIDAE

MEKARSKI, Michelle C., University of Alberta, Edmonton, AB, Canada

Mosasaurs are traditionally considered to be a natural (monophyletic) group of Cretaceous marine lizards possessing aquatically adapted appendicular skeletons; specifically, paddle-like limbs (the hydropedal condition), and a loss of connection between the ilium and the sacral vertebrae (the hydropelvic condition). The semi-aquatic precursor to this derived condition is demonstrated by the 'aigialosaurs': small bodied, elongate lizards showing intermediate stage aquatic adaptations including laterally compressed tails and some reduction of the appendicular skeleton. The aigialosaurs are conventionally placed basally to a monophyletic group of derived mosasaurs, and consequently, are also referred to as 'mosasauroids'. Discoveries over the last decade and a half have challenged the conventional understanding of the concept of a 'mosasaur'. Certain aigialosaur-grade species show close affinities to clades within the derived mosasaurs, suggesting multiple independent origins of the mosasaur bauplan. However, poor cladistic resolution and a high degree of homoplasy within the Mosasauroidea has prevented strong support for this hypothesis. The discovery of a new species of 'aigialosaur' with an exquisitely preserved forelimb provides new, solid evidence in support of the polyphyletic mosasaur hypothesis. It is the limb in particular that provides the robustness of this evidence, given that the definition of a 'mosasaur' is so closely tied to the evolution of the paddle-like limb. A thorough re-examination of all described species of semi-aquatic 'mosasauroid', including *Carsosaurus, Komensaurus, Aigialosaurus, Dallasaurus, Haasiasaurus, Judeasaurus,* and *Vallecillosaurus*, in addition to an examination of a wide variety of derived 'mosasaur' taxa has demonstrated two major limb morphotypes, each with hypothetical intermediate forms demonstrated by aigialosaur-grade species. These patterns provide strong evidence for the multiple, independent evolution and convergence of paddle-like limbs. This model, combined with stratigraphic data, evidence from other skeletal regions, and corroborated by newly produced phylogenetic studies, lead to the conclusion that 'mosasaurs' do not exist in the biological sense, that the term 'mosasaur' must be redefined, and our understanding of this group's evolutionary history reimagined.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

WHAT DOES PUBLIC ACCESS TO THE SCIENTIFIC PROCESS LOOK LIKE AT AN URBAN PALEONTOLOGICAL SITE?

MESRATY, Hanna, La Brea Tar Pits/University of Edinburgh, Los Angeles, CA, United States of America; LINDSEY, Emily, Los Angeles, CA, United States of America; CHAPMAN, Jeff, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; MYCHAJLIW, Alexis, Stanford Univ, Los Angeles, CA, United States of America

In a time of rapid global change, it is critical to engage the public in earth and biological sciences - both by imparting scientific facts on earth systems, ecological change, and extinction, and by sharing the practice of data collection and hypothesis testing, instilling confidence in the scientific process. Natural history museums provide important platforms where visitors see specimens but, with new approaches, witness scientific discovery and analysis as a process. The La Brea Tar Pits and Museum (LBTPM) in Los Angeles, California, (LA) provides immersive public engagement with paleontological processes by showcasing ongoing, active field excavations and a working fossil preparation lab and collections space, as well as Museum exhibits, tours, and public programs operating 361 days a year. This world-renowned Quaternary fossil locality, whose naturally occurring asphalt seeps have captured an encompassing view of LA's prehistory from pollen grains to mammoth bones, has been excavated nearly continuously from the early 1900s to the present day, yielding millions of specimens. Unique to this deposit is its location in the heart of urban LA, the second largest city in North America, which affords an unprecedented opportunity to include locals and tourists in these paleontological processes that unearth the LA climate story.

Encouraging access to paleontological processes is a priority to instill curiosity and wonder about the natural world. At the LBTPM, visitors follow a fossil from excavation, to the laboratory, and into the museum. Daily programs bridge the gap between publics and science with transactional dialogues highlighting relevant topics to the participants. Visitors explore the still-active seeps in the free-access Hancock Park utilizing informative didactic panels and tours. Inside, Museum guests connect with laboratory processes and specimens while engaging in dialogue with preparators. With current trends for more behind the scenes access to science, many museums and institutions are incorporating fishbowls, glass walls, and social media to drive public engagement with actual science as it is happening. At LBTPM the excavations have been on display in open-air since the early 1950's and the laboratory has been on-view since the Museum opened in 1977.

This direct engagement with the scientific process allows LBTPM visitors to come away not only with a better understanding of how Earth has changed in the past, but with tools for empowered thinking about how it may change in the future.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THALATTOSAURIAN BRAINCASE ANATOMY REVEALED THROUGH COMPLETE AND THREE-DIMENSIONAL MATERIAL OF A NEW GENUS FROM THE CARNIAN VESTER FORMATION OF OREGON

METZ, Eric T., University of Alaska Museum, Fairbanks, AK, United States of America; DRUCKENMILLER, Patrick S., University of Alaska Museum, Fairbanks, AK, United States of America; BOONE, Noah R., University of Alaska Museum, Fairbanks, AK, United States of America; KELLEY, Neil P., Vanderbilt University, Nashville, TN, United States of America

Thalattosauria is a poorly known clade of exclusively Triassic, secondarily aquatic tetrapods. The group occupied a variety of shallow marine environments and are known from paleo-equatorial latitudes of North America, Europe, and China. Currently, thalattosaurian phylogeny is poorly understood, both in terms of their placement within Diapsida, as well as their ingroup relationships. This phylogenetic uncertainty is largely due to the dearth of knowledge regarding fundamental aspects of their cranial anatomy. This data gap can be attributed in part to the high degree of morphological disparity in their cranial anatomy, as well as taphonomic issues, given that most taxa are known from crushed or disarticulated skulls, lacking complete, three-dimensional material. Notably, a complete, three-dimensional braincase has never been described. In 2011, the remains of a new thalattosaur genus were found in a large carbonate nodule in the Late Triassic (Carnian) Brisbois Member of the Vester Formation in central Oregon. The nodule preserves the semi-articulated and three dimensionally preserved remains of multiple individuals of different ontogenetic stages, including several complete and well-preserved braincases.

The braincase of the Brisbois Member thalattosaur possesses a nearly circular occipital condyle with a notochordal pit. The occipital condyle is composed ventrally of the basioccipital and dorsally of the exoccipitals, with the former excluded from forming the floor of the foramen magnum. The basal tubercles are massive, posteroventrally oriented and formed posteriorly by the basioccipitals and anteriorly by the parabasisphenoid. Laterally, the metotic fissure is clearly separated into the vagus foramen posteriorly and the fenestra pseudorotunda anteriorly. On the lateral wall, the prootic lacks a crista prootica, and fully encloses the exit for cranial nerve (CN) V, and on the medial wall the exits for CN VIII and CN VII are on the anterior surfaces of the supratrigeminal ridge. Ventrally, the parabasisphenoid encloses the lateral margin of the vidian canal. Anteriorly, the dorsum sellae forms the dorsal margin of the parabasisphenoid and is bounded laterally by a groove for CN VI, and ventrally by the pituitary fossa. These new data reveal previously unknown details of thalattosaurian cranial anatomy, helping to establish new characters for phylogenetic datasets and providing critical new insights into the relationships of this enigmatic clade within Diapsida.

Technical Session X (Friday, October 19, 2018, 9:30 AM)

SAUROPOD TRACKWAY TANGO: A NEW LOOK AT TRACKWAY GAUGE THROUGH TIME

MEYER, Christian A., University of Basel, Basel, Switzerland; BELVEDERE, Matteo, Porrentruy, Switzerland; MARTY, Daniel, Natural History Museum Bassel, Basel, Switzerland

Trackway gauge of sauropods has long been used to explain structural differences of trackmakers and their temporal distribution. Some authors have stated that titanosaurs display a wide-gauge stance and noted a complete absence of narrow-gauge sauropod trackways in the Late Cretaceous. Others have argued that the broadening of sacral width and the varying shape of the femoral condyles have an effect on their stance resulting in wider trackway gauge.

We have studied examples from the Late Jurassic of Morocco and Switzerland and from the Late Cretaceous of Bolivia.The sample of sauropod trackways from the Late Jurassic of NW Switzerland comprises more than 290 trackways of different morphologies, and some of them up to 100 m in length. Most of them are attributed to diplodocids. However, on single ichnoassemblages, the same sauropod track morphotype may display narrow- and wide-gauge patterns, even along single trackways.

Examples from the Late Jurassic of Morocco display generally a narrow gauge, whereas those who display an intermediate gauge are much smaller. Because trackways are rather short, it is not possible to assess variations in gauge along single trackways. In the Late Cretaceous of Bolivia, trackways of basal and derived titanosaurs exhibit narrow- and wide-gauge stance along single, up to 380 m long trackways. Trackways crossing substrate with changing water content without exhibiting changes in gauge, indicate that substrate properties not necessarily have an influence on the basic walking pattern. One particular long trackway (380 meters length) exhibits an extremely narrow gauge with no space between consecutive pes prints in some sections. However, along curves the trackway changes into a wide gauge-pattern with more interspace between pes prints.

Taking into account the large sample of long sauropod trackways regardless of morphotype or geologic age, we suggest that trackway gauge is most probably subjected to speed and individual behavior, like changes in direction, because long and straight trackways exhibit a constant trackway gauge.

Titanosaur tracks have been found in different environments and time intervals ranging from deltaic to fluvial and lacustrine settings as well as in carbonate tidal flats. Therefore we strongly doubt a correlation between paleoenvironment, stability of locomotion, and trackway gauge. The same holds true for using trackway gauge as an osteological correlate because in the Late Cretaceous the only sauropods present were titanosaurs and those left changing gauge patterns along single trackways.

Technical Session XIV (Saturday, October 20, 2018, 11:15 AM)

THE USE OF MORPHOSPACE OCCUPATION TO AID IN UNDERSTANDING TROPHIC ECOLOGY OF ACTINOPTERYGIAN CLADES IN THE WESTERN INTERIOR SEAWAY

MICHELS, Amber N., Fort Hays State University, Hays, KS, United States of America; WILSON, Laura E., Fort Hays State University, Hays, KS, United States of America

Actinopterygians were common throughout the shallow Cretaceous Western Interior Seaway (WIS) of North America. However, the trophic ecology for the actinopterygians that inhabited these waters is poorly understood. The purpose of this study is to use key anatomical traits to better understand the trophic ecology of actinopterygian clades from the WIS. Comparing the distribution of morphotypes among actinopterygian assemblages adds an additional understanding of how trophic structures varied through space and time. WIS actinopterygians within study include: *Apsopelix, Xiphactinus, Ichthyodectes, Gillicus, Cimolichthys, Enchodus, Pentanogmius, Saurodon, Kansius,* and *Pachyrhizodus*. Comparing lower jaw length and orbital diameter to the standard body lengths of these fish provides useful clues about prey preference and hunting styles. Lower jaw length to body length ratios estimate the largest possible gape of the fish. Orbit diameter to body length ratios relate to visual acuity and sensitivity. Residual values of the lower jaw and orbit measurements compared to standard body length were obtained through linear regression and were plotted on a morphospace.

Most of the WIS taxa aligned with the morphospace characterized by fish with small eyes and small jaws relative to body length. A few taxa, *Enchodus, Pentanogmius,* and *Cimolichthys,* fell in the region with large lower jaws and small eyes relative to body length. These regions are both thought to indicate generalist feeding strategies. Comparing morphospace distribution of WIS taxa to taxa from a Cretaceous sea in Namoura, Lebanon shows similar morphospace distributions for the Cretaceous fauna. However, a few Lebanese taxa plotted in the region of morphospace characterized by fish with relatively large eyes and small lower jaws, associated with highly selective diurnal feeding. In general, fish in the regions of morphospace with large orbit diameters relative to their body size show more specialized hunting strategies. Pycnodont fish, one of the taxa which represented this morphotype in the Lebanon fauna, also inhabited the WIS. However, well-preserved full body specimens have not been recovered from the WIS. Because the combination of lower jaw length, orbit diameter, and standard length measurements are not available for WIS pycnodonts, they cannot be included in this analysis. Consequently, more specialized hunting strategies may have also been seen in the WIS, but due to preservation bias, occupation of this region of morphospace cannot be confirmed without new discoveries.

Technical Session XV (Saturday, October 20, 2018, 8:45 AM)

TRACKING AN AMERICAN MASTODON: ISOTOPIC RECONSTRUCTION OF LANDSCAPE USE FROM A SERIALLY SAMPLED TUSK

MILLER, Joshua H., University of Cincinnati, Cincinnati, OH, United States of America; CROWLEY, Brooke E., University of Cincinnati, Cincinnati, OH, United States of America; FISHER, Daniel C., University of Michigan, Ann Arbor, MI, United States of America; SECORD, Ross, University of Nebraska-Lincoln, Lincoln, NE, United States of America

Toolkits for assessing mobility of fossil taxa, including home range size, landscape use, migration, and dispersal, remain poorly developed. This leaves fundamental gaps in our knowledge of extinct faunas and the evolution of a variety of ecological traits. Strontium isotope ratios ($^{87}Sr/^{86}Sr$) show promise for evaluating paleo-mobility because they (1) vary across landscapes largely as a function of bedrock age and composition and (2) are incorporated into biological tissues with minimal fractionation. However, this isotopic system has previously required site-specific assessments of geographic variability in bioavailable strontium, which is costly, time intensive, and imposes first-order limitations on the spatial resolution and extent of subsequent comparisons. Recently developed continental-scale predictive models of strontium isotope ratios offer opportunities to reconstruct movement patterns at previously impractical scales. Here, we combine this resource with a serially sampled male mastodon tusk (late Pleistocene, NE Indiana; ISM 71.3.261) to propose the first reconstruction of landscape use for a fossil individual at high temporal resolution. We also test for changes in geographic use between when the bull was young (part of a matriarchal herd) and mature (when he likely lived in greater isolation). Samples taken from five years early in life were compared with the three years prior to death. Powders were milled in ~0.5 mm increments (averaging eight samples per year) and analyzed for $\delta^{18}O$ and $^{87}Sr/^{86}Sr$. Resulting $\delta^{18}O$ data are strongly cyclic, reflecting seasonal variability. Strontium isotope ratios differ significantly between younger and older samples, indicating shifts in geography. Early in life, strontium isotope ratios display less annual cyclicity compared to $\delta^{18}O$ values. With maturity, strontium isotope ratios become more cyclic. GIS-based reconstructions of movement patterns indicate the bull traveled much less during its younger years, subsequently changing to larger, more continuous movements as an adult (measured as both distance moved between tusk samples and overall cumulative distance). The mastodon spent substantial time in the Minnesota/Iowa/Illinois area early in life. As an adult, he seasonally visited regions in the Indiana/Ohio/Kentucky area, where he died. Reconstructing paleo-mobility patterns of extinct taxa is increasingly practical, opening new avenues of paleobiological inquiry.

Preparators' Session (Thursday, October 18, 2018, 4:00 PM)

DEVELOPING BEST PRACTICES TO IMPROVE FOSSIL DATA QUALITY AND ACCESSIBILITY

MILLHOUSE, Amanda, Smithsonian National Museum of Natural History, Washington, DC, United States of America; LITTLE, Holly, Smithsonian National Museum of Natural History, Washington, DC, United States of America

As the paleontological community pursues greater data mobilization, paleontologists and collections professionals need to evaluate data management practices to determine the best course forward as we share an increasing volume of data. We have a responsibility to maintain high quality collections information and to enable the sharing of that information to stakeholders and communities to promote research, education, and preservation. In order to accomplish this goal we must develop and implement data capture workflows that utilize well documented best practices for recording specimen information in an interoperable, digital format.

The Smithsonian National Museum of Natural History Department of Paleobiology recently completed a two year effort to catalog all terrestrial mammal fossils in our collections to improve data quality. This project allowed us to refine our workflows to capture more detailed specimen data and assess our data management practices. We established controlled vocabularies and guidelines for recording data in specific fields, such as new best practices for morphological data. As part of this we reviewed how our data are structured, identified what data are required, and determined what standards existed or were lacking.

When the cataloging project ended in 2017, we had created over 13,000 new records and enhanced 15,000 existing records. We refined our cataloging workflows and developed best practices for capturing data that can now be applied to other vertebrate fossil collections in the department. By ensuring that the data are standardized according to best practices, we're promoting data quality and accessibility for scientific research.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

PALEOENVIRONMENT OF THE LATE EOCENE WHITEHEAD CREEK LOCALITY, NEBRASKA

MILLS, Samantha M., Saint Cloud State University, St. Cloud, MN, United States of America; ARBOR, Tafline C., Marian University, Indianapolis, IN, United States of America; TORNOW, Matthew A., Saint Cloud State University, Saint Cloud, MN, United States of America

Like other Chadronian-age sites within the Great Plains faunal province, the Whitehead Creek locality in northwest Nebraska has demonstrated the persistence of relict, small mammal taxa. This raises questions regarding the environmental conditions that allowed these relicts to persist after their extinctions elsewhere. To assess the paleoenvironment at Whitehead Creek, we evaluated locomotor guilds of small mammal (<1,000 grams) morphospecies. These morphospecies were identified on the basis of visual assessment and Principal Component Analysis (PCA) of 30 astragali and calcanei. Small mammal locomotor behaviors for Whitehead Creek morphospecies were estimated on the basis of calcaneal and astragalar morphology, and the frequencies of these locomotor behaviors were compared with those of modern biomes using Euclidean distance methods and Sorenson's similarity index.

Results indicate that small mammals at Whitehead Creek practiced a wide range of locomotor activities including leaping, digging, climbing, and running in both arboreal and terrestrial habitats. Comparisons with locomotor guild frequencies found in modern biomes suggest that the late Eocene environment at Whitehead Creek was unlike biomes of present day. When evaluated within the context of paleosol, phytolith, isotopic, and geochemical data for this area in the late Eocene, the mixture of locomotor categories found at Whitehead Creek suggests the presence of trees, water, and open habitats characteristic of a mosaic of open, dry environment with pockets of humid-subhumid 'tropical' forest. These data suggest distinctive environmental differences between the Great Plains and the Rocky Mountains basins and illustrate the importance of the North American Interior in interpreting patterns of dispersal, evolution, and adaptation among tropical species, such

as euprimates, plesiadapiforms, and dermopterans, during the late Eocene in North America.

Grant Information
Support for this project was provided by MU and a Des Moines University IOER grant to TCA, an SCSU Faculty Improvement Grant to MAT, and an SCSU Student Research Grant to SMM.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

PREDICTING THE FEEDING ECOLOGY OF AN EXTINCT KANGAROO FROM CRANIOFACIAL MORPHOLOGY—INFERENCE FROM EXTANT DIPROTODONT HERBIVORES

MITCHELL, D. Rex, University of New England, Armidale, Australia; WROE, Stephen, University of New England, Armidale, Australia

Larger herbivores can act as keystone species, which strongly influence their communities. Present day Australia is home to relatively few large endemic herbivores, the largest being the Red Kangaroo (*Macropus rufus*) with a maximum body mass of ~85 kg. However, Pleistocene Australia was home to many more macropods, including six genera and 26 species of large to gigantic short-faced kangaroos (Sthenurinae) for whom ecology is poorly understood. More accurately identifying diet in this once diverse and widely distributed subfamily will improve our understanding of not only their ecologies, but also of past environments. Cranial morphology corresponds with both the mechanical properties of preferred vegetation and foraging behaviours among extant kangaroos and relatives (Macropodiformes). Here, we apply shape analysis and computational biomechanics to test the hypothesis that feeding ecology corresponds with craniofacial morphology across a taxonomically broad sample of medium-large extant diprotodont herbivores, including 12 extant macropod and two extant vombatiform marsupial species. We find that biting behaviours are reflected in craniofacial morphology for all species studied, but that craniofacial morphology is more a reflection of the hardest bites required for their respective niches, rather than diet composition alone. Applying our findings with respect to extant species to one of the largest extinct sthenurine species, *Simosthenurus occidentalis*, we predict that the combination of brachephaly, hypertrophied musculoskeletal features, and dental arrangements are consistent with *S. occidentalis* being a browser of tougher, more bulky plant matter than extant macropodiforms. An ability to obtain very poor quality, resistant browse in sthenurines may have offset the variable availability of high-quality vegetation across their home ranges during the Pleistocene.

Romer Prize Session (Thursday, October 18, 2018, 8:30 AM)

ONTOGENY OF PALEOZOIC STEM LAMPREYS AS A TEST OF CYCLOSTOME-BASED MODELS OF VERTEBRATE ANCESTRY

MIYASHITA, Tetsuto, University of Alberta, Edmonton, AB, Canada

The ontogeny of lampreys holds a special place in the historical development of ideas about the early evolution of vertebrates. Ammocoete larvae of living lampreys—cephalochordate-like, sand-burrowing filter feeders—have served as a model for primitive vertebrates, whereas the adults—eel-like, blood-sucking predators—are considered specific to that lineage. This recapitulatory view of lamprey ontogeny has long supported a reconstruction of the last common ancestor of all living vertebrates as an ammocoete-like filter feeder.

If the Ammocoete Model is correct, a filter-feeding larval stage should have existed in lamprey stem taxa. I test this prediction using newly discovered specimens of *Priscomyzon riniensis* from the Devonian Witpoort Formation of South Africa. Seven specimens form an ontogenetic series from a 15 mm-long individual (slightly larger than living lamprey hatchlings) to an adult. None of these specimens has any skeletal correlates of filter feeding. Instead, traits associated with the predatory life mode of living adult lampreys are present in all specimens, including: prominent eyes; oral sucker; keratinous teeth; tectal cartilages; short branchial region; and pericardial closure of branchial basket. The larvae have an elongate snout to support the oral sucker. The oral sucker becomes proportionally larger and the snout shorter across metamorphosis. Cladistic and disparity analyses bolster the qualitative observation that the larvae of *Priscomyzon* are distinct from ammocoete larvae of living lampreys. They are also consistent with preclusion of an ammocoete stage in *Priscomyzon* at smaller size than the 15 mm-long larva.

To test whether the absence of the ammocoete stage is (a) a tip state unique to *Priscomyzon* or (b) a general condition of the lamprey stem, I compared two other Paleozoic stem lampreys (*Hardistiella* and *Mayomyzon*) with *Priscomyzon*. The smallest specimens of each taxon closely resemble the late larva to post-metamorphic juvenile stages in *Priscomyzon*, which implies that the ammocoete larval stage of living lampreys represents a secondarily evolved condition, convergent with cephalochordates due to feeding habits. The new cladistic analysis of morphological data supports hagfish and lampreys as a clade (Cyclostomi) and rejects hagfish as primitive morphologically. Therefore, neither living cyclostome lineage can serve as a surrogate for the last common ancestor of living vertebrates.

Grant Information
Royal Society Follow-On Grant, Commonwealth Science Conference
National Science and Engineering Research Council, Discovery Grant to A. Richard Palmer (U. Alberta)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

OSTEOLOGY OF A SMALL BRONTOTHERE (MAMMALIA, PERISSODACTYLA, BRONTOTHERIIDAE) FROM THE LOWER EOCENE NAKAKOSHIKI FORMATION, KAGOSHIMA PREFECTURE, JAPAN

MIYATA, Kazunori, Institute of Dinosaur Research, Fukui Prefectural University, Eiheiji-Town, Fukui, Japan

A small brontothere from the Eocene Nakakoshiki Formation, Kagoshima Prefecture, western Kyushu Island, Japan, was previously reported based on a left dentary fragment with p4–m3. Although not yet formally described, it was previously considered based on the dental characters to be an *Eotitanops*-like species provisionally related to early Eocene brontotheres from North America and Pakistan. Besides the dentary, the Nakakoshiki specimen consists of a few cranial and several postcranial elements from a single individual. Recently completed preparation of these associated elements reveals important osteological features relevant to both taxonomic assessment of the Japanese specimen and to increasing understanding of early brontothere diversity. Cranial specimens include a partial occiput with the occipital condyles, and the left jugal sutured to zygomatic process of the maxilla. Postcranial specimens include an atlas, several ribs, right and left scapulae, a proximal half of the left ulna, two metacarpals, two possible manual phalanges, and a right femur, although these are poorly preserved.

Comparisons with *Eotitanops* and *Palaeosyops* from North America suggest that the Nakakoshiki dentary has a shorter coronoid process and a lower positioned condylar process, with a wider mandibular notch between the two. The slender jugal forms a concave ventral border of the orbit with the maxilla and has no infraorbital jugal process. The atlas is similar to that of *Eotitanops* but is relatively shorter anteroposteriorly. The slender scapula has a tall scapular spine extending distally and running relatively close to the posterior border to form a narrow infraspinous fossa. The glenoid cavity of the scapula is subrounded, and a prominent supraglenoid tubercle is present. The slender ulna has a relatively long olecranon process, and the medial and lateral coronoid processes form a continuous facet for articulation with the proximal end of the radius. The damaged right femur is relatively short (~ 17 cm) and has discernible third and lesser trochanters, but the two trochanters are subequal in position. These osteological characters, as well as the dentition, support the conclusion that the Nakakoshiki specimen represents a previously unknown species of early Eocene brontothere.

Grant Information
This work was supported by JSPS KAKENHI Grant Number JP16K05594.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

GAR SCALE OXYGEN ISOTOPE COMPOSITION ACROSS THE CRETACEOUS–PALEOGENE BOUNDARY IN THE HELL CREEK REGION, MONTANA

MIZRAHI, Nicole S., University of California Berkeley, Berkeley, CA, United States of America; FENDLEY, Isabel M., University of California Berkeley, Berkeley, CA, United States of America; WEAVER, Lucas N., University of Washington, Seattle, WA, United States of America; RENNE, Paul R., Berkeley Geochronology Center, Berkeley, CA, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America; TOBIN, Thomas S., University of Alabama, Tuscaloosa, AL, United States of America

The end-Cretaceous mass extinction is hypothesized to have been caused by the environmental effects of the Chicxulub impact event, Deccan Traps flood volcanism, or both. Both catastrophic events caused significant environmental changes, so investigating climate change in this time interval could help us distinguish the effects of each of these events.

The Hell Creek Formation and Tullock Member of the Fort Union Formation of northeastern Montana span the Cretaceous–Paleogene boundary and are both highly fossiliferous. In this study we measure the oxygen isotope composition of enamel hydroxylapatite (ganoine) from fossil *Lepisosteus* (gar fish) scales collected from both the Hell Creek and Tullock formations. Gar fish form scale enamel in isotopic equilibrium with the water in which they live, so the $\delta^{18}O$ of the carbonate in the enamel depends on the isotopic composition and temperature of that water. Additionally, the chemical composition of scale enamel tends to be well preserved on geologic time scales, as it is resistant to diagenesis due to dense packing of crystals and low organic content. We can therefore use our data, along with river water composition from published Hell Creek and Tullock clumped carbonate isotope data, to back-calculate latest Cretaceous and earliest Paleogene water temperature in northeastern Montana. We are investigating the use of this climate proxy in the Hell Creek and Tullock, as the abundance of gar scale fossils in these formations could make it possible to create a high resolution terrestrial temperature record through this interval.

We have measured $\delta^{18}O$ of carbonate in gar scale enamel hydroxylapatite from the Hell Creek region, and calculated temperatures (18–27°C). Our $\delta^{18}O$ values appear to be primary as they are similar to reported values for gar scales in other time periods (-10 to -13 ‰ VPDB), and our temperatures seem realistic. Our preliminary results show no significant trends in temperature through the Hell Creek and Tullock, but further sampling is underway to better resolve changes across the Cretaceous–Paleogene boundary.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE MECHANICAL MODEL TO CREATE THE GUIDEPOST FOR RECONSTRUCTING MAMMALIAN HIND LIMB POSTURE

MIZUNO, Fumihiro, Tsukuba University, Tsukuba, Ibaraki, Japan

Reconstruction of extinct organisms provides the basis for the study and estimation of their biology and is, therefore, one of the most important missions of paleontology. However, this mission is one of the most difficult because fossils are rarely found comprising the full skeleton components. Even if complete specimens are found, the limb posture when they lived is rarely preserved. The limb posture is important because it directly affects the reconstruction of the whole-body posture. Accordingly, it is necessary to reconstruct limb posture based upon osteological information. However, the relationship between limb-posture and skeleton is not revealed even by extant species.

To reveal the relationship mentioned above, this study focused on the mammalian knee joint. Mammals keep their knee joint angle constant while standing as their body mass adds a downward pressure on that joint. The quadriceps muscle and the semimembranosus muscle extend the knee joint to prevent collapse during standing. The semimembranosus muscle runs from the ischial tuberosity to the anteroproximal end of the tibia and pulls the tibia posteriorly to extend the knee. The muscle keeps working while supporting body mass, and thus, a mechanism is required to help the muscle work. This mechanism is a lever system.

The lever system can be built as a mechanical model. The torque of the lever is maximized where the angle between the ischial tuberosity and the tibia is at 90°, therefore, mammals keep their tibia at that angle. To test the hypothesis, mammals kept in the zoo were videotaped and the tibia angle was measured when the hind limb was supporting body

mass. The leverage efficiency (LE), which is defined as the ratio of the value of the sinθ when 90° is equal to 1.0, was calculated from these measurement data.
This study tested 20 species in 20 genera from 14 families within seven orders of extant mammals. Among them, ungulates such as giraffe, bison, horse, and rhinoceros, had very high values of LE that are greater than 0.98. On the other hand, rodents had relatively low LE. However, most of the studied taxa had high LE, therefore, the mechanical model used in this study could be a powerful tool to reconstruct mammals from their skeletal geometry.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW CAMARASAURID SPECIMEN FROM THE GNATALIE QUARRY IN SOUTHERN UTAH (MORRISON FORMATION, U.S.A.)
MOCHO, Pedro, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; CHIAPPE, Luis M., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America
A new Morrison bonebed (Brushy Basin Member) from San Juan County, Utah, yields abundant remains of sauropods as well as more fragmentary fossils of theropods, ornithopods, and thyreophorans. The 'Gnatalie Quarry' (locality LACM 7683; Natural History Museum of Los Angeles County) contains the remains of at least two sauropod clades: Diplodocinae and Macronaria. Several diplodocine specimens have been found, and one partially skeleton is herein tentatively referred to *Camarasaurus*. This specimen comprises skull remains, dorsal, sacral and caudal vertebrae, dorsal ribs, chevrons and some partial appendicular elements. This sauropod shares with *Camarasaurus* the presence of spatula-shaped teeth with well-developed lingual facets, U-shaped bifurcated neural spines in mid-dorsal vertebrae, short and massive neural spines in posterior dorsal and sacral vertebrae, and strongly convex anterior articulation up to the posterior dorsal centra. Our detailed study of several specimens attributed to *Camarasaurus*, including the type specimens of *C. grandis* (YPM 1901, 1905), *C. lewisi* (BYU 9047), *C. lentus* (YPM 1910) and *C. supremus* (AMNH 5760-1), reveals a possible closer relationship between the Gnatalie specimen and the type specimen of *C. lewisi*. Both specimens share the presence of (1) posterior centroparapophyseal lamina (that can be double in some vertebrae) in the middle-posterior dorsal vertebrae; (2) sacral neural spines with transversely concave anterior and posterior faces; (3) bridged chevrons; (4) dorsoventrally shallow neural canals; and (5) anterior tuberosities on the ventral face of the mid-caudal vertebrae. Both specimens seem to be fully grown individuals, differing on the above-mentioned characters from adult specimens attributed to *Camarasaurus lentus* and *C. grandis*. The Gnatalie camarasaurid is characterized by the presence of markedly robust anterior chevrons with anteroposteriorly compressed distal ends, and very short haemal canals. A detailed phylogenetic analysis of *Camarasaurus* is needed in order to test the validity of the four established *Camarasaurus* species, but the identified set of shared features between the Gnatalie specimen and BYU 9047 (the holotype of *Camarasaurus lewisi*) might justify the re-establishment of *Cathetosaurus*, as previously suggested by other authors. To date, *Camarasaurus lewisi* is the only *Camarasaurus* species known from sediments of the Brushy Basin Member outcropping in the southwestern corner of the Morrison Formation.
Grant Information
This work was supported by a Haaga Family Postdoctoral Fellow

Podium Symposium (Wednesday, October 17, 2018, 3:15 PM)

HINDLIMB POSTURE AND MUSCLE ACTIONS IN STEM CROCODYLIA
MOLNAR, Julia, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America, 11568; BHULLAR, Bhart-Anjan S., Yale University, New Haven, CT, United States of America; HUTCHINSON, John R., Royal Veterinary College, Hatfield, United Kingdom
In contrast to their living descendants, crocodylomorphs from the Early Triassic are thought to have been highly terrestrial, erect, cursorial, and some may even have been bipedal. We used musculoskeletal modeling to characterize limb posture and muscle actions in an exemplar early crocodylomorph (yet to be named) and estimate how they changed within crocodile-line archosaurs. Using bone meshes derived from CT/micro-CT scans and muscle reconstructions based on extant crocodylians, muscle scars, and the literature, we compared a "sphenosuchian" crocodylomorph to an extant crocodile (*Crocodylus johnstoni*), an Early Jurassic crocodylomorph (*Protosuchus richardsoni,* AMNH 3024), and a non-crocodylomorph crocodile-line archosaur (*Poposaurus gracilis,* YPM 57100). Although most muscles had similar (size-normalized) moment arms across taxa, we observed several differences that support previous inferences about habitual posture in the extinct taxa. For example, femoral adductors such as M. adductor femoris had smaller moment arms in *Poposaurus* and the "sphenosuchian," probably because of their narrower pelves. This result supports the inference that these taxa habitually held their femora in more erect positions because femoral adductors are important for body support in more sprawling postures. In the more crownward taxa we studied, moment arms of muscles that cross the knee joint tended to be larger, which—all else being equal—would have produced stronger but slower knee movements. Our modeling analysis leads to the broader inference that the Triassic Period was marked by substantial changes in hindlimb posture and muscle actions in stem Crocodylia. These changes can be quantified by biomechanical modeling and placed into a phylogenetic perspective as we have done here, and with further integration of musculoskeletal simulations with experimental analyses of living Crocodylia they can better test how locomotor function, perhaps even unusual gaits such as bounding and galloping, evolved along the crocodilian stem.

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

THE OLDEST SPHAGESAURID (NOTOSUCHIA, CROCODYLIFORMES) AND IMPLICATIONS FOR THE ORIGINS OF THE NOTOSUCHIAN-DOMINATED ECOSYSTEM IN THE LATE CRETACEOUS OF SOUTHEASTERN BRAZIL
MONTEFELTRO, Felipe C., São Paulo State University, Ilha Solteira, Brazil; RUIZ, Juan V., São Paulo State University, Ilha Solteira, Brazil
Sphagesauridae is a clade of peculiar terrestrial crocodyliforms found in Late Cretaceous deposits of Bolivia and Brazil. The diversification of Sphagesauridae is part of the radiation of the notosuchian crocodyliforms that thrived during the Cretaceous in continental environments of Gondwana. The Late Cretaceous deposits of the Adamantina Formation (Bauru Group, Bauru Basin) epitomize a notosuchian-dominated ecosystem in which a total of 15 valid notosuchian species were found, including six out of a total of eight species of sphagesaurids. The great diversity of notosuchians in the Adamantina Formation lacks analogues elsewhere in the Mesozoic and implies a longer evolutionary history of the notosuchians in the Bauru Basin. However, to date, there was no evidence of notosuchians, or any other crocodyliform, in deposits older than the Adamantina Formation in the Bauru Basin. Here we report the first crocodyliform from the Santo Anastácio Formation (Caiuá Group, Bauru Basin) from northwestern São Paulo. The Santo Anastácio Formation is immediately older than the crocodyliform dominated deposits of the Adamantina Formation, and sometimes dated as Early Cretaceous. The new fossil presents cranial elements including palate, partial neurocranium, and lower jaws. The specimen is readily assigned to Sphagesauridae by the presence of neurovascular foramina anteroposteriorly long as an alveolus along the alveolar edge of the dentary, and the short quadrate process of the pterygoid. The specimen can be differentiated from all other members of the clade by a combination of autapomorphies such as the absence of the edentulous gap between the third and fourth dentary teeth, reduced shelf positioned labial to the occlU.S.A.l surface in lower jaw, and a distinct fossa extending anteroventrally to the mandibular fenestra in the lateral surface of the lower jaw. A parsimony analysis (heuristic search 3000 RAS, hold 20, TBR) conducted in a phylogenetic matrix of Crocodyliformes (93 taxa, 487 characters) retrieved the new specimen nested with *Caipirasuchus* species. The presence of a specialized notosuchian in deposits preceding the notosuchian-dominated ecosystem of the Adamantina Formation, such as the sphagesaurid in the Santo Anastácio Formation emphasizes that establishment of the unique ecosystem occurred earlier in the Bauru Basin. The new specimen fills an important gap in the geographical and temporal distribution of the notosuchians and reveals part of the hidden history of notosuchian in Southeastern Brazil.
Grant Information
This abstract is a contribution to the project FAPESP 2014/03825-3 funded by the São Paulo Research Foundation.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE PHYLOGENY OF MIDDLE-LATE JURASSIC CHINESE SAUROPODS AND THE EVOLUTIONARY DEVELOPMENT OF THE EPIPOPHYSEAL-PREZYGAPOPHYSEAL LAMINA
MOORE, Andrew J., George Washington Univ, Washington, DC, United States of America; CLARK, James M., George Washington Univ, Washington, DC, United States of America; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China
The Chinese sauropods *Mamenchisaurus* and *Omeisaurus* are often included as outgroup taxa in phylogenetic analyses of neosauropod lineages, but the anatomy and systematics of these and related taxa from the Middle-Late Jurassic of China remain poorly documented in the literature. This lack of close study may adversely affect inferences of character polarity and prohibit rigorous testing of the evolutionary relationships of ingroup taxa. Here, we present results from phylogenetic and comparative anatomical study of *Klamelisaurus gobiensis* and *Bellusaurus sui*, two little-studied sauropods from the Middle-Late Jurassic Shishugou Formation of China. Phylogenetic analyses conducted under parsimony and Bayesian optimality criteria on two matrices that sample a diversity of eusauropod taxa recover the Early Cretaceous sauropod *Euhelopus* in a traditional, non-neosauropod Euhelopodidae with *Mamenchisaurus, Klamelisaurus*, and other Chinese taxa. *Klamelisaurus* shares several features with *Euhelopus* that are unique to a subset of Chinese sauropods, including a convex ventral margin of the prezygodiapophyseal lamina in middle-posterior cervical vertebrae, a ventrally bifurcated postzygodiapophyseal lamina in posterior cervical vertebrae, and development of a rugose projection extending anteriorly from the epipophysis into the spinodiapophyseal fossa in most cervical vertebrae. This latter feature has been interpreted as the epipophyseal-prezygapophyseal lamina, and its apparent presence throughout the cervical series was used to diagnose *Euhelopus*. However, studies of extant archosaur myology and comparative anatomical evidence from several sauropod taxa strongly suggest that this lamina-like structure is more appropriately interpreted as a scar for epaxial musculature and is distinct morphogenetically from the well-developed lateral strut of the spinodiapophyseal fossa present in some sauropods, including *Nigersaurus*. Recognizing the anterior extension of the epipophysis as an epaxial muscle scar reconciles the seemingly anomalous development of "segmented laminae" in some titanosaurians, indicating that the stranded epipophyseal lamina is a correlate of epaxial musculature.
Grant Information
AJM support: NSF DGE 1246908 and OISE 1515288, the Cosmos Club, and the Jurassic Foundation. JMC and XX support: NSF EAR 0922187 and National Natural Science Foundation of China.

Technical Session X (Friday, October 19, 2018, 11:15 AM)

FANS EVERYWHERE? ASSESSING THE UBIQUITY OF PALEOENVIRONMENTAL CHANGE CONSISTENT WITH A DISTRIBUTIVE FLUVIAL SYSTEM DRIVER IN THE VERTEBRATE FOSSIL RECORD
MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America
Distributive Fluvial Systems (DFS; alluvial fans, fluvial fans, megafans, etc.) dominate all modern sedimentary basins, forming >85% of the sediments deposited therein. It is expected, therefore, that DFS deposits will dominate the terrestrial rock record. The deposition of DFS leads to a regional pattern of paleoenvironmental change that is replicated stratigraphically as the DFS builds outwards from its apex. Near to the apex (and stratigraphically higher) channels are large, sediments are coarse, environments are open, and soils are well drained. Far from the apex (and stratigraphically lower) channels are small and standing water is more common, sediments are fine, environments are more closed, and soils are poorly drained. These environmental patterns should exert a strong and frequent influence on vertebrate paleoecosystems. If DFS dominate the terrestrial sedimentary record, depositionally driven upward drying and environmental opening

should be common, and should be considered as background when testing other hypotheses of vertebrate response to global or regional climate/paleoenvironment change.
To test the ubiquity of DFS-driven environmental change in the vertebrate fossil record, I surveyed >50 terrestrial vertebrate-bearing sequences for stratigraphic trends and covariance in any of the characteristics expected to be driven by DFS deposition (upward coarsening, drying, opening, and increase in channel size). The surveyed sequences spanned the Carboniferous to Neogene, and were broadly globally and taxonomically distributed. To avoid bias the only criteria for inclusion of a study sequence were: that at least one of the listed paleoenvironmental characteristics was recorded; that vertebrate remains had been reported from the sequence; and that the sequence was sufficiently well temporally constrained (<2 Ma) so as to reasonably be expected to capture the growth of a DFS. Preliminary analyses do not show covariance among DFS-driven paleoenvironmental parameters, but the number of sites with multiple such parameters recorded is sufficiently small that this is plausibly an artifact of sample size. Patterns of environmental change that are coherent with those expected by DFS growth are, however, significantly more common than expected in deep time, although not as dominant as the modern sedimentological record would indicate. This suggests that paleoenvironmental hypotheses in the vertebrate fossil record should be interpreted under the DFS paradigm unless evidence to the contrary is present.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

OUR HOME, OUR WORLD: FORGING RELATIONSHIPS IN MONTANA AND JAPAN THROUGH SCIENCE EDUCATION

MOORE, Sabre, Carter County Museum, Ekalaka, MT, United States of America; SCANNELLA, John, Museum of the Rockies; Montana State University, Bozeman, MT, United States of America; LEGGI, Patrick, Museum of the Rockies; Montana State University, Bozeman, MT, United States of America; ANCELL, Carrie, Museum of the Rockies; Montana State University, Bozeman, MT, United States of America; WEIKERT, Angela, Museum of the Rockies; Montana State University, Bozeman, MT, United States of America; BOWEN, David, Montana State University, Bozeman, MT, United States of America; IKEGAMI, Naoki, Mifune Dinosaur Museum, Kumamoto Prefecture, Japan; IKEBE, Shinichiro, Aso Volano Museum, Aso, Kumamoto, Japan; KUROSU, Hiromi, Goshoura Cretaceous Museum, Amakusa, Japan; NOMURA, Mizuki, Kumamoto City Museum, Kumamoto City, Japan
Montana, U.S.A. and Kumamoto, Japan were formally recognized as sister states in 1982. Since then, there have been many cultural exchanges established between these states' governments, universities, museums, and communities. The Kumamoto Montana Natural Science Museum Association (KMNSMA) was founded in October of 2015 to inspire and connect people and institutions within the natural science museum field, engage in creative collaboration for the advancement of teaching and learning, and to provide professional knowledge and training that will empower Kumamoto-Montana museums to sustain themselves as essential institutions within their communities. To this end, KMNSMA members from six museums in Montana and Kumamoto have embarked on a project to promote educational learning and community engagement through the sciences of paleontology, geology, and astronomy. Currently participating institutions in Japan are the Mifune Dinosaur Museum (MDM), Goshoura Cretaceous Museum (GCM), Aso Volcano Museum (AVM), Kumamoto City Museum (KCM), and the Kumamoto Museum Network. Participating institutions in Montana are the Carter County Museum (CCM) and the Museum of the Rockies (MOR) at Montana State University.
KMNSMA members developed museum curricula highlighting fossils found in different stratigraphic layers and locations, examples of evolutionary patterns found in the fossils of each area, as well as introductions to local geology and astronomy. Authors on the project contributed content from their respective professional backgrounds to create lessons under the unifying statement: starscapes, landscapes, and geologic layers record our past, sustain our present and predict our future; our homes inform our world. The project consists of eleven lessons, an opening lesson that introduces students to their sister state, three each in the subjects of astronomy, paleontology, and geology, and a closing lesson that promotes a learning exchange between classrooms in Montana and Kumamoto. The curricula and associated digital materials will be available for teachers on a designated website in January 2019 and will help inspire lifelong learning regarding the natural history, present, and future of Montana and Kumamoto.
Grant Information
This project is supported by a grant from the Japan Foundation Center for Global Partnership, Museum of the Rockies, and Mifune Dinosaur Museum.

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

2D EXTRUDED FINITE ELEMENT ANALYSIS: A NOVEL BIOMECHANICAL TECHNIQUE IN THE STUDY OF EARLY MAMMALS

MORALES GARCIA, Nuria M., University of Bristol, Bristol, United Kingdom; GILL, Pamela G., University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom
Finite Element Analysis (FEA) is a powerful engineering technique that has been used in vertebrate palaeobiology to assess the performance of the mandible at the moment of biting. FEA commonly uses 3D models generated from computed-tomography (CT) scans; however, these data are not always available or are too expensive to obtain. Here we introduce a novel technique that we call 2D extruded FEA, which uses 3D computer-generated models easily built from simple 2D outlines of the jaw. We compared two sets of 2D extruded models against FE results obtained from traditional 3D FE-models. Our 2D models comprised 1) simple, flat, uniformly wide models extruded medially to the average width of the original jaws, and 2) enhanced models that more accurately represent changes to the width of the ramus while still remaining flat along the body of the jaw. To test the accuracy of the new method, we used jaws of the Early Jurassic mammals *Morganucodon* and *Kuehneotherium*, whose function and dietary ecology have been previously studied using FEA. We found similar von Mises stress patterns between the original 3D reconstructions built from CT-scan data and both types of 2D extruded models. In terms of stress magnitude, the simple, flat extruded models showed a slight decrease in stress comparative to that of the 3D models: the maximum stress in *Morganucodon* represented 86.43% of the original value and 76.44% of the mean. In *Kuehneotherium*, the maximum was 85.13% of the original stress value and 77.2% of the mean. Enhanced 2D extruded FE models generated stress magnitudes that were very similar to those of the 3D models in *Morganucodon*: the maximum was slightly overestimated by 2.97% and the mean was 89.47% of the 3D value. The maximum stress values in *Kuehneotherium* were also slightly overestimated by 2.54%, and the mean was 87.41% similar to the original value. Enhanced 2D extruded FEA models can slightly overestimate the stress to which the jaws are submitted, but replicate stress values more closely than the simple, flat 2D extruded models. Our results provide preliminary support for the use of 2D extruded models for FEA, particularly for relatively flat mandibles.
Grant Information
The first author would like to thank CONACYT for providing financial support during the course of her PhD studies.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

ASTRAGALUS MORPHOLOGY INDICATES INCREASED CURSORIALITY IN LEPTOMERYCIDS, BUT NOT EQUIDS, DURING THE EOCENE–OLIGOCENE TRANSITION OF NEBRASKA

MORAN, Sean M., Florida Museum of Natural History, Gainesville, FL, United States of America
The terrestrial record of the Eocene–Oligocene transition (EOT) in North America has largely supported the hypothesis of increased habitat openness in the early Oligocene relative to the late Eocene. Extinctions of several ungulate clades, such as the oromerycids and brontotheriids, at the end of the Eocene have been associated with this environmental shift and associated climatic cooling. Despite the long history of collection in the White River Group, and subsequent taxonomic work, there are still interesting questions regarding the response of other ungulate taxa to the more open habitat of the Oligocene. Here, using 3D geometric morphometrics, I analyze astragalar morphology of two common ungulates, the equid *Mesohippus* and the leptomerycid *Leptomeryx*, from before and after the Eocene–Oligocene boundary. Specifically, the hypothesis is that these genera display changes in astragalar morphology that relate to an increase in cursoriality in response to a more open environment.
Complete astragali from *Leptomeryx* and *Mesohippus* from the Chadronian (pre-EOT) and Orellan (post-EOT) of the Toadstool area of Sioux County, Nebraska were selected from the Vertebrate Paleontology Collection of the Florida Museum of Natural History. 3D surface files of all specimens were generated using a 3D laser scanner. A series of 20 landmarks (homologous within each genus, but not necessarily across the two genera) was placed to assess shape differences between the Chadronian and Orellan representatives for each taxon. Of these, 14 were fixed landmarks and six were sliding semi-landmarks placed along the curvatures of the medial and lateral trochlear rims. Generalized Procrustes Superimposition was performed to minimize the effect of size in the assessment of shape differences. Principal component analyses (PCA) show that Chadronian and Orellan equid astragali are indistinguishable in shape (MANOVA, $p = 0.546$), but Chadronian and Orellan *Leptomeryx* display significant separation on PC1 (MANOVA, $p = 0.017$; post-hoc ANOVA for PC1, $p < 0.001$). These shape changes in *Leptomeryx* correlate most notably with an increase in trochlear rim height over time; this indicates greater stability in the parasagittal plane and is generally associated with an increase in cursorial habit. Observed changes in *Leptomeryx* can likely be attributed to the more open environments of the Oligocene, whereas selective pressures on *Mesohippus* may have been lower due to an inferred niche occupation of more open habitat prior to the EOT.
Grant Information
This project was supported in part by NSF #0966884 and #1358919.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A CONCENTRATION OF YOUNG ADULT *HESPEROTESTUDO* (TESTUDINES, TESTUDINIDAE) FROM THE LATE NEOGENE OF BEAVER COUNTY, OKLAHOMA, PROVIDES EVIDENCE OF ONTOGENETIC VARIATION AND POTENTIAL BURROWING

MORETTI, John A., Museum of Texas Tech University, Lubbock, TX, United States of America; JOHNSON, Eileen, Museum of Texas Tech, Lubbock, TX, United States of America; BEMENT, Leland C., Oklahoma Archaeological Survey, Norman, OK, United States of America
Oil field dirt work in Beaver County, Oklahoma, exposed a concentration of small *Hesperotestudo* tortoise shells. The Oklahoma Archeological Survey salvaged these specimens before the associated deposits were removed entirely. The deposits, initially viewed as Late Pleistocene terrace alluvium, now are thought to be instead Miocene–Pliocene. Homogeneous reddish fine sediment capped by caliche deposits and located south of the Beaver River indicates the Ogallala Formation, perhaps the Laverne member. Laverne sediments have produced Clarendonian–earliest Blancan Land Mammal Age fauna. The recovered tortoises represent young adult individuals of *H. osborniana* or *H. niobrarensis*. Affinities with the closely related *H. osborniana* and *H. niobrarensis* are demonstrated by the presence of a low conical boss on neural I, sub-triangular/parallelogram shaped pygal, and rounded epiplastra without divergent apices. While both species are giant forms, a series of young adult individuals of *H. osborniana* illustrate ontogenetic variation in size and shell morphology that encompasses generally the Beaver County material. Suprapygal-pygal and epiplastron morphology places the Beaver County specimens closer to *H. niobrarensis* than *H. osborniana*. Further, *H. niobrarensis* is known only from the early late Miocene (early Clarendonian) while *H. osborniana* is middle Miocene in age.
Remains of *H. osborniana* and *H. niobrarensis* are rare and both taxa are relatively poorly known, making this new material significant in terms of understanding biogeography and morphological variation. The Beaver County assemblage also offers important paleoecological data. While no other faunal material was observed during collection or preparation, the shells are tightly clustered, well-preserved with skeletal remains, and vertically oriented. These details suggest that the Beaver County specimens had burrowed into their ultimate position. *Hesperotestudo* tortoises, considered incapable of burrowing, are widely employed as climatic indicators. The Beaver County material suggests temperature regulation behavior existed in *Hesperotestudo*. Adults of these Miocene species approach one meter in diameter and, while too large to burrow, may have had the

body size to tolerate brief temperature extremes. Smaller young adults may have been more vulnerable but capable of burrowing. By extension, the Late Pleistocene small adult species *H. wilsoni*, related to and morphologically similar to the Beaver County specimens, also may have been able to burrow.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A NEW LARGE GAVIALOID FROM THE LATE PALEOCENE OF EASTERN UNITED STATES

MORGAN, Donald J., Ohio University, California, MD, United States of America; WEEMS, Robert E., US Geologic Survey, Reston, VA, United States of America; PARRIS, David C., New Jersey State Museum, Trenton, NJ, United States of America The East Coast of the United States preserves a rich history of Paleocene crocodylians. Much debate has been given to the taxonomic affinity of the late Paleocene crocodylian "*Crocodilus clavriostris*", which has been attributed to both *Thoracosaurus neocesariensis* and *Eosuchus minor*. However, "*Crocodilus clavirostris*" was significantly larger than *T. neocesariensis* and *E. minor*. Our phylogenetic analysis places "*Crocodilus clavirostris*" as a gavialoid, basal to the *Eosuchus* clade. The species can be differentiated from *T. neocesariensis* and *E. minor* based on the morphology of the external naris, choanal septum, lack of an enlarged foramen aereum on the quadrate, frontal morphology, and splenial. In addition to the holotype material, five additional skulls and four lower jaws have also been assigned to this taxon from the Aquia and Vincentown formations. For the first time a complete rostrum of "*Crocodilus clavirostris*" has been discovered, which reveals an enlarged bowl-shaped external naris that nearly encompasses the entire anterior portion of the rostrum. A regression analysis on a composite skull of "*Crocodilus clavirostris*" reveals that the estimated total body length for the animal was 8.25 meters, making it one of the largest North American Cenozoic crocodylians. This species is also known for its peculiar antorbital fenestra, which separates the lacrimals from the prefrontal. However, upon further investigation on three skulls with this purported feature, it is clear that these openings represent breaks in the cortical bone, rather than a distinct anatomical feature. None of the fenestra were symmetric in position or consisting of finished bone their borders, and are likely a preservational or preparational artifact.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

GEOCHRONOLOGY OF THE CHAMITA FORMATION, NEW MEXICO, AND THE FIRST APPEARANCE OF THE LATE MIOCENE (EARLY HEMPHILLIAN) GROUND SLOTH *PLIOMETANASTES* (MEGALONYCHIDAE) IN NORTH AMERICA

MORGAN, Gary, New Mexico Museum of Natural History, Albuquerque, NM, United States of America; ABY, Scott, Muddy Spring Geology, Dixon, NM, United States of America; GENSLER, Philip, U. S. Bureau of Land Management, Santa Fe, NM, United States of America; KONING, Daniel, New Mexico Bureau of Geology and Mineral Resources, Socorro, NM, United States of America; HEIZLER, Matt, New Mexico Bureau of Geology and Mineral Resources, Socorro, NM, United States of America

The onset of the Great American Biotic Interchange (GABI) in North America and the lower boundary of the Hemphillian North American land mammal age are both defined, in part, by the first appearance in North America of two genera of ground sloths of South American origin, *Pliometanastes* (Megalonychidae) and *Thinobadistes* (Mylodontidae). Although these two sloths must have passed through tropical Mesoamerica on their way north, the earliest records of both genera are from temperate North America. *Pliometanastes* is the more widespread of these two sloths, and also has more precise age data. The oldest previously dated ground sloth in North America is a partial skeleton of *Pliometanastes protistus* from the Siphon Canal locality in the Mehrten Formation, Stanislaus County, California, collected 4 m below a tuff dated by K–Ar at 8.19 Ma (earliest Hemphillian, Hh1). The type locality of *P. protistus*, McGehee Farm in Florida, is probably somewhat older (earliest Hemphillian; 8.5–9 Ma), but the age is based only on mammalian biochronology. Specimens of *Pliometanastes* are known from four localities in the middle to late Miocene Chamita Formation (Fm) in the Española Basin of northern New Mexico, three of which have associated geochronology. The type specimen of *Pliometanastes galushai*, a partial dentary, was collected from the middle brown unit of the Chamita Fm in the San Juan locality, about halfway between two tephras dated at 7.02 ± 0.05 Ma and 7.8 ± 0.3 Ma using $^{40}Ar/^{39}Ar$ on sanidine and hornblende, respectively (all dates calibrated to a Fish Canyon Tuff standard of 28.201 Ma). These dates provide an age range for the *P. galushai* jaw of ~7.0–7.9 Ma (late early Hemphillian, Hh2). A partial braincase of *Pliometanastes* from the Chamita Fm north of Santa Clara Canyon was found in strata bounded by a 9.7 ± 0.2 Ma basalt and the 7.8 Ma tephra mentioned above. These dates indicate an age range for the sloth skull of ~7.8–9.7 Ma (Hh1 or possibly late Clarendonian, Cl3). A 3rd metatarsal of *Pliometanastes* from the Chamita Fm near the Frick *Osbornoceros* Quarry in Arroyo del Pueblo was collected from the base of the ~50 m thick Alcalde tuffaceous interval, whose uppermost tephra returned an imprecise and somewhat difficult to interpret $^{40}Ar/^{39}Ar$ date on biotite of 9.52 ± 0.46 Ma. Based on this date and local stratigraphy, the age of the Arroyo del Pueblo *Pliometanastes* is 9.5–10 Ma (late Clarendonian), confirming this specimen as the oldest dated ground sloth in North Funding to conduct the field work and research for this project was provided by the U. S. Bureau of Land Management.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

CAUDAL PLATE SHAPE ANALYSIS OF POLACANTHID TYPE ANKYLOSAURS

MORGAN, Kirsty, University of Arkansas, Fayetteville, AR, United States of America; SUAREZ, Celina A., University of Arkansas, Fayetteville, AR, United States of America; KIRKLAND, James I., Utah Geological Survey, Salt Lake City, UT, United States of America

Phylogenetic analysis of dinosaurs is focused around the morphology of various skeletal elements. Being covered in armor including spikes, plates, and osteoderms makes Ankylosaurs unique within the Dinosauria, because they effectively possess a second skeleton. To date, phylogenetic analyses of ankylosaurs have suffered from limited characters and sampling. The addition of new armor characters would greatly increase the number and diversity of characters able to be used in analysis. It is not uncommon to find isolated pieces of armor which are unidentifiable to even family level and are simply considered to be ankylosaur of indeterminate origin. The ability to identify these specimens to genus level would improve knowledge of paleogeographic and stratigraphic ranges of known ankylosaurs.

This study includes 11 caudal plates from six polacanthid-type ankylosaurs; two *Gastonia,* two *Mymoorapelta*, two from the holotype of *Polacanthus*, two from a paratype *Polacanthus*, two from a Spanish polacanthid, and one *Gargoyleosaurus*. 2-D line drawings were made of several polacanthid caudal plates using Adobe Illustrator. In order to provide consistency in the measurements, the maximum calliper length was identified, and the point half the distance was considered the centre from which all measurements were taken. Polar coordinates were determined by the distance (r) from the centre at every 10 degrees (q). A preliminary cross-correlation was generated to determine initial shape groupings. As expected, specimens from the same genus had higher R^2 values. The two *Mymoorapelta* specimens had R^2 values of 0.64, as did the paratypes of *Polacanthus*. The holotype samples from *Polacanthus* had R^2values of 0.49. When the paratype *Polacanthus* specimens were compared to that of the holotype R^2=0.89 suggesting the two plate shapes to be very similar. However, the Spanish polacanthids have the weakest correlation, R^2=0.0076. Even when compared to all other samples the Spanish polacanthid never exhibited an R^2 value higher than 0.3. *Gastonia* itself did not correlate well with Spanish polocanthids (R^2=0.16). *Gargoyleosaurus* gave a R^2 value of .83 when compared to *Mymoorapelta*, which indicates their plate shapes are highly similar. This may be due to the fact they are both Jurassic in age.

The next steps in this study are to conduct a Fast Fourier Transform of this data to determine trends and groupings in the shapes of polocanthid caudal plates and expand it to include nodosaurid and ankylosaurid ankylosaurs.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

STUDY OF ENDOCRANIAL ANATOMY AND ONTOGENY IN THE LATE CRETACEOUS NON-AVIAN DINOSAUR GENUS *TRICERATOPS* USING COMPUTED TOMOGRAPHY AND 3-D VISUALIZATION

MORHARDT, Ashley C., Washington University, St. Louis, MO, United States of America; CAMPBELL, Carl, St Louis Community College Meramec, St. Louis, MO, United States of America; BHALLA, Sanjeev, Mallinckrodt Institute of Radiology at Washington University School of Medicine, St. Louis, MO, United States of America; STEINKRUGER, Michael, Mallinckrodt Institute of Radiology at Washington University School of Medicine, St. Louis, MO, United States of America; MILLER-THOMAS, Michelle, Mallinckrodt Institute of Radiology at Washington University School of Medicine, St. Louis, MO, United States of America; MELLNICK, Vincent, Mallinckrodt Institute of Radiology at Washington University School of Medicine, St. Louis, MO, United States of America; THOMAS, Brian, Saint Louis Science Center, St. Louis, MO, United States of America

Consideration of ontogenetic patterns and representative developmental stages is important for accurate interpretation of the fossil record and, in turn, for reconstructing the life histories of extinct vertebrate taxa. A rich literature now exists on the growth stages of the iconic and relatively well-represented non-avian dinosaur genus *Triceratops,* and it provides a foundational example of how ontogeny may inform questions of taxonomy, taphonomy, phylogeny, metabolic rate, resource partitioning, parental care, and more. Yet, most of this literature focused exclusively on skeletal variation of the post-crania and external cranium, whereas ontogeny of the endocranium was not considered. Here, we present CT-based, three-dimensional (3-D) digital models of the crania and corresponding cranial endocasts from two previously undescribed individuals, one juvenile, and one potential juvenile, of *Triceratops*. Comparisons with adult *Triceratops* cranial endocasts (and, by proxy, brains) show marked difference in overall size, as well as increase in relative size of the adult pituitary fossa, and a reduction over time in the cephalic and pontine flexures. Such changes represent a potential source of data for growth stage classification. Additionally, several general features—olfactory bulbs, cerebral hemispheres, cranial nerve and blood vessel canals, and the bony labyrinth of the inner ear—are observed clearly in early ontogenetic stages, potentially indicating precociality. Interestingly, similar results have been reported previously by outside researchers for a handful of ornithopod dinosaurs. Similarity in ontogenetic changes in the endocranial anatomy of distantly related ornithischian dinosaurs suggests a broad distribution of a typical pattern that may form the basis for future structural and functional ontogenetic hypotheses for taxa within, and perhaps outside, clade Cerapoda.

Grant Information

Funding was generously provided by both the Department of Neuroscience and Mallinckrodt Institute of Radiology at Washington University School of Medicine in St. Louis.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ABOLISHING THE KIDS' TABLE: A PRELIMINARY ATTEMPT AT ASSESSING THE PHYLOGENETIC POSITION OF *ZUNICERATOPS CHRISTOPHERI* USING ALL OF CERATOPSIA

MORSCHHAUSER, Eric M., Indiana University of Pennsylvania, Indiana, PA, United States of America; MCDONALD, Andrew T., Western Science Center, Hemet, CA, United States of America; WOLFE, Douglas G., White Mountain Dinosaur Exploration Center, Springerville, AZ, United States of America

Zuniceratops christopheri is a ceratopsian dinosaur from the Turonian Moreno Hill formation of the Zuni Basin of western New Mexico. It is known from two main localities, including the multitaxic "Haystack Butte" bone bed. For twenty years it has been the earliest diverging and most completely known member of Ceratopsoidea, the most inclusive clade containing *Triceratops horridus*, but not *Protoceratops andrewsi* (and by extension the clade Protoceratopsidae). The anatomy of *Zuniceratops* contains a blend of plesiomorphic characters and derived characters that otherwise only characterize the large-bodied ceratopsid dinosaurs. Most phylogenetic analyses of ceratopsians in the past decade have focused on either one of the two clades of derived ceratopsians Chasmosaurinae and Centrosaurinae, or on the smaller-bodied taxa that make up the remainder of Ceratopsia. This division is problematic for *Zuniceratops*, as it always remains near the edge of the

analyses in any of these three scenarios, with insufficient sampling of either earlier-diverging or later-diverging lineages.
To better understand the phylogenetic position of *Zuniceratops*, we conducted a parsimony analysis using a new matrix of 348 characters and 44 taxa sampled from throughout Ceratopsia. We recovered 143 most parsimonious trees. Bremer support methods and bootstrapping recovered low overall support across the tree, which is not unexpected given the divergent morphologies sampled and the dramatic incompleteness of some of the taxa involved. Most of the loss of resolution in the strict consensus tree was among basal ceratopsians and basal neoceratopsians.
The resulting phylogeny recovers *Zuniceratops* within Ceratopsoidea but outside Ceratopsidae, along with *Turanoceratops*, a contemporaneous ceratopsian from central Asia. Unexpectedly, both *Ajkaceratops*, from the Santonian of Europe, and *Diabloceratops*, from the Campanian of North America, are also recovered as ceratopsoids. The position of all these taxa are robust, occurring in the agreement subtree as well as the most parsimonious tree.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

CHANGES IN DENTAL DEVELOPMENTAL TRAJECTORY AND BODY SIZE IN PRIMATE TAXA ACROSS THE PALEOCENE–EOCENE THERMAL MAXIMUM
MORSE, Paul E., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; BOYER, Doug M., Duke University, Durham, NC, United States of America; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America
The Paleocene–Eocene Thermal Maximum (PETM) is a brief interval of rapid global warming (~5–10° C) that occurred ~56 Ma. The mammal fossil record across the PETM documents decreases in body size among ~40% of lineages, including two microsyopid plesiadapiforms (stem primates)—the uintasoricine *Niptomomys* and microsyopine *Arctodontomys*—with a subsequent increase in body size at the end of the PETM inferred through changes in m1 crown area. This contrasts with the earliest euprimate genera (*Teilhardina* and *Cantius*) that show little evidence of change in size across the PETM. Relative crown areas (RCA) of mammalian molars are argued to follow a conserved 'inhibitory cascade' (IC) developmental trajectory along which they are most likely to change. According to this model, the proportion of m2:m1 predicts the proportion of m3:m1, with m2 crown area being intermediate in size between that of m1 and m3. Changes in climate and nutrition are linked to disparity in both body size and RCA; however, it is unknown if RCA in lineages undergoing size change adheres to the predicted trajectory of the IC model.
We calculated the RCA in a sample of 747 microsyopid and euprimate lower molars from a high-resolution stratigraphic section spanning the PETM and subsequent early Wasatchian biozones in the southern Bighorn Basin, WY, and average molar proportions in eight extant prosimian genera and the treeshrew *Tupaia*. m3:m1 proportion was regressed against m2:m1 proportion and compared to the predictions of the IC model for each taxon. Significance of differences between PETM versus non-PETM samples within each fossil genus was assessed via ANCOVA. No significant differences in euprimate RCA were detected between PETM and post-PETM samples, yet RCA of *Teilhardina* throughout the sampled time interval falls outside the predictions of the IC model, with m2 area larger than that of either m1 or m3. The RCA of microsyopid taxa are similar to those of extant treeshrews and follow a regression parallel to that predicted by the IC model. However, the regressions of PETM versus non-PETM samples of *Niptomomys* have significantly different intercepts ($p < 0.001$), indicating a shift in RCA coincident with changes in body size that cannot be explained by the IC model. RCA among mammals likely follow trajectories that correspond to different feeding ecologies, potentially explaining the differences observed among the fossil taxa in this study. Yet the fossil record of microsyopids through the PETM suggests that rapid body size shift has a disruptive effect on the mechanisms governing dental development.
Grant Information
NSF EAR-0640076 (JIB, R Secord, J Krigbaum), NSF EAR-0719941 (JIB, F McInerney, S Wing, M Kraus), NSFGRF under DGE-1315138 (PEM), BCS 1440558 (JIB), BCS 1440742 (DMB, G Gunnell)

Technical Session I (Wednesday, October 17, 2018, 8:30 AM)

ORNITHOSCELIDA, PHYTODINOSAURIA, SAURISCHIA: TESTING THE EFFECTS OF MISSCORES IN MATRICES ON BASAL DINOSAUR PHYLOGENY
MORTIMER, Mickey, Maple Valley, WA, United States of America, 98038; GARDNER, Nicholas, WVU Potomac State College, Keyser, WV, United States of America; MARJANOVIĆ, David, Wien, Austria; DECECCHI, Alexander, Queen's University, Johnstown, PA, United States of America
The large-scale phylogeny of Dinosauria was uncontroversial for a long time. Using the largest data matrix of early dinosaurs and their closest relatives that had yet been analyzed, a recent study found strong support for the novel Ornithoscelida hypothesis (Theropoda and Ornithischia as sister-groups). We have reevaluated over a third of this matrix and its even larger successors, finding hundreds of questionable scores and providing citations for each. Many characters are correlated with each other, score for multiple variables at once, or are formed in such a way that potential homology is masked. Despite the large number of multistate characters, polymorphism and partial uncertainty are entirely absent from the original matrix. Many scores were taken from secondary or tertiary instead of primary literature, while at other times recent redescriptions were not consulted, resulting in outdated or spuriously missing data.
Parsimony analyses of our revised matrix find the Ornithoscelida hypothesis is eight steps longer than the traditional alternative (Saurischia: Theropoda and Sauropodomorpha as sister-groups). One further step makes the Phytodinosauria hypothesis (Sauropodomorpha and Ornithischia as sister-groups) possible. Our addition of several taxa to the in- and the outgroup decreases the distance between the Saurischia and Ornithoscelida hypotheses to three steps, but also renders Phytodinosauria only five steps less parsimonious than Saurischia. A Bayesian analysis yields similar results (posterior probability of Saurischia=0.79). In addition, we tested the number of steps implied by further hypotheses about the relationships of many potential early dinosaurs and their closest relatives (e.g., Herrerasauridae, *Eoraptor*, Silesauridae, *Saltopus*, *Nyasasaurus*, *Daemonosaurus*, *Chilesaurus*) and ran taxon-deletion and character-deletion experiments, for a total of 110 analyses. None of these experiments supported Ornithoscelida over Saurischia. Placing ornithischians next to or within Neotheropoda as recently suggested is highly unparsimonious, adding between 10 and 20 steps. Phylogeographic analyses of the original matrix as well as our revised version place the origin of Dinosauria in South America, which should be interpreted as Pangaea south of the low-latitude desert belt(s).
Our results show once again that phylogenetic analysis of morphological data is highly vulnerable to typographic errors and other accidental, unsystematic misscores in data matrices; both quantity and quality of scores are important.

Technical Session XI (Friday, October 19, 2018, 3:30 PM)

NEW SPECIES OF HYAENODONTA (MAMMALIA) FROM THE EARLY MIDDLE EOCENE AT SOUTH PASS, GREEN RIVER BASIN, WYOMING
MULDOON, Kathleen M., Midwestern University, Glendale, AZ, United States of America; GUNNELL, Gregg F., Duke University Lemur Center, Durham, NC, United States of America; ZONNEVELD, John-Paul, University of Alberta, Edmonton, AB, Canada; BARTELS, William S., Albion College, Albion, MI, United States of America
Fieldwork in earliest Bridgerian (Biochron Br1a, early middle Eocene) basin margin deposits along the northeastern edge of the Green River Basin at South Pass, Wyoming, has resulted in the recovery of a diverse assemblage of carnivoran mammals. Here, we describe the hyaenodont fauna, which represents five genera and at least one new species. *Prolimnocyon* sp. nov. is represented by a right dentary including m2–m3 (holotype) as well as isolated postcrania and teeth. The new species from South Pass differs from *P. atavus* and *P. haematus* in having a single-rooted, peg-like m3, a relatively deeper dentary with the postero-inferior margin being straighter, and in being larger in tooth dimensions. *Prolimnocyon* sp. nov. differs from *P. elisabethae* in being larger in tooth dimensions, in having a more robust dentary, and a peg-like m3. The new species further differs from *P. antiquus* in having a relatively smaller and narrower m2, a smaller m3, and a more robust dentary with a straight postero-inferior margin. Other represented hyaenodont genera include *Tritemnodon*, which is rarely found in basin center assemblages but is relatively common at South Pass, as well as *Limnocyon*, *Iridodon*, and *Sinopa*. The hyaenodonts from South Pass support previous evidence that basin margin assemblages are different in composition from time-equivalent basin center assemblages from the Green River Basin. Basin margins are hypothesized to provide heterogeneous habitats conducive to evolutionary innovation. Basin margin samples have also been discussed as evidence of upland refugia as competitor taxa appeared in basin center settings. For these reasons, sampling across wide ranging geographic areas and multiple habitats is crucial to our understanding of mechanisms of evolutionary change, and descriptions of terrestrial biostratigraphy.
Grant Information
Funded by grants from NSF, Albion College, and Duke University Lemur Center Division of Fossil Primates (to GFG and WSB)

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

REAPPRAISAL OF A RHINOCEROTID LUNAR FROM THE MID-PLIOCENE UENO FORMATION OF THE KOBIWAKO GROUP, CENTRAL JAPAN
MURAKAMI, Tatsuro, Ehime University, Matsuyama, Japan; TSUBAMOTO, Takehisa, Ehime University, Matsuyama, Japan
Rhinocerotid fossils, including footprints, have been discovered in the Neogene of Japan, although the rhinocerotids do not inhabit Japan now. Most of the rhinocerotid fossils in Japan are from the Miocene and Pleistocene. In the Pliocene of Japan, in contrast, only three rhinocerotid fossil records are reported. The specimens of these Japanese Pliocene rhinocerotids are very poor, and their tribal and more precise taxonomic identification have not been determined. Therefore, the evolution of the rhinocerotids in the Japanese Islands from the Miocene to Pleistocene is unclear.
Here, we reappraise a right lunar of the Rhinocerotidae (Mammalia, Perissodactyla) from the mid-Pliocene Ueno Formation of the Kobiwako Group, central Japan. This specimen is large among the lunars of mammals, mushroom-shaped in anterior and proximal view, and triangular in lateral view, indicating that it is certainly assigned to the Rhinocerotidae. It is assigned to the tribe Rhinocerotini based on the presence of a third scaphoid facet and a caudal prolongation of the pyramidal facet. It is similar in morphology to that of *Stephanorhinus* in having an ulna facet, an acute distal end of the anterior apophysis, a keel-shaped anterior apophysis, a wide proximal part, and a similar overall shape and size that are indicated by a ratio diagram. However, the generic identification of this specimen is difficult due to the scarcity of the material. This study indicates, for the first time, that the Rhinocerotini existed in the Pliocene of Japan. It also indicates that at least one member of this tribe likely migrated from the Asian Continent into Japan during the latest Miocene or Pliocene because no Rhinocerotini have been recorded in the Miocene ofJapan.

Technical Session VII (Thursday, October 18, 2018, 4:00 PM)

NEW MATERIAL OF *PELLORNIS* CLARIFIES PATTERN AND TIMING OF THE EXTANT GRUIFORM RADIATION
MUSSER, Grace M., University of Texas at Austin, Austin, TX, United States of America; FIELD, Daniel J., University of Bath, Bath, United Kingdom; KSEPKA, Daniel, The Bruce Museum of Arts and Science, Greenwich, CT, United States of America
Phylogenetic relationships at the base of Neoaves—a group comprising approximately 95 percent of all living birds—conflict across morphological and genomic studies. Robust phylogenetic placement of early neoavians is therefore critical for discerning the pattern and timing of deep divergences within the major neoavian subclades, such as Gruiformes. *Pellornis mikkelseni* represents an early gruiform-like-taxon from the latest Paleocene-earliest Eocene Fur Formation of Denmark. At approximately 54 million years old, it is among the earliest clear examples of a gruiform-like fossil. The holotype was initially described as a partial postcranial skeleton, but our additional mechanical preparation of the nodule containing the holotype has revealed the skeleton is in fact nearly complete and includes a well-preserved skull. We also identified and described two additional

specimens of *P. mikkelseni*, which provide further morphological information. These specimens together reveal that *P. mikkelseni* possessed a schizorhinal skull and shares many features with the contemporary "Messel rail" *Messelornis*. To reassess the phylogenetic position of *P. mikkelseni*, we added 16 characters, six gruiform taxa, and novel scorings based on the holotype and referred specimens to existing morphological datasets. Preliminary phylogenetic analyses confirm *P. mikkelseni* as a member of the extinct Messelornithidae, and one of the oldest crown group members of Gruiformes. *P. mikkelseni* illustrates that recent divergence time analyses have underestimated the age of crown Gruiformes. Our results confirm crown Gruiformes as originating during the early Paleogene, thereby bolstering evidence for a rapid early radiation of Neoaves following the end-Cretaceous mass extinction. Our results will thus provide new insight into the outcome of molecular divergence time analyses.

Grant Information
National Science Foundation Graduate Research Fellowship Program (Grant No. DGE-16-4486)

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

SCIENCE FAIR PALEO-PROJECTS AS OPPORTUNITIES FOR HIGH SCHOOL STUDENT MENTORSHIP AND COMMUNITY ENGAGEMENT

MYCHAJLIW, Alexis M., La Brea Tar Pits & Museum, Los Angeles, CA, United States of America; ACOSTA, Livia M., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America

County science fairs are important platforms for high school students to present independent research to a community of their peers and local STEM professionals. Participation in these events benefits high school students in multifarious ways, by strengthening public speaking skills, providing a venue for professional networking, encouraging further STEM engagement, and even offering the chance to win college scholarships. Such confidence-building opportunities are particularly important for female and underrepresented students who may not have been previously encouraged in STEM. However, barriers to participation in science fairs exist for students whose schools may lack the resources to support independent research or awareness of science fair opportunities and guidelines. Natural history museums, including vertebrate paleontology collections, can become hubs for high school student science research in their communities by: (1) providing mentorship for student projects in partnership with local high schools, and (2) encouraging student research in paleontology by sponsoring a community award. Here we describe such ongoing efforts at the La Brea Tar Pits & Museum, a world-renowned Late Pleistocene fossil deposit located in the heart of Los Angeles, California. The Los Angeles Unified School District is extremely socioeconomically diverse, making it an important place for scientists to engage their local community. With support from the Society for Science and the Public's "Advocate" program, we describe the process of how to recruit diverse students from the community, navigate science fair requirements for entry, develop appropriate projects using existing paleontological collections, and develop programming to retain students such as field trips to local fossil sites. Staff at paleontology museums can also engage their local science communities by acting as a community judge for their own institutional award, such as the "La Brea Tar Pits Award for Global Change Research". Ultimately, our goal is to share the workflow of engaging our own local community in high school science research, and invite dialogue for applying this model to other communities across the United States.

Grant Information
This work is supported by an Advocate Grant to AMM from the Society for Science & the Public.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A TALE OF TWO BEARS: EMPLOYING QUATERNARY FOSSILS TO GUIDE ANTHROPOCENE CONSERVATION STRATEGIES IN CALIFORNIA

MYCHAJLIW, Alexis M., La Brea Tar Pits & Museum, Los Angeles, CA, United States of America; BROWN, Kevin C., University of California, Santa Barbara, Santa Barbara, CA, United States of America; CAMPBELL, Beau T., La Brea Tar Pits & Museum, Los Angeles, CA, United States of America; ALAGONA, Pete, University of California, Santa Barbara, Santa Barbara, CA, United States of America; LINDSEY, Emily, La Brea Tar Pits & Museum, Los Angeles, CA, United States of America

In today's rapidly changing world, data from the fossil record is becoming increasingly relevant to conservation decision-making. Bears represent a significant part of California's human history, with grizzly bears featured on the state's flag and in numerous popular culture references prior to their disappearance in the 1920s. In 2014, the Center for Biological Diversity submitted a petition to list grizzlies in California under the Endangered Species Act, thus providing a path to reintroduction. The ecological consequences of such an action are unknown, with few California-specific data available to provide guidance. In this study, we leverage the fossil and historical records to address two ecological questions related to the management of bears in California: 1) the extirpation and hypothetical re-introduction of grizzly bears (*Ursus arctos*) across the state and 2) the true nature of a 1933 human-mediated range expansion of black bears (*Ursus americanus*) to southern California. We apply radiocarbon dating and stable isotope analysis to describe spatiotemporal variation in grizzly resource use and extirpation patterns from the mid-Holocene to the early 1900s. The fossil record provides a comparative dataset for understanding differences in niche breadth and prey preference before and after the arrival of Europeans and their land use practices. Radiocarbon dating of data deficient California grizzly specimens held in mammalogy collections revealed unexpected ages in the mid/late Holocene, rather than historic periods. We employed these Holocene radiocarbon dates in a GRIWM modeling approach of extinction timing for comparison with known last appearances in the historic record. One key question that can be answered only with the fossil record is how grizzlies might interact with California's still extant black bears, particularly in areas where black bears were intentionally translocated to replace grizzlies. Such work has uncovered that the translocation of black bears from Yosemite to the Los Angeles area by California Fish & Wildlife Service in 1933 was in fact a re-introduction (or 'Pleistocene rewilding') of a large carnivore, as fossil records clearly show the presence of the species in the late Pleistocene, followed by a historic absence. Ultimately, we present two case studies that highlight the real-world applications of a 'conservation paleobiology' toolkit and demonstrate the clear benefits of looking to the past for clues to the future.

Grant Information
This project is funded by the California Grizzly Research Network and the Natural History Museum of Los Angeles County.

Technical Session I (Wednesday, October 17, 2018, 10:15 AM)

CRANIAL MUSCULATURE IN HERBIVOROUS DINOSAURS AND THE EVOLUTION OF DIVERSE FEEDING MECHANISMS

NABAVIZADEH, Ali, Cooper Medical School of Rowan University, Philadelphia, PA, United States of America

Herbivorous dinosaurs evolved many cranial feeding mechanisms, as shown by studies in osteology, dental microwear, and biomechanical bite force modelling. Despite this, the evolutionary reorientation of cranial muscles and its phylogenetic influence on significant changes in mandibular feeding motions remains largely unexplored. In this study, 16 muscular traits (i.e., bony traits informative of muscle attachment and orientation) were compared across 116 genera (81 ornithischians and 35 sauropodomorphs), both through personal examination of specimens as well as through the literature. Traits included those relating to the temporal region, adductor chamber, palate, coronoid elevation, and retroarticular process, among others. Major findings show that numerous combinations of traits influence a variety of feeding mechanisms. Some primarily orthal feeders, such as basal sauropodomorphs, basal ornithischians, and stegosaurs variably present with a rostrocaudally expanded, yet mediolaterally compressed temporal region for temporal muscle origin, a rounded or subtriangular coronoid elevation for temporal muscle insertion on either side, and a more prominent palatal muscle attachment site around the postdentary body and retroarticular process. Among orthal feeding neosauropods, however, temporal muscle origins were restricted caudally and, in the case of diplodocoids and titanosaurs, the low-angled, rostroventrally-oriented quadrate positions the jaw joint closer to the more dorsally-angled palate, creating reduced temporal muscle mass and more vertically-oriented and prominent palatal muscles for an orthal vector with slight manipulation capabilities. Caudally restricted temporal regions with low-angled adductor chambers and larger palatal muscles are also seen in pachycephalosaurs (also orthal feeders). Among ankylosaurs, hadrosaurs, and neoceratopsians (especially ceratopsids), an additional rostrolabial expansion of temporal adductor muscles (allowed by flaring jugals and rostrolateral coronoid attachment) and tall coronoid process in ceratopsids and hadrosaurs for deeper adductor attachment, provide greater mechanical advantage and support for stresses across the tooth row in palinal feeding motions observed in tooth wear. This also aids in long-axis rotation against the predentary in hadrosaurs and ankylosaurs. These variations in muscle morphology and orientation show numerous adaptations acquired given certain evolutionary anatomical constraints in the skull.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

UNUSUAL VERTEBRATE ASSEMBLAGE FROM THE MCNEIL QUARRY OF THE BIGHORN BASIN, WYOMING (WILLWOOD FORMATION, EARLY EOCENE, WASATCHIAN NALMA)

NAGENDRAN, Lavania, University of Toronto, Scarborough, ON, Canada; ROSE, Kenneth D., Johns Hopkins University, Baltimore, MD, United States of America; CHEW, Amy E., Brown University, Providence, RI, United States of America; BOWN, Thomas M., Colorado State University, Fort Collins, CO, United States of America; SILCOX, Mary T., University of Toronto, Scarborough, ON, Canada

The Bighorn Basin of northwestern Wyoming preserves highly fossiliferous Paleocene and Eocene deposits. Tens of thousands of specimens have been recovered from the Bighorn Basin through surface prospecting. However, this method of recovery may lead to a sample biased in favour of larger species. The inclusion of smaller vertebrates is critical to gain a better understanding of the paleoecology of particular time periods. One solution to this problem is to look at high density concentrations of fossil material that can be quarried and screen-washed. Such quarry samples have been shown to better represent the smaller mammals in the fauna, although they can also be biased by taphonomic factors related to their formation.

The McNeil Quarry in the Willwood Formation of the Bighorn Basin, Wyoming, covers an area of about $10m^2$ and is located at 347 m in the central basin, making it Wasatchian (early Eocene, Wa4) in age. The productive layer of this locality has been completely quarried and all screen-wash concentrate picked, allowing for a complete faunal analysis. Tallies for total number of specimens and minimum number of individuals were conducted on identifiable fossil remains. A total of 237 fossil specimens have been collected, many of which are jaws from small-bodied mammals. McNeil Quarry includes at least 58 individuals from eight different orders (Multituberculata, Leptictida, Eulipotyphla, Carnivora, Condylarthra, Artiodactyla, Perissodactyla, and Rodentia). The site is unusual both in terms of lithology and taxonomic composition. Compared to other Wasatchian-age quarries in the Bighorn Basin, McNeil Quarry is rich in gypsum and jarosite. This locality has the highest relative frequency of multituberculates (26% of MNI) of any locality from the Bighorn Basin, including Paleocene sites. In addition to numerous small-bodied mammals, remains of at least two individuals of the larger phenacodontid condylarth, *Phenacodus trilobatus*, were also discovered. Assessment of faunal composition indicates that in addition to a high proportion of multituberculates, there is also a disproportionate number of juvenile specimens representing multiple groups (8.6%). These atypical features suggest some kind of unusual taphonomic origin, perhaps related to a predatory assemblage, although the presence of some larger animals suggests a multi- phase process. McNeil Quarry contributes valuable samples of several small species from the Wasatchian, but also poses questions about the impact of taphonomy on the interpretation of such concentrations.

Grant Information
NSERC Discovery Grant to MTS; NSF grant BSR-8215099, BSR-8500732, BSR-8918755, and IBN-9419776 to KDR; fossils collected under BLM (Wyoming) permit 183-WY-PA95

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE FIRST RECORD OF A DINOSAUR FROM THE CADOMIN FORMATION (LOWER CRETACEOUS) OF SOUTHWESTERN ALBERTA, CANADA

NAGESAN, Ramon S., University of Calgary, Calgary, AB, Canada; VAVREK, Matthew J., Royal Ontario Museum, Toronto, ON, Canada; PARDO, Jason D., University of Calgary, Calgary, AB, Canada; CAMPBELL, James A., University of Calgary, Calgary, AB, Canada; ANDERSON, Jason S., University of Calgary, Calgary, AB, Canada

For well over a century, the badlands have been the focus of the fossil collecting effort in southern Alberta. These areas have contributed substantially to our understanding of Late Cretaceous dinosaur faunas. However, the paucity of Early Cretaceous dinosaurs in this region has resulted in a gap in our understanding of the distribution and evolution of earlier dinosaur faunas from Alberta. Here we report on the first record of dinosaur material from the Lower Cretaceous (Berriasian–Barremian) Cadomin Formation (CF.).

The fossils were collected on Grizzly Ridge, near the Highwood Pass region of Kananaskis Country. Along the top of the ridge are exposures of the Berriasian–Valanginian-aged Pocaterra Creek Member of the CF., which are underlain by the Jurassic-aged Elk Formation. The locality is made up of highly resistant, light brown, well-sorted, conglomeratic, fine-grained sandstones which are interbedded with medium-grained, yellow sandstones. A concentration of large vertebrate fossils were found ex- and in-situ and required minor excavation using hammers and chisels to extract from the rock.

The majority of the recovered elements are fragmentary, with loss of cortical bone indicating subaerial or subaqueous weathering. However, a number of elements are identifiable and relatively well-preserved. These elements include three to five partial osteoderms, and several partial ribs. The largest osteoderm is approximately 15 cm wide and 7 cm long, although its margins are incomplete. This osteoderm is arched in cross section, with a rounded midline keel and a concave ventral surface. The dorsal surface of the osteoderm is smooth except for vascular pitting. The other osteoderms preserve similar anatomy. The osteoderms are similar to those of other Early Cretaceous ankylosaurs, particularly nodosaurids. Associated, multi-taxic microvertebrate fossils suggest that this locality was an attritional bone bed.

The discovery of this probable ankylosaur adds to a limited list of large-bodied vertebrates from the Albertan Rocky Mountains, which includes Jurassic plesiosaurs and ichthyosaurs. This discovery extends the dinosaur fossil record of Western Canada further back into the Early Cretaceous, helping to fill in an important biogeographic and evolutionary gap. Given the age of the CF., this material constitutes the oldest known dinosaur from western Canada. Finally, this discovery underscores the importance of surveying the CF., given its extensive north-south exposures along the foothills of southwestern Alberta.

Grant Information

NSERC Discovery Grant 307756-2011 to J. Anderson; Dinosaur Research Institute Grant to M. Vavrek.

Poster Session III (Friday, October 19, 2018, 4:15 – 6:15 PM)

DINOSAUR TRACKS AT THE NEMEGT LOCALITY: PALEOBIOLOGICAL AND PALEOENVIRONMENTAL IMPLICATIONS

NAKAJIMA, Judai, Sapporo, Japan; KOBAYASHI, Yoshitsugu, Sapporo, Japan; TSOGTBAATAR, Chinzorig, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; TANAKA, Tomonori, Sapporo, Japan; TAKASAKI, Ryuji, Sapporo, Japan; KHISHIGJAV, Tsogtbaatar, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada; FIORILLO, Anthony R., Perot Museum of Nature and Science, Dallas, TX, United States of America

The Nemegt locality is one of the most famous dinosaur localities in Mongolia ever since the site was discovered in 1946. It yields abundant dinosaur skeletons; however, little attention had been given to dinosaur footprints at the locality. The only Nemegt dinosaur footprint study focused on descriptions of the footprints, gave only a few taxonomic implications, and provided no comparison with other dinosaur tracksites. This study reports newly recorded dinosaur footprints (hadrosaurs, sauropods, and theropods) at the Nemegt locality during the Nemegt Educational Expedition of 2016. A single footprint-bearing horizon that extends several kilometres was examined within the Nemegt Formation to determine the ichno-taxonomic assemblage of the Nemegt dinosaurs. A significant difference was identified between taxonomic compositions based on skeletal remains and ichnotaxonomic compositions based on footprints. Although the vast majority of the skeletal elements collected in the area belong to theropods, the footprints suggest that the Nemegt locality was dominated by herbivorous dinosaurs. This suggests that the previously inferred *Tarbosaurus* dominant taxonomic composition at the Nemegt locality is a result of a preservational bias. The size distribution of the newly studied footprints suggest that the Nemegt hadrosaurs had an adult-dominant and multigenerational population structure. Comparisons with dinosaur tracksites at the Cantwell (Alaska, U.S.A.) and Tremp (Spain) formations show that the population structure and body sizes of the Nemegt hadrosaurs were similar to those of the high-latitude Cantwell hadrosaurs. It suggests that the Nemegt area was more open and had higher plant productivity than the Tremp area.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

FUNCTIONAL MORPHOLOGY OF THE HUMERUS IN STHENURINE KANGAROOS: IMPLICATIONS FOR LOCOMOTOR MODE AND ECOLOGICAL HABITS

NAPOLI, James G., Richard Gilder Graduate School, New York, NY, United States of America; MARTÍN-SERRA, Alberto, University of Oxford, Oxford, United Kingdom; JANIS, Christine M., University of Bristol, Bristol, United Kingdom

Sthenurinae is the extinct sister taxon of Macropodinae (extant kangaroos and wallabies), clades that diverged approximately 16 Ma. Sthenurine kangaroos exhibit pronounced morphological differences from macropodines, including short, deep crania, specialized long-fingered hands, and monodactyl hind limbs. Due to this strongly divergent anatomy, it has been argued that sthenurines employed different locomotor strategies than their modern relatives, in particular that they used bipedal striding rather than pentapedal locomotion at low speeds. Prior work using 2D morphometrics to compare the morphology of the humeral head between sthenurine kangaroos and extant mammals of known locomotor strategy found sthenurines to be morphologically distinct from extant kangaroos; however, this analysis was not done in a phylogenetic context and only analyzed the shape of the outline of the humeral head, not the relative sizes of the humeral tuberosities (which may be of primary concern with regard to function). To bypass these limitations, we compared the relative sizes of the humeral tuberosities in a phylogenetic context. We measured the relative areas in 2-D perspective of the greater tuberosity, lesser tuberosity, and humeral head in 118 mammalian species, including 14 extant macropodines, two extinct macropodines, and four sthenurines. The taxa included in the dataset were sampled from throughout the therian phylogeny, and come from five broad locomotor groups (terrestrial, scansorial, arboreal, suspensory, and ricochetal). We tested for phylogenetic signal and allometric effects before using phylogenetic ANOVA to compare measurements among locomotor groups. We found that the humeral head morphology of sthenurine kangaroos was most similar to that found in arboreal and suspensory mammals, and markedly distinct from that of extant macropodines, suggesting that sthenurines used their forelimbs in a manner fundamentally distinct from their modern macropodine relatives. This supports both a previous hypothesis that sthenurines used their forelimbs for overhead browsing, and the current hypothesis that they did not use their forelimbs for weight-bearing in pentapedal locomotion.

Grant Information

Marie Curie Incoming Fellowship Award 623328 to CMJ

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

FIRST VIRTUAL CRANIAL ENDOCASTS OF THE GIANT ARMADILLO *HOLMESINA* (XENARTHRA, CINGULATA, PAMPATHERIIDAE)

NARDUCCI, Rachel E., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; HULBERT, Richard C., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America

Cingulates (armadillos, pampatheres, and glyptodonts) vary in body mass from 85 g to about 1,000 kg and have had an impressive diversity in morphology and ecology since their first appearance in the early Eocene of South America. These range from myrmecophagy and fossorial behaviors in extant taxa to inferred grazing, carnivory, and graviportal adaptations in extinct forms. The evolution of the brain in this diverse clade is not well known. In attempt to better understand the evolution of cingulate endocranial morphology, high-resolution nano-CT scans were used to create the first virtual endocranial models for *Holmesina*, a herbivorous pampathere first described from North America but now also recognized from South America. Our sample is based on three skulls of *Holmesina floridanus* (early Pleistocene, 2.1–1.7 Ma) and two skulls of *Holmesina septentrionalis* (late Pleistocene, 50–12 ka), all from Florida (U.S.A.). This *Holmesina* lineage more than doubles in size with body mass estimates taken from the literature of 92 kg for *H. floridanus* and 216 kg for *H. septentrionalis*. For comparison to other cingulates, virtual cranial endocasts were also made for a Pleistocene glyptodont (*Glyptodon* from Bolivia), 10 extinct armadillos in four genera spanning the late Oligocene of South America to the Pleistocene of Florida, and 28 extant taxa representing six genera. Results highlight the diversity of endocranial morphologies among cingulates. Olfactory bulbs are relatively large in all specimens, with variable cortical sulci and overall shape, and glyptodonts exhibit proportionally greater mass of the cerebellum than do pampatheres or armadillos. Virtual cranial endocasts of *H. septentrionalis* and *H. floridanus* most resemble each other among all sampled taxa with only minor variation. The only previously studied virtual cranial endocast of a pampathere is of *Pampatherium humboldtii* from the late Pleistocene of Uruguay. The cranial endocasts of *Pampatherium* and *Holmesina* are similar with the most notable difference being a lesser constriction of the olfactory bulb peduncle in the latter. Endocasts of *P. humboldtii* and *H. septentrionalis*, both known from the late Pleistocene with similar inferred body mass, share anterior extension of the superior sagittal sinus, as opposed to that of *H. floridanus*. An ossified cerebellar tentorium is present in extant armadillos, undetermined in *Pampatherium*and *Holmesina*, and considered absent in glyptodonts.

Grant Information

Supported by NSF EAR 0639307 (JIB, RCH), NSF DBI 1203222 (JIB, B. Macf.adden, RCH), and The Florida Paleontological Society Gary S. Morgan Student Research Award (REN)

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

RECOVERY AND CURATION OF A CRITICALLY IMPORTANT LATE MIOCENE FOSSIL DEPOSIT IN NORTH-CENTRAL FLORIDA: A RARE OPPORTUNITY FOR CITIZEN SCIENCE AND PUBLIC EDUCATION

NARDUCCI, Rachel E., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; HULBERT, Richard C., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; MACF.ADDEN, Bruce J., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; BOURQUE, Jason R., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; POYER, Arthur R., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; PIRLO, Jeanette, University of Florida, Gainesville, FL, United States of America; VITEK, Natasha S., University of Florida, Gainesville, FL, United States of America; GRANT, Claudia A., University of Florida, Gainesville, FL, United States of America; ZIEGLER, Michael J., University of Florida, Gainesville, FL, United States of America

The Montbrook fossil site (MFS) was discovered in 2015 by private property owners in a shallow pit excavated as part of a sand-mining operation in Levy County, Florida. Since then, the Florida Museum of Natural History (FLMNH) has recovered >30K identifiable vertebrate fossils from the MFS, making it one of the largest vertebrate site collections in Florida. Over 85 taxa are known and biochronology places it in the late Hemphillian, ca. 5 Ma. To date, the FLMNH has excavated at the MFS for 430 days. A typical daily field crew consists of 1–2 FLMNH personnel, 1–2 UF VP graduate students, and 8–15 public volunteers and UF undergraduates. Over 700 citizen scientists have worked at the site,

contributing ~12,000 person-hours of labor. Most live within a 50-mile radius of the site, but about 10% traveled over 100 miles. New participants were recruited through FLMNH and FOSSIL project websites and blogs, local news outlets, presentations at surrounding community events, and fossil fairs. A private Facebook forum is used to communicate, share images of new fossil discoveries (some uploaded minutes after they are found), and provide updates from the VP collection and prep lab. Many of the scientifically most valuable fossils from the MFS were found by citizen scientists, including bones of an early swan, a skull of a smilodontin felid, and dentaries of a borophagine canid and an otter. Students and volunteers prepared Montbrook fossils in a public lab as part of the Florida Museum's 100-year Anniversary Exhibition in November 2017. A public exhibit on the MFS highlighting the finds of the volunteers will open at the FLMNH during the summer of 2018. To bring the MFS specimens back to their roots and broaden representation of museum-goers, a 'pop-up' exhibit manned by FLMNH personnel is planned for Levy County's most attended community event, the 30th Annual Peanut Festival, in Williston, the closest town to the MFS. Over 10 high school students, who wish to pursue a career in paleontology, have volunteered at the site along with one or both of their parents, gaining hands-on experience in real field work. Excavations at MFS have also been used for a variety of education levels. This includes elementary school groups, a youth fossil club run by local high school teachers, college students for course credit, and training K–12 educators associated with the GABI-RET project. This recovery effort therefore promotes public participation in scientific research while also advancing learning about paleontology in both formal and informal settings.

Grant Information
Supported by NSF EAR 1645530 (JIB, BJM, D. Steadman, RCH), NSF DBI 1756306 (JIB, BJM, D. Steadman, RCH, D. Blackburn), and a grant from The Felburn Foundation (JIB)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

PRELIMINARY OSTEOLOGICAL EVIDENCE FOR SECONDARY LOSS OF A TYMPANIC MEMBRANE IN MULTIPLE CLADES OF ORNITHISCHIAN DINOSAURS

NASSIF, James P., Ohio University, Athens, OH, United States of America; WITMER, Lawrence M., Ohio University, Athens, OH, United States of America; RIDGELY, Ryan C., Ohio University, Athens, OH, United States of America

The middle ear is thought to have evolved to decrease the loss of energy as sound waves are conducted from the environment to the inner ear. In living diapsids, a single rod-like ossicle (the columella) typically connects to a tympanic membrane (eardrum) by cartilage. Birds and nonavian dinosaurs present the opportunity to explore the ear across diverse ecologies and sizes. Cadaveric specimens representing a diverse sample of birds, crocodilians, and lepidosaurs were µCT scanned, and ear structures including columellae were digitally reconstructed using Avizo. Specimens also were dissected to visualize the anatomy and to validate CT-based interpretations. Fossil specimens were also scanned and photographed. These data were integrated to identify tentative osteological correlates including the rostrodorsal attachments of the tympanic membrane and grooves for the stapedial artery and branches of the facial nerve. These correlates were compared to the osteology of extinct taxa, consistent with established methods of phylogenetic bracketing. The soft tissue middle-ear structures of fossil specimens were modeled using these and other well-established osteological correlates in Maya. Multiple representative ankylosaurian and neoceratopsian species show morphologies that may be consistent with atympanic middle ears (i.e., loss of the eardrum), including dorsal expansion of the paraquadrate foramen and absence of a distinct periotic crest present on the quadrate in more basal taxa. Digital reconstruction of the muscles delimiting the otic region indirectly supports this hypothesis by constraining the maximum size of a hypothetical tympanum. In contrast, strong osteological correlates for the tympanic membrane are preserved in ornithopodan and pachycephalosaurian species. Though the tympanic membrane has been independently lost in many clades of lepidosaurs and anurans, these independent losses in Ornithischia represent the first evidence of this modification of the sound-conduction system in dinosaurs. These modifications are not strongly correlated with absolute head size but appear contemporaneously with the evolution and elaboration of cranial ornamentation (i.e., the dermal ossifications of ankylosaurs and the frills of neoceratopsians), as well as lateral expansion of the skull. Ecological and functional consequences of these morphologies require additional investigation.

Grant Information
Supported by US National Science Foundation Grants (IOB-0517257, IOS-1050154, IOS-1456503, DGE-1645419)

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

COULD PTEROSAURS BITE HARD? A STUDY THROUGH FINITE ELEMENT ANALYSIS OF *PREJANOPTERUS CURVIROSTRIS* AS A POSSIBLE DUROPHAGOUS ANIMAL

NAVARRO-LORBÉS, Pablo, University of La Rioja, Logroño, Spain; TORICES, Angelica, University of La Rioja, Madrid, Spain; LOSTADO-LORZA, Rubén, University of La Rioja, Logroño, Spain; CID, Rodrigo, University of La Rioja, Logroño, Spain; SAN JUAN-PALACIOS, Raúl, University of Valencia, Valencia, Spain

As the first vertebrates able to conquer the air in life's history, pterosaurs adapted to several lifestyles and feeding strategies. The morphological characteristics of their skull and mandible, as well as the more developed external adductors over the internal, could have limited their bite strength. Bite strength could have been sacrificed in order to increase the speed of closing their jaws, a strategy documented in extant birds. However, some groups or species may be an exception to this general condition.

The Iberian pterosaur from La Rioja, *Prejanopterus curvirostris,* has been proposed as a durophagous organism due to the combination of several features of its rostrum. This still enigmatic taxon has been identified as a member of the family Pterodactylidae. Nevertheless, some authors have suggested that *P. curvirostris* could belong to the controversial family Lonchodectidae, since it shares some diagnostic features proposed for this group. These features include: low jaw profile, raised and regularly spaced tooth sockets, uniform small teeth with constricted bases and presence of ridges and grooves in the midline of the upper and lower biting surfaces.

The fragmentary rostrum of *P. curvirostris* has been analysed with micro-CT scanning, in order to see its inner structure and generate 3D models to test its strength with Finite Element Analysis (FEA). The results of micro-CT scan show a hollow rostrum, subtriangular in cross-section with regular spaced and deep sockets. The inner structure of the rostrum shows a canal in the ventral part of the inner cavity that could be the maxillary canal. The most interesting feature revealed by micro-CT scan is the presence of almost regularly spaced, dorsoventrally oriented bony columns. These structures may be thickened trabeculae that allowed the light structure of the rostrum to resist considerable bite forces. To test the function and behaviour of these columns, a 3D model was generated from the micro-CT scans and analysed with the finite element method (FEM). A previous destructive test was performed with two types of extant molluscs (genera *Cerastoderma* and *Mytilus*), obtaining a maximum force of 23 Kg to break a shell. When this force is applied to the model, columns support a considerable amount of stress (in the order of 15 MPa), giving structural stiffness to the rostrum. Furthermore, results show that rostrum and teeth are never subjected to stresses exceeding their breakage indexes. The results of the internal anatomy study and FEA would support the hypothesis that this taxon had a durophagous way of living.

Technical Session III (Wednesday, October 17, 2018, 3:15 PM)

A NEW PLATANISTOID (CETACEA, ODONTOCETI) AND ITS PLACE IN THE EVOLUTION OF THE SQUALODELPHINIDAE AND THE PLATANISTIDAE

NELSON, Margot D., George Mason University, Fairfax, VA, United States of America; UHEN, Mark D., George Mason University, Fairfax, VA, United States of America

The Platanistoidea is an enigmatic superfamily of early diverging crown odontocetes. While they were highly diverse in the Oligocene to middle Miocene, in modern times the Ganges River dolphin, *Platanista gangetica*, is the sole representative of this diverse clade. As some of the earliest crown odontocetes, understanding their distribution, morphology, and phylogeny is critical to understanding the radiation of toothed whales in the early Miocene. Here we present a new platanistoid from the late Oligocene–early Miocene Nye Mudstone of Oregon. USNM 335224 is a nearly complete skull with associated left periotic and right tympanic bulla. This specimen has an articular rim on the lateral side of the periotic, a synapomorphy that unites the Platanistoidea. When added into previous cladistics analyses of the Platanistoidea and of the Odontoceti, USNM 335224 is a platanistoid that is the sister taxon to the clade Squalodelphinidae + Platanistidae, the first known specimen to be a possible intermediate between more basal platanistoids, such as the Waipatiidae and the Squalodontidae, and the more derived groups, the Squalodelphinidae and the Platanistidae. However, other traits of the skull resemble those of the Eurhinodelphinidae, suggesting that this other early odontocete family may be closer allied to the Platanistoidea than previously thought. The novel combination of traits in USNM 335224, and its phylogenetic position, lead us to consider USNM 335224 as a new genus and species of platanistoid. Furthermore, the Nye Mudstone's age, straddling the Oligocene–Miocene boundary, has the potential to place USNM 335224 as one of the earliest derived platanistoids.

Technical Session I (Wednesday, October 17, 2018, 8:15 AM)

PREVALENT ONTOGENETIC CHANGES CHARACTERIZE EARLY DINOSAURS AND THEIR CLOSEST RELATIVES: IMPLICATIONS FOR SPECIES IDENTIFICATION, PHYLOGENY, AND THE LOSS OF THESE CHANGES IN LATER DINOSAURS

NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; GRIFFIN, Christopher, Virginia Tech, Blacksburg, VA, United States of America; EVANS, Elizabeth, Virginia Tech, Blacksburg, VA, United States of America; MUELLER, Rodrigo T., CAPPA, Santa Maria, Brazil; PACHECO, Cristian, CAPPA, Santa Maria, Brazil; PRETO, Flavio, CAPPA, Santa Maria, Brazil; CABREIRA, Sérgio F., Museu de Ciencias Naturais, Universidade Luterana do Brasil, Canoas, Brazil; MARSH, Adam, Petrified Forest National Park, Holbrook, AZ, United States of America; WYND, Brenen M., Virginia Tech, Blacksburg, VA, United States of America; LANGER, Max, Universidade de Sao Paulo, Ribeirao Preto, Ribeirao Preto, Brazil

New discoveries of well-preserved early dinosaur skeletons have revolutionized insights into their paleobiology, diversity, and character evolution, but have also ignited debate about the relationships of major dinosaur lineages. With a growing sample of early dinosaurs and increasing evidence that early dinosaurs and their closest relatives had many skeletal changes throughout ontogeny, we critically examined ontogenetic variation in Dinosauria and their immediate outgroups. We identified ontogenetically variable character states within the postcrania of single species in non-dinosaurian dinosauromorphs (e.g., *Asilisaurus*), sauropodomorphs (e.g., *Buriolestes*), ornithischians (e.g., *Heterodontosaurus*), phylogenetically ambiguous taxa (e.g., *Tawa*), and neotheropods (e.g., *Coelophysis*). From these variable character states that were scored across taxa, we implemented a new method of examining ontogenetic morphospace (using non-metric multidimensional scaling) combined with body size (i.e., femoral length) to estimate intra- and interspecific ontogenetic trajectories. A similar 'ontogenetic path' is recovered in most early dinosaurs and their relatives, extending from smaller individuals with immature ontogenetic character states to larger individuals with more mature ontogenetic character states, although the sequence of character state transitions may be variable. These trajectories also aid in identifying ontogenetic stages of early dinosaurs represented by a single specimen. Importantly, most early ornithischians, tetanuran theropods, and massopodan sauropodomorphs do not follow the common 'ontogenetic path' of early dinosaurs and their close relatives. In these taxa, the character states that appear later in ontogeny in early dinosaurs are absent, and there are comparatively fewer ontogenetically variable characters throughout growth. These results have a number of novel paleobiological implications including: 1) ontogenetically variable characters states should not be used to differentiate early dinosaur species; 2) early dinosaurs and their close relatives grew differently from other reptiles and later dinosaurs; 3) multiple dinosaur lineages lost many ontogenetic state changes. independently and retain less mature character states of early dinosaurs. In constraining the ontogenetic pathways and the

phylogeny branches through which these characters are variable, we provide a testable way to assess phylogenetic characters for estimating the relationships of early dinosaurs.
Grant Information
NSF EAR 1337291; NSF EAR 1349667

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

A NEW MIDDLE PALEOCENE MAMMALIAN FAUNA FROM THE FORT UNION FORMATION, GREAT DIVIDE BASIN, WYOMING

NEU-YAGLE, Nicole, University of Colorado - Boulder, Boulder, CO, United States of America; EBERLE, Jaelyn J., University of Colorado Boulder, Boulder, CO, United States of America

Middle Paleocene mammalian faunas are documented throughout the North American Western Interior. Faunas near, or spanning, the Torrejonian–Tiffanian transition have been reported by others from Wyoming's Hanna, Carbon, and Bighorn basins and are important for assessing this transition period, which has many overlapping mammalian occurrences. Here, we report a late Torrejonian (To3) mammalian fauna from the upper China Butte Member of the Fort Union Formation in Wyoming's Great Divide Basin (GDB). The GDB assemblage is comprised of isolated mammal teeth, collected primarily from anthill localities, and is a representation of some of the smallest members of the fauna due to the selection bias of their insect gatherers. The To3 assemblage from the GDB is comprised of at least 12 mammalian species in seven orders, identified primarily by comparison with specimens and casts from multiple institutions as well as the literature. Faunal affinities with Swain Quarry in the Washakie Basin suggest that these two assemblages are temporally correlative, corroborating stratigraphic relationships hypothesized by others. The marsupial, *Swaindelphys cifelli*, previously documented only from Swain Quarry, is found in the late Torrejonian assemblage in the GDB. Occurring taxa with wider ranges (both temporal and geographic), such as the large multituberculate *Ptilodus mediaevus*, show particular morphologic resemblance to the fossils from Swain Quarry. In the GDB assemblage, there are teeth of multiple small neoplagiaulacids, including *Krauseia clemensi*, which also occurs at Swain Quarry. Our analysis agrees that *Mixodectes malaris* is present in To3 localities in south-central Wyoming, although it is more abundant in To2, and is not documented from the Tiffanian. The known temporal ranges of many taxa identified from this assemblage, such as the carnivore *Simpsonictis tenuis*, the cimolestid *Gelastops parcus*, the 'condylarth' *Haplaletes disceptatrix*, and paromomyoids *Paromomys maturus* and *Plesiolestes problematicus*, suggest that the GDB faunal assemblage cannot be older than To3. The absence of characteristic taxa of the Tiffanian, such as members of the Plesiadapoidea, suggest that the GDB faunal assemblage is of late Torrejonian age. Our report is the first of this age to be described from the GDB and is important for furthering our understanding of North American mammalian diversity and evolution during the middle Paleocene.

Grant Information
Research made possible by funding from the CU Museum of Natural History (UCM) and a grant from WIPS. Fieldwork supported by a grant to JE from the David B. Jones Foundation.

Podium Symposium (Friday, October 19, 2018, 8:15 AM)

MICRO-FEATURES AND MEGA-DATA: A CASE STUDY FOR EXPLORING LIFE ON THE SMALL SIDE AT THE SYNCHROTRON

NEWHAM, Elis, University of Southampton, Southampton, England; CORFE, Ian J., University of Helsinki, Helsinki, Finland; GILL, Pamela, University of Bristol, Bristol, England; SCHNEIDER, Philipp, University of Southampton, Southampton, United Kingdom; ROBSON BROWN, Kate, University of Bristol, Bristol, United Kingdom; BREWER, Pip, Natural History Museum London, London, United Kingdom

All mammalian mineralised dental tissues deposit growth layer groups (GLGs) that record their growth and development. Cementum is unique as growth is continuous through life, and its GLGs are circum-annual in nature. Each year, one thick hypomineralised band is formed during seasons preferable for growth, and one thin hypermineralised band formed during seasons of restricted growth. Counts of GLGs have been used to estimate lifespan in 70+ extant mammal taxa. However, their use has been limited for fossil mammals due to the destructive nature of traditional histological methods.

We have used synchrotron radiation computed tomography (SRCT) to non-destructively analyse cementum GLGs in a range of fossil and extant mammals, from early mammaliaforms to archaeological humans. High levels of coherency and flux of synchrotron X-ray beams and phase contrast information provide SRCT imaging with comparable image quality to thin-sections and overcome several caveats of histological imaging. SRCT imaging is, however, sensitive to a number of factors originating from the physical laws governing the interaction of X-rays with samples. Evaluation of a series of experimental parameters before, during, and after scanning suggests that SRCT micro-feature image quality is highly dependent on these parameters. Experimentation and understanding of the effects of these settings on the desired data, before acquiring primary SRCT scans, is key to successful imaging.

SRCT systems also provide un-paralleled throughput speed, scanning at sub-micron resolutions in 2 minute samples that would take 20+ hours with lab CT. Although most synchrotron studies deal with individual or low numbers of specimens, our studies and others with population sized or broad macroevolutionary samples will require orders of magnitude more specimens and scans. Since tens-to-hundreds of gigabytes of SRCT data is generated per minute, resulting datasets are tens of terabytes in size, providing a unique challenge for data storage and analysis.

We, therefore, generated a protocol for processing SRCT data to isolate cementum, reduce file sizes and maximise GLG contrast using straightening, binarisation, and steerable filtering. We further developed and validated quantitative analyses to count GLGs, and isolate and compare aspects of their structure. We present this workflow as a case study for future SRCT imaging of micro-features and analyses of SRCT data, in order to optimise the efficiency and quality of imaging, storage, and processing of data and robusticity of analyses.

Grant Information
Natural Environmental Research Council U.K. studentship, Engineering and Physical Sciences Research Council U.K. studentship

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

MIOCENE GEOGRAPHIC VARIATION OF BIOMES IN NORTH AMERICA FROM STABLE ISOTOPES IN LARGE HERBIVORES

NGUY, Willow, University of Nebraska Lincoln, Lincoln, NE, United States of America; SECORD, Ross, University of Nebraska Lincoln, Lincoln, NE, United States of America

During the Miocene, North America experienced many biotic and abiotic changes. Environments experienced increasing aridity and a long-term cooling trend with a peak in temperature during the Middle Miocene Climatic Optimum. Combined climatic forcing and environmental feedbacks fundamentally changed regional terrestrial biomes to open canopy biomes. Towards the end of the Miocene, plants utilizing C_4 photosynthesis increased greatly in biomass. In addition to changes in vegetation, North America saw a large peak in ungulate browser diversity in the middle Miocene followed by a slow decline. To examine how these changes in biomes varied throughout the Miocene across North America, we use stable carbon isotopes from fossil mammals. Stable carbon isotopes in C_3 dominated environments reflect water availability and vegetation density, and herbivores that consume vegetation from those environments record dietary values in their tissues with predictable offsets. We conducted a meta-analysis using published herbivore enamel carbon isotope values to recreate representative communities from the Coastal Southeast U.S.A., Great Plains, Northwest U.S.A., Southwest U.S.A., and Central America throughout the Miocene. To interpret regional paleoenvironments, we use a predictive model based on $\delta^{13}C$ values in modern C_3 dominated biomes. The model adjusts for difference between modern atmospheric $\delta^{13}C$ values and Miocene values, for latitudinal and altitudinal differences in $\delta^{13}C$ plant values normalized to a central datum, and for diet-to-enamel $\delta^{13}C$ enrichment in ungulates.

Results show that regional mean $\delta^{13}C$ faunal values from the Great Plains and Western U.S.A. plot above modeled closed canopy values. This is consistent with previous interpretations of fairly open biomes being present by the early Miocene. The Southeast region showed a trend towards more positive carbon isotopes approaching the Pliocene, but this is likely due to incorporation of C_4 grasses into diets rather than a change in openness. Comparisons between regions indicate that the timing of changes in vegetation density differed between coastal and intercontinental regions. Miocene habitats were likely more homogeneously open in the Great Plains and Western US than in the coastal Southeast. Overall, the opening of habitats and change in vegetation density in the Miocene of North America was not a synchronous progression of events.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

NEW ORNITHOMIMID MATERIAL FROM THE DINOSAUR PARK FORMATION OF ALBERTA, CANADA, REVEALS THE PRESENCE OF TWO LARGE ORNITHOMIMOSAUR TAXA DURING THE LATE CAMPANIAN IN NORTH AMERICA

NOTTRODT, Rachel E., University of Calgary, Calgary, AB, Canada, T2N 1N4; THERRIEN, Francois, Royal Tyrrell Museum of Paleontology, Drumheller, AB, Canada; ZELENITSKY, Darla K., University of Calgary, Calgary, AB, Canada; KOBAYASHI, Yoshitsugu, Hokkaido University Museum, Hokkaido, Japan

Large (>4m long) ornithomimosaurs are well known from the Cretaceous (Aptian–Maastrichtian) of Asia but remain poorly understood in North America, where they are primarily represented by undescribed partial skeletons from upper Maastrichtian formations of the northern Great Plains. Isolated skeletal elements from the Dinosaur Park Formation (DPF) of Alberta, Canada, have been previously attributed to large ornithomimosaurs, alluding to their presence in North America during the late Campanian. However, the scarcity and highly fragmentary nature of the material precludes precise taxonomic identification and accurate determination of the number of large taxa represented. Two large ornithomimosaur pedal unguals recently recovered from the DPF differ from a previously identified large ornithomimosaur ungual in being straight and lacking a prominent flexor tubercle ridge within a deep flexor fossa, suggesting the presence of a new taxon. The new pedal unguals, with an estimated length exceeding 10 cm, are ascribed to Ornithomimidae based on their elongate, narrow, and straight shape, a shallow, weakly ginglymous proximal articular facet, deep keratin grooves, and a distinct arrowhead-shaped ventral surface. They can be further differentiated from unguals of the contemporaneous ornithomimids *Ornithomimus* and *Struthiomimus* based on the presence of deep medial and lateral flexor fossae separated by a central hourglass-shaped ridge, with numerous elongate foramina located distally. Also, some previously collected pedal unguals of typical ornithomimid size display the same diagnostic characters as the large unguals and indicate that this taxon is distinct and does not represent pathologic or exceptionally large individuals of a previously known ornithomimid species. These fossils reveal that a very large ornithomimid co-existed with typical-sized ornithomimids and another large ornithomimosaur during the late Campanian in North America. Given the known taphonomic size bias favoring the preservation of large taxa in the DPF, the perplexing paucity of large ornithomimid material known from this formation could indicate that these animals constituted only a small portion of the DPF dinosaur assemblage.

Grant Information
This work was supported by a NSERC Postgraduate Scholarship-Doctoral and RTMP Cooperating Society Student Research Grant to REN, and a NSERC Discovery Grant to DKZ.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

THE CONVERGENCE CONUNDRUM: ADDRESSING MORPHOLOGICAL CONVERGENCE IN THE FAMILY TALPIDAE

OBERG, Danielle, East Tennessee State University, Johnson City, TN, United States of America; SAMUELS, Joshua X., East Tennessee State University, Johnson City, TN, United States of America

Morphological convergence due to ecological specialization has made taxonomic identifications and understanding evolutionary relationships in talpids a challenge. Previous phylogenetic analyses using large data sets and complete taxon sampling have shown large discrepancies between molecular and morphological cladograms, making the placement of fossil taxa highly questionable. Due to its robustness and distinctive morphology, the humerus has been the primary osteological element used to diagnose fossil talpid species and study their relationships. Here, we performed a 2D geometric morphometric analysis of humerus shape in talpids using 24 landmarks digitized onto 135 individuals from 47 extant and extinct species. Relative warp and canonical variates analyses show that humerus shape strongly reflects locomotor ecology in extant talpids, highlighting convergence among highly fossorial clades, and also allows ecological inferences for fossil talpids.

A hierarchical cluster analysis, using the UPGMA clustering method with squared Euclidian distance, was conducted with a reduced set of morphometric data to examine morphological similarity among taxa. The resulting phenogram showed strong similarity to the most up-to-date molecular cladogram and actually matched phylogenetic relationships substantially better than any morphological cladistic analyses to date. All six extant tribes were represented in the cluster analysis phenograms, all of the 'shrew mole' groups (Scaptonychini, Urotrichini, and Neurotrichini) clustered together, and there was some separation between the tribes Talpini and Scalopini. Additionally, the cluster analysis provides new information about the placement of fossil taxa and which parts of the tree still need better resolution.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

EARLY PLEISTOCENE GRASSLAND DYNAMICS AT EAST TURKANA: SPATIOTEMPORAL PATTERNS OF MESIC- AND XERIC-ADAPTED UNGULATES AND NEW INSIGHTS INTO NICHE PREFERENCES OF *EURYGNATHOHIPPUS* AND *KOLPOCHOERUS*

O'BRIEN, Kaedan, University of Utah, Cadott, WI, United States of America; ALLEN, Kayla, Georgia College and State University, Milledgeville, GA, United States of America; BIERNAT, Maryse, Arizona State University, Tempe, AZ, United States of America; BRAUN, David R., The George Washington University, University of Cape Town, Max Planck Instit. for Evol. Anthropology, Washington, DC, United States of America; GUERRERO, Amanda "Billie", University of La Verne, La Verne, CA, United States of America; MCGROSKY, Amanda, Arizona State University, Tempe, AZ, United States of America; PATTERSON, David B., University of North Georgia, The George Washington University, Dahlonega, GA, United States of America; TORRES, Felipe, Universidad Austral de Chile, Valdivia, Chile; FAITH, J. Tyler, University of Utah, Salt Lake City, UT, United States of America

Sediments of the Upper Burgi (1.98–1.87 Ma), KBS (1.87–1.54 Ma), and Okote (1.54–1.38 Ma) members of the Koobi Fora Formation in northern Kenya (East Turkana) are perhaps best known for their extensive hominin fossil record. However, the complex dynamics of the ecosystems inhabited by these hominins remain somewhat unclear. To investigate paleolandscape dynamics at East Turkana during this period, we examine spatial and temporal change in the relative proportions of xeric- and mesic-adapted grazing ungulate taxa from a sample of approximately 2,600 specimens. We find that the Karari subregion at East Turkana experienced significant faunal turnover during this period, in particular between the Upper Burgi and KBS members. This turnover may be the result of aridification during the recession of Lake Lorenyang, as the dominant mesic-adapted taxa, such as bovids of the tribe Reduncini, were replaced with xeric-adapted taxa including Alcelaphini, *Equus*, and *Metridiochoerus*. Furthermore, we find that the suid genus *Kolpochoerus* tracks the abundance pattern of Reduncini, supporting existing assertions that these suids were mesic-adapted in the Turkana Basin. Similar patterns are evident in the relative abundance of the equid species *Eurygnathohippus cornelianus*, which notably differs morphologically from earlier members of its genus. Further analyses are needed to understand the relationships between relative abundance of ecologically diverse grassland taxa and the evolution of ecomorphological characteristics such as hypsodonty in these grazing taxa. Additionally, these findings may be applied to current paleoanthropological studies of niche partitioning and behavioral ecology of early *Homo* if corresponding spatial patterns can be found in the hominin lineage.

Technical Session VII (Thursday, October 18, 2018, 3:15 PM)

A SPECIMEN OF *ARCHAEORHYNCHUS* PRESERVING SIGNIFICANT SOFT TISSUE INCLUDING THE FIRST PROBABLE OCCURRENCE OF FOSSILIZED LUNGS

O'CONNOR, Jingmai, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; MAINA, John, Johannesburg, South Africa; PAN, Yanhong, Nanjing, China; WANG, Min, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; WANG, Xiaoli, Linyi University, Lingyi, China; WANG, Yan, Linyi University, Lingyi, China; ZHENG, Xiaoting, Linyi University, Lingyi, China; ZHOU, Zhonghe, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

We describe a new specimen of the basal ornithuromorph *Archaeorhynchus spathula* from the Lower Cretaceous Jiufotang Formation with extensive soft tissue preservation. Although it is the fifth specimen to be described, it is the first to preserve significant traces of the plumage, revealing a pin-tail morphology previously unrecognized among Mesozoic birds but common in extant neornithines. In addition, this specimen preserves the probable remnants of the paired lungs, an identification supported by topographical and macro- and microscopic anatomical observations. The preserved morphology reveals a lung very similar to that of living birds. It indicates that pulmonary specializations such as exceedingly subdivided parenchyma that allow birds to achieve the oxygen acquisition capacity necessary to support powered flight were present in ornithuromorph birds 128 Ma. This is the first documented occurrence of preserved lung soft tissue in a fossilvertebrate. Among extant air breathing vertebrates, birds have structurally the most complex and functionally the most efficient respiratory system, which facilitates their highly energetically demanding form of locomotion even in extremely oxygen poor environments. *Archaeorhynchus* is commonly resolved as the most basal known ornithuromorph bird, capturing a stage of avian evolution in which skeletal indicators of respiration remain primitive yet the lung microstructure appears modern. This adds to growing evidence that many physiological modifications of soft tissue systems (e.g., digestive system and respiratory system) that characterize living birds and are key to their current success may have preceded the evolution of obvious skeletal adaptations traditionally tracked through the fossil record.

Grant Information
National Natural Science Foundation of China (41688103, 41472023, 41372014, 41402017)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

POPULATION STRUCTURE OF FOSSIL CYPRINIDS FROM HUATEPEC, A SITE AT THE NORTHEAST BASIN OF MEXICO

OLLINGER, Kimberley G., Instituto Nacional de Antropología e Historia, Ciudad de México, Mexico; GUZMÁN, Ana F., Instituto Nacional de Antropología e Historia e Instituto Politécnico Nacional, México, Mexico

Huatepec Hill is located in the Northeast Basin of Mexico, near to other Pleistocene sites of interest such as Santa Isabel Ixtapan, Tepexpan, and Tocuila. In Huatepec, fish remains are abundant. Our aim is to analyze the population structure (mortality profiles and survivorship curves) of Cyprinidae cf. *Algansea,* based on the most abundant bone: the cleithrum. Cleithrum abundance was higher at the middle of the stratigraphic column (a basaltic black layer of sand and ashes probably referred to the GBA or Tláhuac Tephra found in other sites of the Basin of Mexico, supposed fallen between 26,000 and 33,500 yrs BP), with 63 left elements recovered above the upper limit of this layer and 33 left elements below it (counting only the most abundant anatomic side in each stratigraphic layer). Cleithra were measured to 0.01 mm and boxplots (raw data) and size frequencies histograms (raw data and specimen estimated sizes based on *Algansea* modern material) were constructed. The size of the fossils ranged from 83.8 to 239 mm SL (?=174.7); four cleithra were fussed to the scapula and coracoid, an age-related pathology (specimen estimated sizes: 172–188 mm SL). In both layers, survivorship curves are type III (corresponding to fishes without parental care), and mortality profiles have an attritional structure (numerous large-sized individuals). Both assemblages display natural and stable populations, with old individuals dying from natural causes, although the great volcanic activity characteristic of Tláhuac Tephra could accelerate this process and affect the most vulnerable size classes. We suggest to explore new sites near the locality with the same approach to discern if it exist a bias related to spatial and temporal variation within the population or the patterns supports our observations.

Technical Session XIX (Saturday, October 20, 2018, 3:30 PM)

ALLOMETRY OF BONY SOUND RECEPTION STRUCTURES: CHAMELEONS AS A POTENTIAL FUNCTIONAL ANALOG FOR HEARING ABILITY IN NON-MAMMALIAN THERAPSIDS

OLROYD, Savannah L., University of Washington, Seattle, WA, United States of America; SIDOR, Christian A., University of Washington, Seattle, WA, United States of America

The evolution of the mammalian middle ear bones is documented by a rich fossil record. However, the functional role of the postdentary bones in non-mammalian therapsid hearing is still uncertain, precluding a full understanding of the selective pressures that drove this evolutionary change. The current leading hypothesis for the hearing abilities of non-mammalian therapsids is that they used their reflected laminae, the homolog of the ectotympanic bone of mammals, to capture airborne sound vibrations and transmit them to the articular, quadrate, stapes, and ultimately to the fenestra ovalis. Assessing function in extinct vertebrates is difficult, so we aim to test the function of the reflected lamina through comparison with a modern analog: the pterygoid plate of chameleons. Experimental studies have shown that some chameleon species have co-opted this structure to receive airborne sound, while other chameleons have not. This study system provides a uniqueopportunity to develop morphological proxies that indicate a sound reception function for bony structures. One aspect of pterygoid plate morphology that might be suspected to correlate with hearing is its allometry with skull size. Sensory structures tend to exhibit negative allometry because the optimal size for performing a sensory function generally does not increase with body size. If this is true for bony sound reception structures, then chameleons that use their pterygoid plate for hearing should have more negative allometry of this bone than do the ‘non-hearing’ (i.e., cannot hear airborne sound) species. We photographed an ontogenetic series of skulls for 'hearing' and ‘non-hearing’ chameleon species, and the basal skull length and pterygoid plate area were measured in ImageJ. These data were fit to an allometric growth equation. Preliminary results from three species indicate that 'hearing' chameleons have a more positive coefficient of allometry than ‘non-hearing’ ones do. This surprising result could be attributed to the small body size of the chameleons studied, as they may be too small for their pterygoid plate to reach an optimal size for sound reception. The 'hearing' species may prioritize growth of the pterygoid plate in order to approach its optimal size. If this is true, then differential allometry may be informative in assessing the function of the reflected lamina in very small therapsids.

Grant Information
University of Washington Richard C. Snyder Award

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

PHYLOGENETIC INCLUSIVITY OF *CHUBUTOPHIS* (SERPENTES, BOIDAE) WITH THE REPORT OF A NEW SPECIES FROM THE LATE MIOCENE OF BRAZIL

ONARY, Silvio, Universidade de São Paulo, Ribeirão Preto, Brazil; HSIOU, Annie S., Ribeirão Preto, São Paulo, Brazil

The South American Paleogene has yielded records of gigantic extinct snakes, such as madtsoiids, the remarkable boid *Titanoboa cerrejonensis*, and the early to middle Eocene

Chubutophis. Nevertheless, usually only isolated vertebral records were recovered, with their biological affinities suggested only by the overall vertebral similarities with no detailed phylogenetic analysis. Here we present a new phylogenetic hypothesis, which was conducted to investigate the inclusivity of the extinct genus *Chubutophis* within Booidea. The new data matrix is comprised of 261 morphological characters across 21 booid snake taxa, including the type species *Chubutophis grandis* and the new specimen from the late Miocene of Solimões Formation, Brazil. Preliminary results show that the new specimen is within Boidae in a sister group relationship with the Argentinean taxon, together being the sister group to the extant *Boa constrictor*. Alpha taxonomical analysis supports this interpretation as *Chubutophis* shares with *Boa* the following combination of exclusively vertebral features: lacriform neural spine morphology in cross section; strongly oriented articular facets of the zygosphene (~30°) above the horizontal plane; zygosphene roof with a strongly V-shaped notch; and the synapomorphic presence of well-developed paracotylar foramina on deep paracotylar fossae. Additionally, the Brazilian fossil can be considered a new species due to the subtriangular morphology of the centrum together with a considerable lower neural spine. The presence of *Chubutophis* in the Brazilian proto-Amazonia supports the interpretation of a paleoenvironment composed by great concentration of arboreal elements together with the presence of permanent body of water. This record sheds light on boid evolution in South America, and also significantly expands the range of occurrence of the genus by ~30 Ma.

Grant Information
Fundação de Amparo à Pesquisa do Estado de São Paulo, FAPESP, Brazil, Ph.D. fellowship for SO

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE HISTOLOGICAL ONTOGENY OF ORNAMENTED ADOCUSIANS AND TRIONYCHIDS FROM THE UPPER CRETACEOUS (CAMPANIAN) KAIPAROWITS FORMATION OF UTAH

ONG, Nathan S., University of Utah, Salt Lake City, UT, United States of America; IRMIS, Randall, University of Utah, Salt Lake City, UT, United States of America; LEVITT-BUSSIAN, Carolyn G., Bountiful, UT, United States of America

We here describe the histological variance of four genera from the Upper Cretaceous (Campanian) Kaiparowits Formation of southern Utah, U.S.A. Twenty-seven slides were produced from multiple ontogenetic stages to understand how and why shell growth varies on a histological level. While an emphasis is placed on diagnostic surficial ornamentation, bulk histological anatomy is also described herein and contextualized within a broader ecological and phylogenetic framework.

Consistent with previous studies, relative zone thickness is ecologically derived. Terrestrial turtles like *Basilemys* exhibit relatively thick and avascular cortices, while aquatic and semiaquatic genera exhibit thin, vascularized cortices. Vascularization patterns in all genera support a standard reptilian growth model. Ornamentation is also an ontogenetically derived feature, with mature specimens exhibiting increasingly defined ornamental morphologies in all genera.

Two mechanisms of ornament deposition are proposed that fall along higher taxonomic classification. Trionychids rapidly deposit a basal layer, then continue laminar deposition at an asymptotic rate. Adocusians erode the external surface of the previous ornamentation and laminarily deposit derived ornamentation a top it. As a result, resorption lines are present in genera where lateral migration exceeds radial growth. While collected histological data provides no definitive ornamental function, the depth and orientation of Sharpey's fibers and primary vascularization suggest mechanical and exogenic influences respectively.

The trionychid plywood-like structure expands externally, with additional layers being added along the distal margins of the shell. Although biomechanical testing is needed, we hypothesize that the structure distally thickens in response to mechanical stress inflicted upon the shell. The adocusian Lower External Cortex consists of a dense mat of secondary osteons, which we hypothesize to serve a similar function to that of the trionychid plywood-like structure.

The medullary cavity and internal cortex are taxonomically consistent relative to the external cortex. All genera exhibit externally expanding medullary cavities with canals that preferentially remodel ISF bundles between LAGs. The internal cortex is laminar and largely unaltered, save sparse radially decreasing primary vascularization in the trionychids that reflects early asymptotic growth.

Grant Information
This research is supported by the Office of Undergraduate Research at the University of Utah, the Natural History Museum of Utah, and the Bureau of Land Management.

Technical Session XVIII (Saturday, October 20, 2018, 3:00 PM)

THE SKELETON OF *OTOSPERMOPHILUS MCKAYENSIS* AND THE EVOLUTION OF BURROWING IN GROUND SQUIRRELS

ORCUTT, John D., Gonzaga University, Spokane, WA, United States of America; VIETRI, Claire B., Gonzaga University, Spokane, WA, United States of America

The Hemphillian North American Land Mammal Age has long been the focus of research on vertebrate paleoecology. This is due not only to the major ecosystem and community changes that occurred during this interval (particularly those driven by cooling climates, expanding grasslands, and immigration of taxa from Asia and South America) but to its rich vertebrate fossil record. The Dalles Group of northeast Oregon provides particularly clear insight into the structure of Hemphillian ecosystems due to its preservation of a diverse vertebrate microfauna that includes frogs, songbirds, moles, bats, lagomorphs, small carnivorans, and rodents. Unusually, postcranial elements of these microvertebrates are abundant at Dalles Group localities, though most of these postcrania are isolated and not diagnostic below the family level. Recent fieldwork at McKay Reservoir near Pendleton has yielded a skull and associated postcrania of the ground squirrel originally described as *Spermophilus mckayensis*. This skeleton, among the most complete Hemphillian sciurid fossils known, allows "*S. mckayensis*" to be reassigned to the genus *Otospermophilus*. It also allows for the calculation of numerous functional indices informative about locomotion in general and degree of fossoriality in particular. Data from modern comparative analyses suggests that humeral functional indices are especially valuable tools for distinguishing fossorial squirrels from terrestrial or arboreal taxa. These individual indices, most notably humeral robustness index, indicate that the degree of fossoriality was lower in *O. mckayensis* than in extant ground squirrels, a conclusion further supported by multivariate analyses. Ongoing analyses incorporating other Miocene sciurid specimens will shed further light on the tempo and mode of the evolution of burrowing in ground squirrels. On a more local scale, data from this specimen of *O. mckayensis* will be included in ecomorphological analyses of the structure of Dalles Group paleocommunities, informing studies of Hemphillian ecological change.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

FIRST PARTIAL EGGS FOUND IN THE UPPER CRETACEOUS KAIPAROWITS FORMATION OF SOUTHERN UTAH, U.S.A. REPRESENT A NEW OOTAXON OF LAEVISOOLITHID EGGSHELL

OSER, Sara E., University of Colorado, Boulder, CO, United States of America; CHIN, Karen, University of Colorado, Boulder, CO, United States of America; SERTICH, Joseph J., Denver Museum of Nature & Science, Denver, CO, United States of America; VARRICCHIO, David J., Montana State University, Bozeman, MT, United States of America

The macroevolutionary transition from non-avian theropod dinosaurs to avians is characterized by a diverse assemblage of taxa that display an array of transitional morphological and behavioral features. The study of dinosaur eggs and eggshell has revealed a similar mosaic pattern in reproductive behavior and eggshell features, a characteristic exemplified by a new ootaxon of theropod eggshell from the Campanian Kaiparowits Formation of Grand Staircase Escalante National Monument, Utah. Analysis of two partial eggs and 29 eggshell fragments by radial thin sectioning, scanning electron microscopy, and micro computed tomography scanning facilitated characterization and identification of the new eggshell. The partial eggs are small (12–16 mm) and appear spherical, though they may also represent the poles of ellipsoidal eggs. We estimate that intact eggs had a diameter of ~17.7 mm based upon curvature. Ornamentation consists of isolated, flattened nodes which grade from circular to oval in plan view over the surface of the egg, with long axes of oval nodes aligned. Eggshell is 0.31–0.59 mm thick and consists of two structural layers of calcite separated by an abrupt linear boundary. Pores branch towards the surface of the eggshell with openings located atop the nodes. The suite of features preserved in this ootaxon is unique among theropod eggs and warrants a new oogenus and oospecies. Furthermore, the specimens represent the first laevisoolithid eggshell reported from North America, extending the geographic range of this oofamily. The new eggshell taxon is also among the smallest Mesozoic eggs described and adds to our understanding of reproductive biology characterizing the non-avian to avian theropod transition.

Grant Information
Funding for this research was provided by the University of Colorado Museum of Natural History.

Technical Session VI (Thursday, October 18, 2018, 9:15 AM)

A LEG UP: *WHATCHEERIA* AND ITS NEW CONTRIBUTIONS TO TETRAPOD ANATOMY

OTOO, Benjamin K., University of Chicago, Chicago, IL, United States of America; BOLT, John R., The Field Museum, Chicago, IL, United States of America; LOMBARD, Eric, University of Chicago, Chicago, IL, United States of America

When described in 1995, *Whatcheeria* was one of few Mississippian tetrapods. It has consistently occupied a position on the tetrapod stem in phylogenetic analyses, often as the first-diverging post-Devonian taxon outside the crown group. *Whatcheeria* is key for establishing character polarities on the tetrapod stem, particularly in the context of recent controversies about age of the tetrapod crown group and the timing and pattern of the lissamphibian/amniote split.

Whatcheeria is also the type genus for Whatcheeriidae. When first diagnosed, it was the earliest post-Devonian tetrapod clade, composed of *Whatcheeria*, *Ossinodus*, and *Pederpes*. However, most phylogenetic analyses have not recovered a monophyletic Whatcheeriidae. To complicate the issue, multiple fragmentary Devonian fossils have been termed 'whatcheeriid'. Uncertain composition and potential paraphyly of Whatcheeridae complicate interpretations of survivorship during the end-Devonian extinction, and raise the possibility of extensive convergence among early tetrapods.

Since the initial description of *Whatcheeria* many more specimens have been prepared. The *Whatcheeria* collection is now nearly 100 specimens, including at least eight articulated specimens and many bones preserved in three dimensions. A preliminary morphometric analysis reveals that the overall proportions of the femur of *Whatcheeria* differ from those of many tetrapods. The femur of *Whatcheeria* can be readily distinguished from those of many other tetrapods- including other 'whatcheeriids'- based on the following features: anteroposterior offset of the femoral heads; great expansion of the distal head relative to the proximal head; a thickened adductor crest with a bend in its course and overall shorter extent along the flexor surface; and lack of anterior deflection of the adductor crest. The curve of the adductor crest is otherwise only known in *Icthyostega*, and the lack of deflection is shared with *Proterogyrinus* and *Archeria*. The femur of *Limnoscelis* shares the great expansion of the distal head, and closely resembles the smaller, presumably less mature, *Whatcheeria* femora, which have relatively shorter shafts than the larger specimens. Larger/more mature *Whatcheeria* femora are more similar to those of the *Eoherpeton*, *Archeria*, and, in particular, *Proterogyrinus*. This combination of features in the femur emphasizes the moasic of characters present in *Whatcheeria*, and, in conjunction with recent Tournaisian discoveries, emphasizes the complexity of post-Devonian tetrapod evolution.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

ADVANCES IN THE STUDY OF CRICETIDAE RODENTS FROM LATE HEMPHILLIAN–IRVINGTONIAN OF CENTRAL MEXICO AND THEIR RELATIONSHIP WITH NORTH AMERICA FAUNAS

PACHECO-CASTRO, Adolfo, Universidad Nacional Autónoma de México, Querétaro, Mexico; CARRANZA-CASTAÑEDA, Oscar, Universidad Nacional Autónoma de

México, Querétaro, Mexico; JIMÉNEZ-HIDALGO, Eduardo, Universidad del Mar, Oaxaca, Mexico

The family Cricetidae is the second largest group of mammals with 792 species in 147 genera. They evolved in the Northern Hemisphere during the Paleogene, and were well adapted to Neartic ecosystems, and during the Great American Biotic Interchange, their Sigmodontinae subfamily diversified in South America into 80 genera and 400 species. Despite its importance, there is no consensus on the taxonomic and biostratigraphic limits of Sigmodontinae in the Hemphillian–Blancan of southern North America, because the fossils are rare, incomplete, and without radiometric ages.

Here we present material of sigmodontines and neotomines from the late Hemphillian, early Blancan, and Irvingtonian faunas in central Mexico, within the San Miguel de Allende Basin, Guanajuato (SMA), and Tecolotlán Basin, Jalisco. This material has been collected by Harley Garbani and Carranza-Castañeda since the 1980s in different projects of the Universidad Nacional Autónoma de México (UNAM), and continues to be collected in recent projects of the Centro de Geociencias, UNAM.

The species of sigmodontine reported are *Prosigmodon* and *Calomys*. These are the most complete known material for both genera, with complete jaws, fragments of maxillaries, and isolated teeth. Using the material attributed to *Prosigmodon* sp. from Tecolotlán and 16 taxa from the Hemphillian–Recent of North America (*Copemys*, *Prosigmodon*, *Sigmodon*, *Neotoma*, and *Reithrodontomys*), we built a systematic phylogenetic model (38 characters) with maximum parsimony in TNT software. The topology of the single most parsimonious tree (consistency index = 0.653, retention index = 0.851) shows *Prosigmodon* radiating at the Clarendonian–Hemphillian boundary, and we suggest the possibility that *Prosigmodon* originated in the Clarendonian faunas of California, in relation to the lineage *Copemys-Prosigmodon*, and later migrated to central Mexico.

In our biostratigraphic study in the SMA Basin, we determined that in the latest Hemphillian (Hh4), radiometric age ~4.7 Ma, species of *Prosigmodon* are common, and species of *Calomys* and *Neotoma* are rare. In the early Blancan (3.6 to 3.3 Ma), the presence of species of *Neotoma* increases, and new morphospecies related to *Sigmodon* appear, which have yet to be formally described. In the Irvingtonian, the rodent faunas are dominated by species of *Neotoma*, *N.* cf. *albigula*, and *N.* cf. *magnodonta* or *N.* cf. *alleni*. We discuss this faunistic succession and the evolutionary trends of hypsodonty, which are events that are likely a response to the diversification of the open and arid ecosystems in the late Neogene of North America.

Grant Information
This Project was funded by PAPIIT 102817, UNAM.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

LAUNCH MECHANICS OF *QUETZALCOATLUS* AND OTHER LARGE PTEROSAURS: A TEST OF THREE HYPOTHESES

PADIAN, Kevin, University of California Berkeley, Berkeley, CA, United States of America

Withdrawn

There are three main hypotheses about how large pterodactyloids may have launched themselves from the ground: (1) a running takeoff in bipedal posture, (2) a st[illegible]ing takeoff in bipedal posture, and (3) a standing takeoff in quadrupedal [illegible]ed almost entirely by the forelimbs. The viability [illegible] each hypothes[illegible] size and functional mechanics, including bone stre[illegible]nd models at the Vertebrate [illegible], enabled measurements [illegible] thrust from the legs durin[illegible] be effective. But at the same time, [illegible] sweep of the wings), which along with wingb[illegible] the wings, is limited by shoulder height, body size, a[illegible]-correlated). Because wing length is positively correlated with b[illegible]ingbeat frequency is negatively correlated at 0.355 for birds, 0.26 for bats), l[illegible]e p[illegible]rosaurs could not have achieved a stroke reaching 40° below the horizontal (considered minimally effective for thrust) without leaping. So a running takeoff is unlikely. (2) The femur + tibiae + metatarsals of most large pterosaurs were nearly as long as the humerus + forearm + carpometacarpus, and each set of bones was three times the gleno-acetabular length, which is approximately proportional to the cube root of the body mass. The erect parasagittal hindlimbs, proportionally longer relative to body length than those of herons and egrets, needed to effect a wing-assisted jump to bring the animal to approximately three hip heights above the ground to enable a wingstroke to reach 40° below the horizontal. If this was possible, as it seems, then (2) is plausible. (3) When the humerus is laterally extended, rotation effecting retraction of the forelimb is prevented by a bony stop at the deltopectoral crest. To retract the forelimb for a quadrupedal launch, it must be supinated (rotated outward) at least 135°, and thrust must be provided by a sudden and massive extension of the elbow and wrist joints, for which no adequate musculature is known. Failure of the limb bones is predicted because the long bone walls are only 1-2 mm thick and are not built to withstand compression. Hypothesis (2) appears to be the only plausible one.

Grant Information
Sakana Foundation, Uplands Foundation, UCMP

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

DINOSAUR FOOTPRINTS FROM THE CONIACIAN FRONTIER FORMATION DEPOSITS OF SOUTHWESTERN MONTANA

PANASCI, Giulio, Montana State University, Bozeman, MT, United States of America, 59715; VARRICCHIO, David J., Montana State Univ, Bozeman, MT, United States of America

The dinosaur fossil record for the early Late Cretaceous of northwestern America is sparse. In Montana, the dinosaur fauna consists solely of the neornithopod *Oryctodromeus cubicularis* and fragmentary material ascribed to ankylosaurian dinosaurs from the early Cenomanian-aged Blackleaf Formation. Subsequent dinosaur records are concentrated in Campanian and younger deposits, resulting in a temporal gap of approximately 10 Ma. Here we present the first dinosaur footprints from the Coniacian-aged Frontier Formation deposits of southwestern Montana. Recent paleontological expeditions in the Centennial Mountains, near the Idaho state border, recovered tracks ascribed to, in decreasing order of abundance, ornithopod, ankylosaurian, and theropod dinosaurs. The Frontier Formation in this area mostly consists of sandstone, siltstones, and silty mudstones locally displaying root traces and limestone nodules, and interpreted as alluvial plain deposits. Tracks are primarily preserved as hyporelief on fine sandstones strata or weathered out natural sandstone casts in mudstone or fine sandstone isolated blocks. This is the first record of dinosaurs for Coniacian deposits of Montana, and suggests that a considerable diversity of dinosaurs inhabited these terrestrial habitats. Their description will be fundamental to understand dinosaur evolution and biogeographic trends across the early part of the Upper Cretaceous. The Frontier Formation represents an important burgeoning paleontological source and provides a new target for future studies.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEO-TAPHONOMIC COMPARISON OF THE MASS DEATHS OF CETACEANS THAT OCCURRED IN THE CHILEAN PATAGONIA IN MARCH 2015 AND JULY 2016

PARADA-ARRAU, Fernanda P., University of Chile, Santiago, Chile; GUTSTEIN, Carolina S., Consejo de Monumentos nacionales, Santiago, Chile

In general, long term neo-taphonomic studies of cetaceans and marine vertebrates are rare in the literature, and most existing studies are based on small temporal-scale observations and small sample. The largest mass mortality of baleen whales (sei whales) ever recorded occurred in the Chilean Patagonia in 2015, and an additional mass mortality of pilot whales occurred in 2016. These two mass mortality events have given us a great opportunity to analyze the neo-taphonomic states of decomposition and disarticulation for these two species and to make neo-taphonomic comparisons between two differently sized cetaceans: the large baleen whale (Balaenoptera borealis*)* and the smaller toothed whale (Globicephala melas*)*. The initial states of both cetaceans were compared, along with their orientation, and the substrate where they were deposited. For the mass mortality event of *Balaenoptera borealis*, 68.8% (n = 205) of the carcasses were Class 1 (carcasses with low or medium decomposition status), and most were in a ventrolateral position with the mouth wide open (n = 97; 55.7%), reflecting the inflation process of the tongue once the animal was dead. Its position with respect to the sea was generally parallel to the coastline (n = 337; 73.3%) and on a sand beach substrate (n = 295; 66.1%). Meanwhile, the mass mortality event of *G. melas* (n = 124) was characterized by two predominant taphonomic states (over 90%: Class 1 and 2), and most of the carcasses were lying on their right side (n = 79; 93.7%), probably due to the adverse weather conditions registered in the area and its fusiform body. Its position with respect to the sea shows a tendency to be parallel to the coastline (n = 124; 62.9%) and on a sand beach substrate (n = 124; 83.9%).

The speed at which the decomposition process began suggests different taphonomic criteria for both species and determined their body position once they were deposited on the coast (swelling of the tongue in mysticetes, for example). The direction of the carcasses with respect to the coastline, reflects the action of the tidal movements (parallel to the coastline), and their deposition on sandy beaches could suggest possible fossilization pathways.

Grant Information
ACT172099, FONDECYT N° 3160710

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

CLIMATE AND CULTURALLY MEDIATED CHANGES TO THE HUMAN NICHE ALTERED INTERSPECIFIC INTERACTIONS WITH ENDEMIC CANIDS IN NORTH AMERICA

PARDI, Melissa I., Vanderbilt University, Nashville, TN, United States of America; SMITH, Felisa A., University of New Mexico, Albuquerque, NM, United States of America

Today, humans are found in virtually all habitats on Earth: from high elevation settlements in Tibet, to below sea level in Death Valley, and from harsh and inhospitable deserts such as the Sahara, to the subarctic city of Oymyakon, Russia. However, humans are animals with physiological limitations, and earlier in their evolutionary history as hunter gatherers, their distributions were constrained by abiotic conditions. Understanding the abiotic constraints on humans as they expanded their global range may provide important insights into their own evolutionary history, as well as their impacts on landscapes and biota.

There has been growing interest in describing the prehistorical distribution and ecological niche of humans (e.g., Neanderthals during the last interglacial). In our present study, we characterized the climatic niche of modern humans in North America using species distribution models (SDM, in Maxent) throughout the Holocene. Records of this time period are important in their recording of the geographic expansion and adaptation of anatomically modern humans on a new continent. Models were trained using occurrences from the Canadian Archaeological Radiocarbon Database and spatially downscaled CCSM3 paleoclimate simulations for North America. Likelihood of occurrence of humans across the North American landscape was reconstructed at 1,000-year intervals, from 10,000–1,000 yr BP. We then compare the distribution of humans with canids, a predatory guild that was very successful in North America throughout the late Quaternary. Interactions between humans and canids may be especially intriguing due to potential overlap in dietary resources, and the fact that early humans utilized domesticated dogs.

We find Holocene human distributions were well described with climatic niche models; however, the climatic variables important in defining the human niche changed over the Holocene. The timing of these changes correspond to cultural and technological adaptations. In turn, these changes are reflected in the differing associations between humans and canids during the Holocene. Early–middle Holocene wolves and coyotes appear to be positively associated with humans, but become negatively associated in the late Holocene. Humans also develop a positive association with foxes during the late Holocene. Our results suggest that the human niche is variable, yet predictable, and has shaped our interactions with endemic species for thousands of years.

Technical Session XIV (Saturday, October 20, 2018, 10:30 AM)

PALEOZOIC CROWN LUNGFISHES FROM GONDWANA FORESHADOW THE EARLY TRIASSIC RECOVERY FAUNA

PARDO, Jason D., University of Calgary, Calgary, AB, Canada; KAMMERER, Christian F., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; MARSICANO, Claudia A., Universidad de Buenos Aries, Buenos Aires, Argentina;

ANGIELCZYK, Kenneth D., Chicago, IL, United States of America; FRÖBISCH, Jörg, Museum für Naturkunde, Berlin, Germany; SMITH, Roger M., University of the Witwatersrand, Cape Town, South Africa; CISNEROS, Juan C., Universidade Federal do Piauí, Teresina, Brazil; RICHTER, Martha, The Natural History Museum, London, United Kingdom

Modern lungfishes are renowned for tolerance of extreme environmental variation, which is thought to contribute to their abundance during the recovery from the Permo–Triassic Mass Extinction (PTME). However, the Paleozoic origins of this clade and its biogeographic context remains unclear, with a 60 Ma ghost lineage at the base of the crown lungfish diversification. This gap is perplexing given the exceptional record of archaic lungfishes within this interval, particularly within paleoequatorial Euramerica, but also within eastern Europe. One possibility is that the assembly of the crown lungfish bauplan from known Carboniferous and Permian archaic lungfish groups occurred rapidly in the recovery from the PTME. However, an alternative explanation is that the crown lungfish bauplan evolved earlier in geographic regions outside the well-sampled Carboniferous and Permian basins of Euramerica, Russia, and South Africa. The sudden appearance of a diverse crown lungfish fauna in the earliest Triassic would then represent a biogeographic release in response to climate or diversity trends associated with the PTME. New lungfish faunas from outside these basins provide an opportunity to test these hypotheses.

Here we report a diverse lungfish fauna from the Early Permian Pedra de Fogo Formation (Parnaíba Basin, northeastern Brazil) comprised of abundant lungfish toothplates and rarer associated or articulated skeletal remains. This fauna lacks archaic lungfish taxa characteristic of contemporary localities in equatorial Euramerica. Instead, the Parnaíba fauna preserves a diverse assemblage of derived lungfishes, including a gnathorhizid and several crown lungfishes (ceratodontiforms). The gnathorhizid is represented by abundant toothplates and several partial skulls and shows similarities to the North American gnathorhizid genera. The ceratodontiform, which is represented by toothplates as well as several partial skeletons, shows affinities with Triassic taxa currently considered early members of the lepidosireniform stem group. Comparison with lungfish toothplate assemblages from the Paraná Basin of southern Brazil shows that the lungfish assemblage from the Parnaíba basin is also present in the Middle Permian of Brazil, likely representing a persistent biogeographic province in western Gondwana. We hypothesize that the lungfish crown group originated early in western Gondwana but remained biogeographically restricted until the PTME eliminated incumbent competition in better-known biogeographical provinces.

Grant Information
Nat. Geog. CRE (9601-14), Conselho Nacional de Desenvolvimento Científico e Tecnológico (to JCC), Negaunee Found.., Grainger Found., Alex. von Humboldt Found. SKA (to JF)

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

CORRELATED BODY SIZE CHANGES IN CENOZOIC TURTLES, CROCODILIANS, AND MAMMALS

PARKER, Abigail K., University of Cambridge, Cambridge, United Kingdom; HEAD, Jason J., University of Cambridge, Cambridge, United Kingdom

Environmental factors regulate maximum body size in living poikilotherms: increases in temperature can facilitate evolution of larger sizes, whereas competitive exclusion or predation by endothermic taxa impose upper limits on size. The relative influence of these factors over evolutionary timescales is poorly understood for Cenozoic reptiles, despite pronounced changes in Earth's climate regime and changes in endothermic vertebrate diversity during this interval. To examine the history of body size change in reptiles over the Cenozoic, we compiled maximum sizes for turtles and crocodilians for each sub-epoch from specimen examinations and literature searches. We correlated size trends over time with global temperature proxies derived from benthic foraminifera $\delta^{18}O$ values and with maximum mammal body sizes, representing potential competition and predation pressures. Our results show a significant positive correlation between body size in reptiles and mammals from the Paleogene through the Neogene. During that period, reptile body size increased as global temperatures dropped, in contradiction to predictions based on modern environmental drivers. Hypotheses that the rise of mammals limited the niches available to large reptiles are complicated by our data showing that reptiles' size increased alongside mammals'. This shared increase in size suggests that ecological release after the K-Pg extinction allowing evolution into niches previously filled by dinosaurs is an unsatisfactory explanation for mammal body size increase in the Cenozoic; instead, a common mechanism may have driven maximum body size to increase across classes of terrestrial vertebrates.

Podium Symposium (Wednesday, October 17, 2018, 3:00 PM)

THE PURPORTED LATE TRIASSIC CROCODYLOMORPH *PARRISHIA MCCREAI* IS A JUVENILE PHYTOSAUR

PARKER, William G., Petrified Forest National Park, Petrified Forest, AZ, United States of America; STOCKER, Michelle R., Virginia Polytechnic Institute and State University, Blacksburg, VA, United States of America; MARSH, Adam D., Petrified Forest National Park, Holbrook, AZ, United States of America

Parrishia mccreai was originally described solely from vertebrae as an early non-crocodylian crocodylomorph archosaur from the Upper Triassic Chinle Formation of Arizona. Subsequent reviews have questioned the validity of the taxon, but few have questioned its crocodylomorph affinities despite the lack of diagnosable vertebral apomorphies for Crocodylomorpha. New specimens from Petrified Forest National Park suggest that *Parrishia mccreai* is not a crocodylomorph, but instead represents a less skeletally mature ontogenetic stage of a phytosaurian archosauriform, verifying its taxonomic status as a nomen dubium. These new specimens include partial skeletons comprising skull fragments diagnostic for Phytosauria (including a quadrate and partial dentaries), sub-triangular osteoderms, and vertebrae that would otherwise be referred to *Parrishia mccreai* based on centrum length and the development of ventral keels. The cervical vertebrae of phytosaurs at early ontogenetic stages are anteroposteriorly elongate, have closely-situated diapophyses and parapophyses, and have well-developed ventral keels, which are all features that are also present in crocodylomorphs, but also represents the plesiomorphic condition for Archosauromorpha. Through ontogeny, the cervical vertebrae of phytosaurs become anteroposteriorly shortened with respect to the rest of the presacral vertebral column, and the ventral keel is reduced or completely lost. These new specimens help to estimate the taxonomic affinities of *Parrishia mccreai*, in effect restricting the crocodylomorph diversity in the Chinle Formation to *Hesperosuchus agilis* (a problematic taxon in itself) and an unnamed long-limbed form. Furthermore, these new specimens provide a better understanding of the skeletal changes that occur throughout the ontogeny of Phytosauria and provide a hypothesis for the apparent lack of juvenile phytosaur axial material in Upper Triassic deposits.

Grant Information
The Petrified Forest Museum Association supported a portion of this work.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

GROWTH OF THE DROMAEOSAURID THEROPOD DINOSAUR *DEINONYCHUS ANTIRRHOPUS*

PASCUCCI, Thomas R., Adelphi University, Westbury, NY, United States of America; D'EMIC, Michael D., Adelphi University, Garden City, NY, United States of America

The dromaeosaurid theropod *Deinonychus antirrhopus* has played a large role in shaping debates about the origin of birds, the evolution of flight, and dinosaur metabolism. *Deinonychus* is also one of the largest known dromaeosaurids. Despite its iconic status, *Deinonychus* is definitively known from relatively few specimens from just two horizons, the Cloverly and Antlers formations of Wyoming/Montana and Oklahoma, respectively. Within a few years of its initial description, a significant degree of anatomical variation was recognized in *Deinonychus*, but competing hypotheses to explain this variation—individual, ontogenetic, sexual, or hidden taxonomic differences—have received little scrutiny. Specimens substantially smaller than the largest known individual have been suggested to be histologically mature, signifying extensive variation in growth that mirrors the osteological variation in the current hypodigm. We use new histological data to test hypotheses that explain sources of variation in *Deinonychus* and investigate the growth strategy underlying its unusually large size. We provide the first mass-based growth rates for the genus based on histological and CT-derived data. We fit growth models to our new dataset and weighed competing models against one another using information criteria. Mass-based growth curves are congruent with one another and all histologically sampled individuals of *Deinonychus* yield similar asymptotic age estimates (ca. 13 years). This is similar to the asymptotic age of much smaller dromaeosaurids, suggesting acceleration of growth rate was responsible for the large body mass of *Deinonychus*.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A SERIES OF HIGHLY DIVERSE HERPETOFAUNAS FROM THE EOCENE–OLIGOCENE OF NEBRASKA

PAUL, Hannah S., University of New Mexico, Albuquerque, NM, United States of America; JACISIN, John J., Texas A&M University, College Station, TX, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America

Description of a series of four new microfaunas from the Eocene–Oligocene White River Group of Toadstool Geologic Park, Nebraska has revealed a previously undescribed diversity of small reptiles and amphibians, and has provided important new insight into White River environments and organismal responses to climate change during the Eocene–Oligocene Climate Transition (EOCT, ~33.7 Ma). The EOCT represents a drop in global mean annual temperature of approximately 7–9 degrees Celsius and a shift from "greenhouse world" to "icehouse world" conditions. This rapid cooling event was accompanied by the formation of permanent Antarctic polar ice caps, as well as changes in both marine and terrestrial faunas. Marine faunas at this time have been well studied, but information on the terrestrial reptilian record is deficient, and the ecological implications that a global climate shift of this magnitude presents for mid-continent reptiles are unclear. We collected over 5,000 specimens representing a range of vertebrate taxa from four different microsites spanning the Eocene–Oligocene boundary in Toadstool Geologic Park. From this collection, >160 reptile and amphibian specimens (primarily vertebrae) were isolated and identified, and represent the most diverse herpetofauna from this time and region. Our newly described White River reptile fauna contains at least two previously undescribed taxa, including a new species of potentially fossorial booid snake and the first record of salamanders from the White River Group, as well as several specimens that represent significant range extensions for known taxa. Preliminary analyses indicate a decrease in body size in the younger Oligocene deposits that may be associated with EOCT cooling. Analyses of herpetofaunal composition and abundance shows little change in the abundances of the common reptile taxa across the four study sites, but the loss of salamanders and the addition of a new fossorial snake taxon in younger sediments suggests an upwards aridification, and possibly cooling, of the White River Group at thislocality.

Technical Session XIX (Saturday, October 20, 2018, 3:45 PM)

VERTEBRAL OSTEOLOGY OF *HIPPOSAURUS BOONSTRAI* (THERAPSIDA, BIARMOSUCHIA) FROM THE MIDDLE PERMIAN OF SOUTH AFRICA, WITH IMPLICATIONS FOR THE EVOLUTION OF ARCHOSAUROMORPHA

PEECOOK, Brandon R., Field Museum of Natural History, Chicago, IL, United States of America; JONES, Katrina, Harvard University, Cambridge, MA, United States of America; SENNIKOV, Andrey G., Borissiak Paleontological Institute, Russian Academy of Sciences, Moscow, Russia; SMITH, Roger M., Evolutionary Studies Institute, University of the Witswatersrand, Johannesburg, South Africa; PIERCE, Stephanie E., Harvard University, Cambridge, MA, United States of America; ANGIELCZYK, Kenneth D., Field Museum of Natural History, Chicago, IL, United States of America

Biarmosuchia is an enigmatic clade of early therapsids from the middle and late Permian of southern and eastern Africa and European Russia. Biarmosuchian taxonomy and phylogenetic relationships are based on cranial characters; most taxa completely lack known postcrania. The holotype of *Hipposaurus boonstrai* from South Africa is a rare exception and includes a nearly complete skeleton described over 80 years ago, despite remaining largely unprepared. We micro-CT scanned the vertebral column of *H. boonstrai* and are now able to fully describe its unexpected morphology, which is strikingly different from other early synapsids.

The cervical and dorsal vertebrae of *H. boonstrai* are dominated by prominent prezygadiapophyseal, paradiapophyseal, and posterior centrodiapophyseal laminae, as well as a longitudinal lamina on the lateral surface of the centrum. The cervical centra are parallelogram shaped in lateral view, and reduced transversely to a thin sheet, resulting in a large keel. The articular faces are notochordal throughout the presacral series. There is a transpostzygapophyseal lamina with a midline notch for a small process on the anterior margin of the succeeding neural spine, as in some trilophosaurid archosauromorphs. We examined cervicals of other biarmosuchians (*Lobalopex mordax*, *Niuksenitia sukhoensis*, *Biarmosuchus tener*), as well as isolated vertebrae, and found they shared most character states.

The Permian archosauromorph record consists of only four species, despite the clade's tremendous radiation in the Triassic, and the extension of several ghost lineages into the late Permian. The archosauromorphs *Eorasaurus olsoni* from Russia and *Aenigmastropheus parringtoni* from Tanzania, each known predominantly from vertebrae, share nearly identical character states with *H. boonstrai*, and come from strata also containing biarmosuchian skulls (*Proburnetia viatkensis* and *N. sukhoensis*, and Burnetiidae indet., respectively). We propose that *E. olsoni* and *A. parringtoni* are biarmosuchians, further reducing the number of Permian archosauromorphs. Phylogenetic analysis underscores the startling homoplasy between biarmosuchians and archosauromorphs: when biarmosuchian vertebrae are coded into an archosauromorph data matrix, they form a monophyletic clade within Avemetatarsalia. Extreme caution is needed when interpreting Permian vertebrae as archosauromorphs.

Grant Information
NSF EAR-1524938, NSF EAR-1337569, NSF EAR-1337291

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

DENTAL TOPOGRAPHIC ANALYSIS OF MAXILLARY AND MANDIBULAR PHYLLOSTOMID BAT DENTITIONS: IMPLICATIONS FOR DIETARY PREDICTION IN THE FOSSIL RECORD

PELLEGROM, Colin W., Grand Valley State University, Allendale, MI, United States of America; STROIK, Laura K., Grand Valley State University, Allendale, MI, United States of America

Mammalian dental anatomy has evolved in accordance with the physical properties of its diet, and multiple features on each tooth have specific functions related to the breakdown of food during mastication and ingestion. Tooth structure is under tight genetic control and much of the anatomical variation in dentition across species is related to adaptation to a specific dietary regime. This diet-dentition relationship can be exploited to reconstruct mammalian diets from fossil specimens through calculation of dental topographic metrics. To date, most studies of dietary reconstruction using dental topography have focused on mandibular molars; thus, this study seeks to test whether the dietary signal from maxillary molars is congruent with that of the mandibular dentition.

As a test case, an extant sample of maxillary and mandibular phyllostomid bat dentitions from Balta, Peru were collected and classified by dietary regime: frugivorous, insectivorous, nectarivorous, frugivorous-insectivorous, and insectivorous-frugivorous. The specimens were cast using epoxy material, after which second molars were excised, mounted on discs, and microCT-scanned at 13 µm resolution. The resulting images were compiled to create a 3D surface model of the anatomical tooth crown, and topographic metrics were then calculated.

Paired t-tests of RFI, DNE, and OPCR values of maxillary and mandibular molars within each dietary group demonstrated that there is a significant difference between upper and lower dental topographies across diets ($P < 0.05$) with the exception of insectivores ($P = 0.074$). Additionally, discriminant function analysis of upper and lower dental topography indicated that maxillary second molars are as effective at predicting a species' diet as mandibular molars, and a combination of maxillary and mandibular dental topographic values predicts diet with a 93% success rate. Results from this study increase the dietary prediction accuracy for complete fossil specimens, expand paleontological dental topographic analysis to include maxillary molars, and demonstrate the potential of incorporating an occlusal approach to dental topography.

Grant Information
This research was funded by a Presidential Research Grant from The Graduate School at Grand Valley State University.

Technical Session VIII (Thursday, October 18, 2018, 3:15 PM)

AN ONTOGENETIC INVESTIGATION OF A CRETACEOUS NORTH AMERICAN MAMMAL, *DIDELPHODON VORAX* (METATHERIA, MARSUPIALIFORMES, STAGODONTIDAE), THROUGH QUANTITATIVE AND DESCRIPTIVE ANALYSES OF THE DENTARY

PENG, Amanda, University of Oregon, Eugene, OR, United States of America; TOEWS, Natalie, Seattle, WA, United States of America; BRANNICK, Alexandria, University of Washington, Seattle, WA, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America

Didelphodon vorax is a North American stagodontid metatherian and is the largest-bodied therian mammal known from the Late Cretaceous. Previous researchers have posited that this taxon was durophagous (i.e., it consumed hard-object foods) on the basis of its dental and skull morphology. However, little is known about the pattern of acquisition of those morphological adaptations through ontogeny and the associated implications for its feeding behavior. More broadly, there have been few ontogenetic studies of early mammals due to the generally incomplete nature of the Mesozoic fossil record of mammals. Here, we investigated morphological changes in an ontogenetic series of dentaries of *Didelphodon vorax* with the aim of understanding the acquisition of durophagous adaptations in this taxon. We classified 12 relatively complete dentaries of *Didelphodon vorax* into three ontogenetic stages (juvenile, young adult, mature adult) on the basis of tooth eruption and tooth wear patterns. We made gross anatomical comparisons of specimens across these stages (e.g., depth of masseteric fossa and bone porosity), and used beam theory to model the biomechanical properties (i.e., bending strength values) at various points along each dentary. We performed the same bending strength analyses on an ontogenetic series of each of two extant taxa—the marsupial *Didelphis virginiana*, which is phylogenetically proximal to *Didelphodon*, and the placental *Lontra canadensis*, which is proximal in feeding behavior to *Didelphodon*. Our bending strength results show that through ontogeny, *Didelphodon vorax* increased dorsoventral reinforcement of the horizontal ramus, particularly at the p3 crushing locus. This pattern is similar to that in *Lontra canadensis* but differs from that of *Didelphis virginiana*. These results imply that juvenile stage individuals of *Didelphodon vorax* were poorly equipped for the biomechanical stresses of durophagy compared to adult stage individuals. Our results highlight the importance of ontogenetic studies in understanding feeding behavior as a dynamic trait and expand our knowledge of the developmental patterns of Mesozoic mammals.

Technical Session III (Wednesday, October 17, 2018, 2:30 PM)

FROM TEETH TO BALEEN: TOOTH LOSS PRECEDES THE ORIGIN OF BALEEN IN WHALES

PEREDO, Carlos M., Laurel, MD, United States of America

Modern baleen whales (mysticetes) filter feed using keratinous baleen plates to strain large quantities of prey from the water. Although filter feeding has evolved multiple times in tetrapods, baleen represents a wholly novel integumentary structure that is a key innovation linked to the evolutionary success and ecological diversity of modern baleen whales. Although living baleen whales are born without teeth, paleontological and embryological evidence demonstrate that they evolved from toothed ancestors that lacked baleen entirely. The evolutionary transformation from teeth to baleen is one of the most enigmatic macroevolutionary transitions in vertebrates. Understanding this transformation in baleen whales is as important as the morphological changes during the land to sea transition earlier in whale evolutionary history, and akin to other macroevolutionary transitions in vertebrates such as the transition of scales to feathers in birds, or fins to limbs in tetrapods. This study reframes previous work on the subject into distinct, testable hypotheses for the origin of baleen and explicitly tests each hypothesis within the context of new fossil material from the early Oligocene of Oregon. This new material includes a transitional fossil mysticete that lacks both teeth and baleen entirely, demonstrating that tooth loss precedes the origin of baleen in mysticetes. This fossil demonstrates that the evolutionary history of baleen whales includes a transitional state that lacked both teeth and baleen. This finding explicitly falsifies other hypotheses for the origin of baleen, which are inconsistent with the morphology and phylogenetic position of the newly presented fossil material. Moreover, this finding is consistent with recent evidence that the evolutionary loss of teeth and origin of baleen are decoupled, each with a separate morphological and genetic basis.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

TAPHONOMY OF THE LOWER JURASSIC BLUE LIAS ICHTHYOSAURS OF SOUTHERN ENGLAND

PEREZ, Myria L., Dallas, TX, United States of America; BEHRENSMEYER, Anna K., Smithsonian Institution, Washington, DC, United States of America

The fossils of the Blue Lias Formation (BLF) are world-renowned for exceptional preservation, but the preservation processes responsible for this have received limited attention. The BLF consists of alternating dark grey marl, limestone, and shale layers that preserve unusually complete vertebrates and invertebrates. Our study focused on gathering information pertaining to death-burial intervals of BLF ichthyosaurs, including those originally found and collected by Mary Anning.

Fourteen BLF ichthyosaurs from collections in the Smithsonian Institution, National Museum of Natural History, Sedgwick Museum of Earth Sciences, Lyme Regis Museum, and the Natural History Museum, London were examined for this study. We collected evidence of post-mortem alterations in the lithologies, including skeletal part representation and degree of articulation, the presence of carbonate nodules, traces of soft tissue and stomach contents, and plastic deformation of the bones. Biases generated in the collecting of the specimens and alterations due to preparation methods also had to be taken into account. Such alterations included composite skeletons, removal of original matrix, and fabrication of matrix and bones, and these efforts to "improve" the specimens were not necessarily obvious without close examination.

The fourteen carcasses were divided into anatomical units, each assigned to stages of disarticulation (0-4). These stages were averaged and plotted to show a correlation between anatomical units and articulation as well as articulation in carcass averages and matrix. Most ichthyosaurs in our sample came from the variable marl layers exposed between the eroding shale and resistant limestone. BLF ichthyosaurs varied in preservation among the three main lithologies but nonetheless retained high skeletal articulation. Cervical vertebrae and pelvic girdles were less articulated compared to the other body units, likely reflecting lower strength in their anatomical connections.

Overall there is remarkable consistency in the taphonomic features of the Blue Lias ichthyosaurs we examined. Though this sample is undoubtedly biased from the selective collecting of complete specimens, its consistency in carcass preservation indicates recurring anoxic conditions of the depositional settings where the bodies of ichthyosaurs came to rest. The results of this study, particularly the lack of evidence for scavenging, support previous research indicating that anoxic waters played an important role in the burial and preservation of these animals.

Grant Information
National Science Foundation (REU Site, OCE - 1560088)

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

BODY LENGTH ESTIMATES OF FOSSIL LAMNIFORM SHARKS DERIVED FROM SUMMED WIDTH OF ASSOCIATED DENTITIONS

PEREZ, Victor, University of Florida, Gainesville, FL, United States of America; LEDER, Ronny, Naturkundemuseum Leipzig, Leipzig, Germany; BADAUT, Teddy, Thoirette, France

Carcharocles megalodon is often regarded as the largest shark that ever lived, yet current estimates have been highly variable, ranging from 40 to 148 ft for a single individual. Among the various metrics for estimating body length, the linear relationship between tooth crown height and total body length for each tooth position of the Great White, *Carcharodon carcharias*, is most frequently applied to isolated teeth of *C. megalodon*. While there are numerous issues with this approach, one that stands out is the need to identify tooth position. *Carcharocles megalodon* exhibits both monognathic and dignathic

heterodonty; however, the shape changes from the anterior to posterior and between the upper and lower jaws are subtle, making it exceedingly difficult to confidently and accurately identify tooth position.
To resolve this issue, a novel method for estimating body length in lamniform sharks is proposed based solely on associated dentitions. The proposed method uses a simple mathematical concept referred to as the rule of three and essentially assumes direct proportionality between the ratio of summed crown width to body length in fossil and modern taxa. Summed crown width is used as a proxy for jaw size and, for the most part, eliminates the necessity of identifying teeth to their original position. This method is applied to 10 fossil dentitions representing five lamniform taxa: *Carcharocles chubutensis*, *C. megalodon*, *Carcharodon hastalis*, *Carcharodon hubbellii*, and *C. carcharias*. A total of 19 modern dentitions representing three lamniform taxa (*C. carcharias*, *Isurus oxyrinchus*, and *Isurus paucus*) are used as analogs. Summed crown width for each of these dentitions was segmented into four regions: upper left, upper right, lower left, and lower right. The rationale for segmenting the summed width into these four regions is due to the partial preservation of many of the fossildentitions.
Our results found that estimates based on the lower jaw tend to be higher than the upper jaw, likely due to differences in the dental formula between fossil and modern taxa. Unsurprisingly, estimates derived from Mako sharks, *Isurus*, were always greater than those derived from modern Great Whites, which can likely be attributed to different feeding ecologies and corresponding narrower teeth of Mako sharks. Our best estimate for an average adult *C. megalodon*, based solely on Great Whites and after removing outliers, is 16.68 m (54.7 ft).
Grant Information
National Science Foundation Graduate Research Fellowship Grant No. DGE-1315138

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE SINGULAR UPPER CRETACEOUS VERTEBRATE SITES OF THE GUADALAJARA PROVINCE (CENTRAL SPAIN): NEW DATA ON THE FAUNAS FROM THE CENOMANIAN OF ALGORA AND THE UPPERMOST CRETACEOUS OF POYOS
PÉREZ-GARCÍA, Adán, UNED, Madrid, Spain; BARDET, Nathalie, Museum National D'Histoire Naturelle, Paris, France; GASCÓ, Francisco, UNED, Madrid, Spain; DE LA HORRA, Raul, Universidad Complutense de Madrid, Madrid, Spain; MARTÍN-JIMÉNEZ, Marcos, UNED, Madrid, Spain; MOCHO, Pedro, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; NARVÁEZ, Iván, UNED, Madrid, Spain; TORICES, Angélica, Universidad de La Rioja, Logroño, Spain; VULLO, Romain, Université de Rennes 1, Rennes, France; ORTEGA, Francisco, UNED, Madrid, Spain
The Cretaceous vertebrate fauna of the Guadalajara Province (Castilla-La Mancha, Central Spain) was unknown until a few years ago. In fact, the systematic excavation campaigns in Guadalajara began in 2013, those carried out in 2016 and 2017 being especially relevant. These works were performed in two fossiliferous areas, separated from each other by about 60 km, both located in the Castilian Branch of the Iberian Ranges: the Cenomanian area of Algora, especially the ALG-B site (Algora municipality); and the uppermost Cretaceous outcrops of the western margin of the Buendía Reservoir, especially the Poyos site (Sacedón municipality).
Localities with fossil vertebrates from the lower part of the Upper Cretaceous are very scarce in Europe and, to date, the locality of Algora shows the highest concentration of vertebrate remains recognized in the Cenomanian of this continent. Thus, the fossils from Algora add important data for the understanding of the faunal turnover recognized when the Lower Cretaceous and the uppermost Cretaceous faunas are compared. The study of the new remains presented here allows us to analyze in more detail the fauna of fishes, characterize the primitive turtle members present in this locality, know new anatomical characters for the oldest European pleurodiran turtles, identify and describe remains of elasmosaurids, recognize the presence of eusuchian crocodyliforms, describe the oldest lithostrotian titanosaurs of the Iberian Peninsula, and perform a detailed analysis of the theropod fauna. Several lineages from this site show a Gondwanan origin.
Poyos is an uppermost Cretaceous site located in one of the worldwide largest dinosaur nesting areas, found in 2016. Thus, these fossiliferous levels extends over more than 10 km. With the exception of an isolated vertebral centrum of a titanosaur sauropod, no other specimen from this locality has been published so far. The preparation of the fossils found in 2006 and 2017 allows us to analyze both oological and osseous remains. Not only isolated sauropod eggshells, but also complete eggs and several dinosaur clutches, have been found. They show several singularities relative to both the microstructure of the eggshells and the disposition of the eggs, in relation to those previously found in other uppermost Cretaceous Iberian regions. In addition to elements of bothremydid turtles and probably allodaposuchid crocodiles, the remains of dinosaurs are abundant in this region, including several partial skeletons. Among them, a probable new middle-sized theropod is identified.
Grant Information
Ministerio de Economía, Industria y Competitividad (CGL2015-68363-P, IJCI-2016-30427) and Viceconsejería de Cultura de Castilla-La Mancha (SBPLY/0021-0070).

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

AN EXTINCT SPECIES OF *TRICHECHUS* LINNAEUS, 1758 (SIRENIA, TRICHECHIDAE) FROM THE LATE PLEISTOCENE OF SOUTHWESTERN AMAZONIA
PERINI, Fernando A., Universidade Federal de Minas Gerais, Belo Horizonte, Brazil; COZZUOL, Mario A., Universidade Federal de Minas Gerais, Belo Horizonte, Brazil
The genus *Trichechus* (Mammalia, Sirenia, Trichechidae) harbors a modest diversity, comprising only three living species of manatees, with no full species currently recognized as fossil. Herein we report a new extinct species of *Trichechus* from the late Pleistocene of the Brazilian Amazonia. The new species comes from the deposits of the Rio Madeira Formation along Madeira River, state of Rondônia, Western Brazil, and is represented by two right dentaries and a partial palate with both molar series. The new species shows a mosaic of characteristics resembling other manatee species, as well some unique characters. It resembles *T. inunguis* and *T. senegalensis* by having a slender mandible lacking a deep mandibular symphysis and keel, like *T. manatus*, and by having smooth enamel. However, it differs from *T. inunguis* by having relatively larger and fewer erupted molars, as well by having only two mental foramina. It differs from all other *Trichechus* species by possessing a wide space between the lower tooth row and the ascending ramus of the dentary, and by having the anterior border of the ascending ramus covering the posterior end of the tooth row in lateral view. The results of morphometric analyses, including principal component analysis and discriminant analysis, highlight the distinction of the new species. A phylogenetic analysis recovers the new species in a polytomy with *T. inunguis* and the clade formed by *T. senegalensis* and *T. manatus*. The levels from which the remains were recovered produced a radiocarbon date of 44,710 ± 880 years before present, suggesting that, until recently, at least two species of manatees coexisted in the fluvial systems of western Amazonia.

Technical Session I (Wednesday, October 17, 2018, 11:30 AM)

A REAPPRAISAL OF THE BASAL SAUROPODOMORPH *ANCHISAURUS POLYZELUS* AND ITS IMPLICATIONS FOR HETEROCHRONY IN SAUROPOD SKULL EVOLUTION
PETERMANN, Holger, Yale University, New Haven, CT, United States of America; FABBRI, Matteo, New Haven, CT, United States of America; HANSON, Michael, New Haven, CT, United States of America; BHULLAR, Bhart-Anjan S., Yale University, New Haven, CT, United States of America
After decades of study, the evolutionary history of sauropod dinosaurs, the largest land-dwelling vertebrates to ever have evolved, is far from resolved. In particular, several questions regarding body size evolution and the phylogenetic relationships characterizing the divergence of the branches in basal Sauropodomorpha are still unanswered. Here, we present a comprehensive study of the Early Jurassic taxon *Anchisaurus* with implications for our understanding of the evolution of Sauropodomorpha. Compared to its closest relatives, *Anchisaurus* is a slender and lightly built sauropodomorph. Moreover, *Anchisaurus'* phylogenetic position within Sauropodomorpha, traditionally at the base of the derived basal sauropodomorph clade Anchisauria, was recently challenged when it was placed among the more basal massospondylids. Skeletochronological analysis of thin sections from femora, humeri, and ribs of three *Anchisaurus* specimens housed at the Yale Peabody Museum found two sexually mature and one adolescent individual. MicroCT scan data enabled the reconstruction of the skull morphology for the youngest and second oldest individuals. Based on these new data the diagnostic cranial features of *Anchisaurus* are reevaluated; we found an interesting mosaic of basal and derived characters expressed in this taxon. We performed geometric morphometrics on a dataset of 60 taxa and 80 individuals, including early archosauromorphs, crocodiles, theropods, and sauropodomorphs, including all available ontogenetic stages per taxon. Our results suggest a heterochronic event in *Anchisaurus* that also shaped the general sauropod skull morphology. Based on our own evaluation of its phylogenetic position in combination with its small body size in comparison to the closest sister taxa, we hypothesize that *Anchisaurus* is a dwarfed basal sauropodomorph, the first one recovered in the basal branches of Saurischia.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A LEATHERBACK TURTLE (TESTUDINES, DERMOCHELYIDAE) FROM THE MIOCENE OF THE WESTERSCHELDE, THE NETHERLANDS
PETERS, Marit, Utrecht University, Utrecht, Netherlands; REUMER, Jelle W., Utrecht University, Utrecht, Netherlands; BOSSELAERS, Mark, Antwerpen, Belgium; POST, Klaas, Urk, Netherlands
The Westerschelde Estuary in The Netherlands is known for its rich vertebrate fossil content. In a recent trawling campaign aimed at sampling a late Miocene marine vertebrate assemblage, over 5000 specimens were retrieved, all currently stored in the Natuurhistorisch Museum Rotterdam. One specimen is a well preserved fragment of a dermochelyid sea-turtle carapace. The Westerschelde specimen is an addition to the scant hypodigm of dermochelyids from the Miocene North Sea. The carapace fragment is described and identified as *Psephophorus polygonus*. The various secondary marks present on the fragment are suggestive of both predatory and scavenging origin. Based on the assumption that *P. polygonus* had a similar carapace structure as recent *D. coriacea*, the minimal size of the complete carapace is estimated to have been 168 x 126 cm. Furthermore, based on the physical traits of the Westerschelde specimen and a re-examination of *P. polygonus* specimens, including the neotype stored at the Naturhistorisches Museum Wien (Austria), it is argued that previously assigned characteristics cannot be used as discriminative taxonomic properties of dermochelyids in general, and of *P. polygonus* in particular. An improved cladistic analysis on dermochelyids is performed based on previously defined and new taxonomic characters. Using this analysis it is argued that *Psephophorus calvertensis* is a junior synonym of *P. polygonus*. Hence, a new diagnosis of *Psephophorus polygonus* is defined. The 'addition' of *P. calvertensis* to the species *P. polygonus* confirms its presence on both sides of the Atlantic Ocean. Therefore, we suggest *P. polygonus* to have had a cosmopolitan distribution, similar to the extant species *Dermochelys coriacea*.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

HUMAN ORIGINS SCIENCE FOR MIDDLE AND HIGH SCHOOL STUDENTS AND TEACHERS: BUILDING AN ONLINE COMMUNITY OF LEARNING
PETERSON, Amy, Arizona State University, Tempe, AZ, United States of America; SMAIL, Irene E., Arizona State University, Tempe, AZ, United States of America; DALY, E. Susanne, Arizona State University, Tempe, AZ, United States of America; ORTIZ, Alejandra, Arizona State University, Tempe, AZ, United States of America; EDMONDS, Hallie, Arizona State University, Tempe, AZ, United States of America
The quality of K–12 science education in the United States has deteriorated in recent decades. For example, US 15-year-olds ranked 23rd in the world in science literacy, according to a 2012 assessment by the National Center for Education Statistics. As measured by a 2011 National Assessment of Educational Progress, 68 percent of 8th graders lack proficiency in basic science. Intimately connected to these statistics is the sizeable percentage of American adults who accept a creationist, as opposed to

evolutionary, account of human origins (42 percent, according to May 2014 Gallup poll). While acceptance of human evolution as a natural process is partly a function of education level, a large number of Americans believe that Darwinian evolution is either "unsupported by evidence" (35 percent) or "do not know enough to say" whether it is supported by evidence (29 percent).
For more than 35 years, the Institute of Human Origins (IHO) at Arizona State University has informed the public about the science behind the knowledge of our origins. Through a grant for public outreach provided by the John Templeton Foundation, IHO created AskAnAnthropologist.asu.edu to address deficiencies in the teaching of human origins in primary and secondary school science classrooms. Through this web-based, interactive resource, IHO has expanded its public outreach to young people on the fundamental scientific question, **"**How did we become human?"
Many resources on the web provide facts about how we became human, but too few provide classroom teachers with curricular tools and content that engage young people in human origins and the scientific method. Translations to Spanish, interactive activities, and links to Next Generation Science Standard (NGSS) categories provide teachers and their students with invaluable tools to investigate our ancient past. Inspired by the Webby-award winning BecomingHuman.org and modeled after AskABiologist.asu.edu, AskAnAnthropologist.asu.edu aspires to build an online community of science and social studies educators focused on middle- and high-school learners.
Grant Information
Funding provided by The John Templeton Foundation and Institute of Human Origins, Arizona State University.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

COMPUTED TOMOGRAPHY, SEGMENTATION, AND RAPID PROTOTYPING OF THE DENTAL BATTERIES OF AN APATOSAURINE (SAUROPODA, DIPLODOCIDAE) SPECIMEN FROM THE UPPER JURASSIC MORRISON FORMATION, COMO BLUFF, WYOMING

PETERSON, Joseph E., University of Wisconsin Oshkosh, Oshkosh, WI, United States of America; LOVELACE, Dave M., University of Wisconsin Madison, Madison, WI, United States of America; CONNELY, Melissa V., Casper College, Casper, WY, United States of America; MCHUGH, Julia B., Museums of Western Colorado, Grand Junction, CO, United States of America; HARTMAN, Scott, University of Wisconsin Madison, Madison, WI, United States of America; HAYES, Leigh, University of Wisconsin Oshkosh, Oshkosh, WI, United States of America; STREY, Falyn, University of Wisconsin Oshkosh, Oshkosh, WI, United States of America

Dental batteries of sauropod dinosaurs have been studied in Diplodocidae, Rebbachisauridae, and Camarasauridae. However, the disparity of the number of replacement teeth between the premaxilla, maxilla, and dentary of apatosaurine sauropods has yet to be fully investigated. To examine unerupted dental batteries, the right premaxilla, maxilla, and dentary of TATE-099, a nearly complete and associated apatosaurine skull, were imaged and reconstructed using computed tomography (CT). TATE-099 was collected in 1996 from the Upper Jurassic Nail Quarry at Como Bluff, Wyoming in the Morrison Formation. Following CT imaging, unerupted dental batteries were segmented and exported as stereolithograph models (STL) for rapid prototyping. Results indicate the premaxilla contains four alveolar positions each with 6–7 unerupted replacement teeth, the maxilla contains ten alveolar positions each with 3–5 unerupted replacement teeth, and the dentary contains ten alveolar positions each with only 1–2 unerupted replacement teeth. The capacity of replacement teeth in TATE-099 is higher than reported in *Diplodocus* and supports likely niche partitioning among Morrison Formation sauropods. The disparity among the capacity of dental batteries in the premaxilla, maxilla, and dentary of TM-099 further suggests novel feeding mechanics in apatosaurines. The high-capacity of replacement teeth in the premaxilla is only succeeded in one known taxon (*Nigersaurus*) and suggests frequent wear of the premaxillary teeth. However, considerably fewer replacement teeth in the dentary of TATE-099 suggests less-frequent wear. Similar disparity is also seen in the sauropod *Dicraeosaurus*, which possesses 1–3 replacement teeth in the dentary and 4–5 and 4–1 replacement teeth in the premaxilla and maxilla, respectively. These results may offer insight into the feeding mechanisms of sauropods within Flagellicaudata.

Technical Session XII (Friday, October 19, 2018, 3:30 PM)

PELVIC AND HINDLIMB ANATOMY IN EXTANT AND FOSSIL SNAKES: IMPLICATIONS FOR RESOLVING CONTROVERSIAL PHYLOGENETIC HYPOTHESES

PHANTRATANAMONGKOL, Minky Warinporn, University of Cambridge, Cambridge, United Kingdom; HEAD, Jason J., University of Cambridge, Cambridge, United Kingdom

Fossil evidence for the origin and evolution of snakes remains controversial due to alternate interpretations of skeletal anatomy of Late Cretaceous taxa, primarily macrostomatan cranial anatomy of simoliophiid taxa and otoccipital anatomies of *Dinilysia patagonica* and *Najash rionegrina*. The phylogenetic significance of the well-developed pelves and hindlimbs in these taxa has not been critically examined, due in part to a paucity of comparative anatomical data in extant snakes. To determine the importance of pelvic and hindlimb anatomy for resolving the systematics of fossil taxa, we examined appendicular skeletal anatomies of extant snakes based on Micro-CT reconstructions of 34 taxa, representing all major clades of crown Serpentes. We placed anatomies in a comparative phylogenetic framework based on both morphological and molecular tree topologies, and then optimized fossil anatomies relative to those in extant taxa. Our analyses revealed much greater variation in both pelvic and hindlimb morphologies than previously reported for snakes, and that character distributions along both topologies failed to follow a phylogenetic stepwise pattern of reduction or loss. Instead, crown snakes demonstrate repeated histories of limb and girdle reduction or loss, secondary hypertrophy of the femur and zeugopodial elements as adaptations to function as a copulatory aid, and derived shifts in the relative orientations of pelvic elements. Comparison of fossil anatomies with extant taxa revealed that pelvic morphologies of simoliophiids are consistent with a stem-alethinophidian position in snake phylogeny as opposed to a more exclusive position with Macrostomata, and that muscle attachment morphology of the femur in *N. rionegrina* is more consistent with the condition in anilioids and macrostomatans than in limbed lizards. These results suggest distinct phylogenetic positions from current debates and demonstrate the utility of appendicular characters in analyses of "limbless" taxa.
Grant Information
Wellcome Trust / Isaac Newton Trust ISSF Joint Grant to Dr Jason J. Head.

Technical Session XV (Saturday, October 20, 2018, 11:30 AM)

LESSONS IN DESIGNING DATABASES FOR EXAMINING PALEOCOMMUNITIES THROUGH GEOLOGICAL TIME

PINEDA-MUNOZ, Silvia, Smithsonian Institution National Museum of Natural History, Alexandria, VA, United States of America; LYONS, S. Kathleen, Lincoln, NE, United States of America; TÓTH, Anikó B., Macquarie University, Sydney, Australia; BEHRENSMEYER, Anna K., Smithsonian Institution, Washington, DC, United States of America

Paleontological databases offer an exceptional tool for paleoecological studies across space and time as well as other areas of research such as biostratigraphy, taphonomy, and functional morphology. The basic entities in many databases are fossil localities with essential information about time and place (age, geographical place, collecting methods, etc.) and species lists. Taxa can be linked to morphological and ecological descriptors, and localities can be linked with taphonomic and depositional context data. In this talk, I will be reviewing paleoecological database design and analysis. Consistency and interdisciplinary standardization are fundamental for any database aiming to promote collaboration between neontologists, ecologists, and paleontologists and to facilitate communication among researchers working on broad comparative studies. Strategic use of open source programming and statistical software such as R can significantly improve data preparation and analysis. An important first step for paleoecological and paleoclimatological studies is to carefully evaluate the research question and available data to determine the most appropriate analytical methodologies. For functional ecological analyses, we need to choose traits that are measurable or easy to infer in both extinct and extant taxa. For example, we may be able to estimate body mass from fossil species but not litter size or average life span. Meanwhile, for community assembly studies it is important to include corrections for sampling bias, differences in the length of time bins and spatial extent. We also need to ground truth our fossil data sets and make sure that the ecological or climatological variable that we want to infer from fossil assemblages is strongly correlated in present ecosystems with the species traits chosen for our study. This might be difficult when working with extinct clades lacking modern representatives, but corrections may be applied using functionally analogous organisms. To evaluate the reliability of the methods used for paleoenvironmental or paleoecological inferences, we can use tests on simulated data with known distributions and model different ecological case-scenarios. Thus, we need to carefully validate ecological proxies, acknowledge their methodological limitations and thoughtfully align them with the spatial and temporal scale of our datasets. With proper design and analytical procedures, community databases have the potential to facilitate many research questions in paleoecology.
Grant Information
Support for this research was provided by a National Museum of Natural History Program grant to the Evolution of Terrestrial Ecosystems Program (ETE) and NSF-DEB1257625.

Technical Session VII (Thursday, October 18, 2018, 2:30 PM)

GRADUAL BUILD-UP OF POWERED FLIGHT POTENTIAL AMONG CLOSE AVIAN RELATIVES REVEALED BY COMBINING PHYLOGENETIC, AERODYNAMIC AND ANATOMICAL DATA

PITTMAN, Michael, The University of Hong Kong, Pokfulam, Hong Kong (CN); PEI, Rui, The University of Hong Kong, Pokfulam, Hong Kong (CN); GOLOBOFF, Pablo A, Unidad Ejecutora Lillo, Tucumán, Argentina; DECECCHI, T Alexander, University of Pittsburgh Johnstown, Johnstown, PA, United States of America; HABIB, Michael B, Keck School of Medicine of USC, Los Angeles, CA, United States of America; KAYE, Thomas G, Foundation for Scientific Advancement, Sierra Vista, AZ, United States of America; LARSSON, Hans CE, McGill University, Montreal, QC, Canada; NORELL, Mark A, American Museum of Natural History, New York, NY, United States of America; BRUSATTE, Stephen L, University of Edinburgh, Edinburgh, United Kingdom; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

The evolution of birds from paravian theropod dinosaurs is a classic evolutionary radiation, but a deeper understanding of it, including early flight history, has been frustrated by disagreements over the interrelationships of birds and their closest relatives, the dromaeosaurids and troodontids. We address these discrepancies through a larger, more resolved phylogeny produced by a novel automated pipeline tailored for large morphological datasets. This phylogeny reaffirms the deinonychosaurian grouping (dromaeosaurids+troodontids) as the sister taxon to birds, and corroborates the recovery of Anchiornithidae (*Anchiornis* and its close kin) as basalmost avialans. Using these phylogenetic results, wing loading and specific lift are calculated as proxies of flight capacity through this transition, using maximum and minimum estimates from available data for vaned feathered taxa. Wing loading and specific lift are then interpreted in the context of the updated phylogeny to provide lower and upper bounds for the evolution of powered paravian flight. The findings show a broad range of paravians with near flight capability, suggesting more widespread experimentation with wing-assisted locomotion than previously appreciated. In this context, we find that fully powered flight originated multiple times from these near flight-capable ancestors, including twice within dromaeosaurids (in *Rahonavis* and *Microraptor*).
Grant Information
HK Research Grant Council General Research Fund (M.P., X.X. & P.A.G.); HKU PDF Scheme (to M.P. for R.P.); NSF of China (X.X.); Proyecto de Unidad Ejecutora from CONICET (P.A.G).

Technical Session IX (Friday, October 19, 2018, 11:00 AM)

REGIONAL PATTERNS IN LOCOMOTOR ECOMETRICS IN CARNIVORA: MIOCENE AND PRESENT

POLLY, P. David, Indiana University, Bloomington, IN, United States of America; HEAD, Jason J., University of Cambridge, Cambridge, United Kingdom

Living communities of Carnivora are sorted by locomotor characteristics, notably by the hind-limb gear ratio that describes variation between plantigrade and digitigrade postures. This sorting is mediated by large-scale patterns of vegetation type and topography. Communities in grassland, tundra, or topographically rugged scrub biomes have more digitigrade species and a wider range of gear ratios than communities in forested or less rugged areas. The sorting effects are strongly phylogenetic, with canids and felids contributing the more digitigrade species to local community pools and ursids and mustelids contributing the more plantigrade species.

However, modern biomes have different distributions from the Miocene and carnivorans have had substantial phylogenetic turnover (loss of amphicyonids, borophagines, and nimravids), so we used ecometric analysis to compare the patterns of regional sorting in late Miocene communities. Ecometrics is the study of the distribution of functional traits within and between communities. We measured hind-limb gear ratio in 330 fossil carnivore specimens representing 33 species distributed among 71 localities in the Clarendonian Land Mammal Age, just before the onset of widespread C4 biomes. To avoid sampling biases at individual localities, we grouped localities to create regional species pools to use as units of analysis: west coast, northern, middle, and southern Great Plains, and the southeast. We calculated means and standard deviations of the gear ratio to characterize the average digitigrady in local species pools and the diversity of locomotor postures. We also analysed the taxonomic composition of the regional pools.

We found that the magnitude sorting among regions was similar in the Miocene to today, but the specifics of the patterns were quite different. Today the southern Great Plains has the most digitigrade regional species pool, but in the Clarendonian, the west coast and northern Great Plains had the most digitigrade pool. Overall, mean digitigrady was much lower in the Clarendonian than today because of the commonness of comparatively plantigrade amphicyonids, barbourofelines, and borophagines, and because the felines of the Clarendonian were considerably less digitigrade than today's. Diversity of gear ratios were also substantially lower in the Clarendonian than today. These results are consistent with Clarendonian environments being, on average, more closed than today's yet with considerable variation from one region of the continent to another.

Grant Information
NSF EAR-13388298 to PDP, NSF EAR-1338028 to JJH

Podium Symposium (Friday, October 19, 2018, 11:00 AM)

THREE-DIMENSIONAL RECONSTRUCTION AND BIOMECHANICAL MODELLING OF TETRAPOD SKULLS ACROSS THE WATER–LAND TRANSITION

PORRO, Laura B., University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom

The conquest of the land by vertebrates was landmark event in the history of life. Profound changes in skull shape across the water-land transition are inferred to reflect changes in the size and arrangement of jaw muscles, feeding mechanism, and/or differing constraints imposed by aquatic versus terrestrial ecosystems. Here we explore the anatomy and mechanics of fossil tetrapod skulls spanning the transition—from the Late Devonian to Early Triassic—as well as their extant relatives. Computed tomography (CT) was used to capture skull shape in fossils, including *Eusthenopteron*, *Acanthostega*, *Greererpeton*, *Crassigyrinus*, and *Lydekkerina.* Scans were processed to separate individual bones, and damage and deformation were removed, resulting in new three-dimensional reconstructions of iconic fossil tetrapod skulls. Contrast-enhanced scanning was used to obtain skeletal and jaw muscle morphology in the heads of extant bracketing taxa, including basal ray-finned fish, lungfish and salamanders. We compare skull suture morphology in living and fossil taxa to predict load regimes and feeding modes across the fish-tetrapod transition. Osteological correlates and information from digital dissections of extant taxa were used to reconstruct the major jaw-closing muscles of early tetrapods for the first time. These data shed light on the evolution of the tetrapod head—including increasing skull strength and more efficient transfer of force from jaw muscles to bite points—and changes in feeding mode during the water–land transition. Furthermore, our reconstructions form the basis for ongoing finite element and musculoskeletal modelling.

Grant Information
Research funded by NERC standard grant NE/P013090/1 ("Skull evolution and the terrestrialization and radiation of tetrapods")

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

NEW IGUANODONTIAN DINOSAURS FROM THE LATE CRETACEOUS IBERO-ARMORICAN ISLAND OF THE SOUTHWESTERN EUROPEAN ARCHIPELAGO

PRIETO-MARQUEZ, Albert, Catalan Institute of Paleontology, Sabadell, Spain; FONDEVILLA, Victor, Catalan Institute of Paleontology, Sabadell, Spain; G. SELLÉS, Albert, Catalan Institute of Paleontology, Sabadell, Spain; VILA, Bernat, Catalan Institute of Paleontology, Sabadell, Spain; GALOBART, Angel, Catalan Institute of Paleontology, Sabadell, Spain

During the Late Cretaceous, a diverse assemblage of dinosaurian clades roamed the European Archipelago. In one of the largest islands, Ibero-Armorica (most of present day Iberian Peninsula and France), iguanodontian dinosaurs were one of the dominant herbivore clades. In particular, the 40 km long Tremp Basin in the Pyrenean region preserves one of the best-documented paleontological records of these and other European terrestrial vertebrates during the last million years of the Mesozoic.

We introduce two new coeval iguanodontian taxa from lower Maastrichtian strata of the Conques Fm, eastern Tremp Basin, Lleida Province, NE Spain. One of them is a new genus and species of rhabdodontid characterized by apomorphies of the scapula. The proximal region of this bone is extremely thick mediolaterally, wider than the proximal scapular constriction. The deltoid fossa is extremely deep and bounded dorsally by a well-demarcated deltoid ridge that is continuous with the ventral margin of the scapular blade. Distally, the blade greatly expands gradually while thinning mediolaterally to end in a delicate lamina. The second taxon is a new species of *Pararhabdodon*, a genus of tsintaosaurin lambeosaurine hadrosaurid, from horizons nearly four million years older than the type locality of *P. isonensis* (uppermost Maastrichtian of the Talarn Fm). This form is diagnosed by the following unique combination of characters: sternum with caudoventral process shorter than craniomedial plate and scapula with relatively unexpanded and short blade (three times the length of the proximal region). It differs from *P. isonensis* in having an ilium with deeper central plate (depth over 80 percent of length) and narrower acetabular margin.

These findings clarify the systematics and relationships of a number of hitherto indeterminate hadrosaurid specimens from various localities of the Tremp Basin, providing insights into the evolution of *Pararhabdodon*, among the largest and more widespread hadrosaurids of western Europe. Both the shortening of the caudoventral process of the sternum and relatively underdeveloped scapular blade suggest a reduction of the size and leverage of the dorsal brachial and pectoral musculature in the new *Pararhabdodon* species. This indicates a unique functionality among hadrosaurids of the pectoral girdle and probably the upper forelimb of this animal.

Grant Information
Study supported by the Ramón y Cajal Program (RyC-2015-17388) and CGL2016-73230-P grant, both from the Government of Spain, and CERCA Program from the Government of Catalonia.

Technical Session XVII (Saturday, October 20, 2018, 2:30 PM)

TESTING FUNCTIONAL HYPOTHESES IN A TRIASSIC DIAPSID REPTILE—3D MODELING OF MODERN MUSCLES AND RANGE-OF-MOTION MODELING INFORM DIGGING IN *DREPANOSAURUS*

PRITCHARD, Adam C., Smithsonian Institution, Washington, DC, United States of America; CLARK, Elizabeth, Yale University, New Haven, CT, United States of America; WALLS, Katharine, Yale University, New Haven, CT, United States of America; BHULLAR, Bhart-Anjan S., Yale University, New Haven, CT, United States of America

General anatomical comparisons between modern and fossil taxa have long been a source for functional and behavioral hypotheses in extinct lineages. For example, the forelimb morphology and hook-and-pull digging behavior of anteaters has been used as a model for the Triassic diapsid *Drepanosaurus*, which possesses a bizarre forelimb anatomy with asymmetrical radius and ulna, enlarged post-axial carpals, and a massively expanded second manual digit. We tested the hypothesis that the *Drepanosaurus* forelimb could have functioned like a modern anteater through musculoskeletal reconstruction and range-of-motion modeling, based on exceptional *Drepanosaurus* fossils from the Upper Triassic Chinle Formation of New Mexico.

Our musculoskeletal reconstruction was phylogenetically bracketed using high-fidelity 3D renderings of bone-muscle associations based on a series of contrast-stained modern tetrapods, including *Crocodylus*, *Anolis*, *Sphenodon*, and *Hynobius*. The correlates for the deltoid musculature in *Drepanosaurus* were uniquely expanded and would have allowed strong protraction of the forelimb. Correlates for the flexor and extensor musculature of the manus (e.g., ent- and ectepicondyles of humerus, flexor and extensor surface of ulna) are markedly expanded relative to other early diapsids, indicating a capacity for powerful flexion and extension of the enlarged manual unguals.

We conducted our range-of-motion estimates in Maya, assigning degrees of freedom to joints based on articular morphology. The glenoid fossa is positioned laterally relative to the posterolateral position on the scapulocoracoid in most early diapsids, allowing a greater degree of protraction of the forelimb. The enlarged second digit and its associated ungual are both hyperextensible. Both the musculoskeletal reconstruction and joint range-of-motion support the hypothesis of hook-and-pull digging, involving protraction of the forelimb with the second digit hyperextended. The entire limb could then be powerfully retracted in tandem with flexion of the second digit. The context developed for this study can be used to test other functional hypotheses for archaic reptile lineages.

Grant Information
A. Pritchard is funded by NSF BIO 1523871. B.-A. Bhullar is supported by Yale University and the Yale Peabody Museum.

Romer Prize Session (Thursday, October 18, 2018, 9:15 AM)

MORPHOLOGICAL, BIOMECHANICAL, AND SENSORY EVOLUTION IN EARLY PENGUINS FOLLOWING THE TRANSITION TO FLIGHTLESS WING-PROPELLED DIVING

PROFFITT, James V., UT Austin, Austin, TX, United States of America

Study of vertebrate locomotor transitions highlights a key role for the fossil record in documenting the acquisition of anatomical, functional, and even sensory innovations linked to new behaviors and ways of moving. Avian flight is a notable example, but less considered are subsequent transitions allowing birds to exploit new environments and resources. The origin of flightless wing-propelled diving in the penguin lineage is a particularly ideal case for study due to a robust fossil record. I present data sourced from seven new specimens from New Zealand that are among the oldest basally diverging Paleocene (61.5 Ma) penguin fossils. I used x-ray computed tomography data to describe skeletal and endocranial anatomy of these early penguins, examining musculoskeletal and neuroanatomical evolution following the transition to flightless wing-propelled diving. I also produced biomechanical models using the new fossils and extant birds to test if upright posture and walking gait in extant penguins are correlated with body shape and mass property shifts linked to aquatic ecology. The origin of flightless wing-propelled diving affected musculoskeletal traits earlier than whole-body biomechanical traits (e.g., center of mass) and neuroanatomy. Stem penguins display many modifications linked to wing-propelled diving, but key features of the pectoral girdle show that their swimming mechanics likely differed from modern taxa. Estimates generated from the biomechanical models show that stem penguins also had a more cranially positioned center of mass than extant taxa, as in aquatic outgroups. In combination with morphological data, these estimates indicate that stem penguins may have used less upright postures and walking gaits than extant taxa. Unexpectedly, crown birds are less variable in craniocaudal center of mass position than non-avian theropods and stem birds, with most variation linking to

trunk shape. Numerous traits of the stem penguin brain endocast are distinct from crown taxa but shared with diving outgroups, showing that the modern penguin brain evolved gradually. Comparisons between stem penguins and crownward taxa show that subsequent penguin evolution, as in the origin of avian flight, involved change across multiple anatomical systems that modified the novel locomotor behavior (e.g., swim stroke) and altered plesiomorphic function (e.g., terrestrial locomotion). Going forward, more synthetic work is needed to test if this pattern is common to other locomotor transitions within birds and across vertebrates more broadly.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A NEW SPECIES OF THE MIOCENE PECCARY *MACROGENIS* WITH BIZARRE FLARING CHEEKBONES

PROTHERO, Donald R., Natural History Museum of L.A. County, LA CRESCENTA, CA, United States of America

The late Miocene peccary *Macrogenis crassigenis* was named for a skull with broad flaring cheekbones and a very long rostrum. In the Frick Collection of the American Museum, there are several skulls that are similar to *Macrogenis crassigenis*, but about 25% larger, with a longer rostrum and longer post-canine diastema. Most of the specimens are from the latest Clarendonian (late Miocene) of north-central Nebraska, including the Frick *Leptarctus* Quarry and Kat Quarry. All of these skulls have broad flaring wing-shaped zygomatic arches ('zygomatic wings') that stick out laterally from the side of the skull and form a point with a twist at the base. This condition is unlike the very different flaring cheekbones of *Macrogenis crassigenis*, *Skinnerhyus shermerorum*, or any other peccary known so far. Based on the morphology of the canine tusks, both male and female skulls can be identified, and this might explain some of the variability in the shape of the flaring zygomatic wings. Based on these differences, these specimens represent a new species of *Macrogenis* to be named elsewhere. The broad flare of the zygomatic arch in several groups of peccaries parallels the condition found in some entelodonts as well as suids, such as the warthogs. The flaring zygomatic wings may have served for species recognition, or for establishing dominance in the group, and (as is demonstrated in modern suids) helps protect the eyes and face when males battle with their sharp tusks.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

NEW INSIGHTS ON A UNIQUE EGGSHELL LOCALITY WITHIN THE LATE CRETACEOUS UPPER TWO MEDICINE FORMATION OF MONTANA

PRZYBYSZEWSKI, Eric R., Montana State University, Bozeman, MT, United States of America; GERMANO, Paul, Montana State University, Bozeman, MT, United States of America; VARRICCHIO, David J., Montana State Univ, Bozeman, MT, United States of America; TREXLER, David, Two Medicine Dinosaur Ctr, Bynum, MT, United States of America

Here we expand on prior findings by describing new locality and fossil eggs within the Upper Two Medicine Formation of northwestern Montana. The lithology of the site consists of a grey bentonitic mudstone with aragonite veins. Terrestrial gastropods are common throughout. Igneous samples extracted from an ash layer directly above the site are being UR/PT dated. The site is near the top of the formation, and equivalent stratigraphic sites were previously dated to 74 Ma. Thus far, 14 partial eggs have been recovered, with nine partial and uniformly spaced eggs forming a potential discrete clutch. From these nine, eggshell fragments were extracted and have been thin sectioned showing diagenetic alteration with a mean average thickness of 0.603 mm. The clutch was CT scanned and does not show discernable embryonic remains. Equatorial and polar measurements were taken for the seven most complete eggs from the site. Those dimensions, respectively, are approximately 149x170 mm for the largest and approximately 118x143 mm for the smallest, with a mean average size of 129x150 mm. Their shape is sub-spherical, and some of the eggs show signs of post-burial distortion including compression ridges and eggshell overlap. Lateral compression is observed in all eggs. Recent distortion to the eggs' morphology may be attributed to the expansion of bentonite during wet conditions and bioturbation influence from plant roots penetrating the eggs' outer surfaces. Significant similarity to other known eggshell types links this material only to other collected egg material from the formation and this group may represent a clade. Future and ongoing efforts include collecting and preparing remaining field jackets, as well as conducting scanning electron microscopy, and cathodoluminescence of collected materials. The discovery of a potential new clade of eggshell showing transitions from the Lower Two Medicine and Judith River through the Hell Creek formations would be significant for future studies.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

TESTING THE SENSITIVITY OF DENTAL MICROWEAR TEXTURE ANALYSIS AS A DIETARY PROXY: CAN IT DETECT NICHE PARTITIONING IN SYMPATRIC SPECIES?

PURNELL, Mark A., University of Leicester, Leicester, United Kingdom; ADAMS, Neil F., University of Leicester, Leicester, United Kingdom; NEDZA, Chris, University of Leicester, Leicester, United Kingdom; RYCHLIK, Leszek, Adam Mickiewicz University, Poznan, Poland

Recent work shows that tooth microwear analysis can be applied further back in time and deeper into the phylogenetic history of vertebrate clades than previously thought (e.g., niche partitioning in Early Jurassic insectivorous mammals). Furthermore, quantitative approaches to analysis based on parameterization of surface texture are increasing the robustness and repeatability of this widely used dietary proxy. Discriminating between taxa within dietary guilds has the potential to significantly increase our ability to determine resource use and partitioning in fossil vertebrates, but how sensitive is the technique? Can microwear texture analysis detect differences between sympatric species that exhibit niche partitioning with significant dietary overlap?

To address these questions, we combined detailed dietary analysis with tooth microwear texture analysis of sympatric populations of shrew species (*Neomys fodiens*, *Neomys anomalus*, *Sorex araneus*, *Sorex minutus*) from Bialowieza Forest, Poland. Dietary analysis reveals that these populations exhibit varying degrees of niche partitioning with greatest overlap between the *Neomys* species. *Sorex araneus* also exhibits some niche overlap with *N. anomalus*, while *S. minutus* is the most specialised. Multivariate analysis based only on tooth microwear textures recovers the same pattern of niche partitioning, demonstrating that validated microwear texture analysis can provide very subtle dietary discrimination in fossil insectivores. Application of these results to a combined dataset of extinct and extant taxa has some surprising implications.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A NEW JURASSIC ALVAREZSAURIAN THEROPOD FROM THE SHISHUGOU FORMATION OF WESTERN CHINA DEMONSTRATES AN EARLY DIVERSIFICATION OF THE GROUP

QIN, Zichuan, Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China; CLARK, James M., George Washington Univ, Washington, DC, United States of America; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

Alvarezsaurian dinosaurs, a group of bizarre theropods with highly shortened and modified forelimbs, are known mostly from the Late Cretaceous of Asia and South America. Here we report a new alvarezsaurian based on a specimen recovered from the Middle–Upper Jurassic Shishugou Formation of Junggar Basin, western, China, together with two other alvarezsaurians from this formation, representing the only known Jurassic alvarezsaurians worldwide. Similar to two other Shishugou alvarezsaurians, this new alvarezsaurian displays initial development of the highly modified alvarezsaurian forelimb, but it possesses a number of manual features closer to typical coelurosaurian theropod condition than the other Shishugou alvarezsaurians. Combining morphological and histological features, our analysis indicates that the earliest known alvarezsaurians are variable in size and other important morphological features, and in particular display a mosaic distribution of forelimb features. The new find demonstrates an early diversification of alvarezsaurian theropods near the Middle-Late Jurassic boundary, and shed new light both on forelimb morphology and body size evolution in primitive alvarezsaurians.

Grant Information
This study was supported by the National Natural Science Foundation of China (No. 41688103, 91514302,41120124002, and 41602013).

Technical Session X (Friday, October 19, 2018, 9:45 AM)

NOVEL DATA ON TROPHIC FOOD WEBS IN ANCIENT ECOLOGICAL COMMUNITIES REVEALED FROM COPROLITES (FOSSIL FECES)

QVARNSTRÖM, Martin, Uppsala University, Uppsala, Sweden

Coprolites carry important information that can be used to unravel paleoecological relations. However, much information has remained unexploited because of difficulties in visualizing the contents and linking the coprolites to producers. Synchrotron microtomography has recently allowed visualization of full coprolite contents in 3D, resulting in an unprecedented harvesting of paleoecological information. Here I present two examples from Poland that cast new light on the diets of Late Triassic archosaurs. From the Carnian locality at Krasiejów, five morphologically similar coprolites are shown to contain abundant small beetle remains. The coprolites are linked by shape, size, and association to the body fossil record to the early dinosauriform *Silesaurus opolensis*. The beak-shaped jaws of *S. opolensis* were likely used to peck small insects off the ground, a feeding behaviour comparable to some extant birds. From the latest Norian/early Rhaetian locality at Lisowice, three large coprolites contain highly fragmented bones (constituting up to 50% of the coprolite volume) and crushed, serrated teeth. The fossil record of the site together with the coprolite characteristics suggest that the large, theropod-like archosaur *Smok wawelski* was the producer. Several of the fragmented teeth are attributable to *S. wawelski* and were probably accidentally swallowed. The coprolites are associated to bone-rich regurgitalites and numerous dicynodont bones with major bite damage, also attributable to actions of *S. wawelski*. These remains suggest that *S. wawelski* exploited bones, which is thought to be rare among extinct archosaurs with the exception of the Late Cretaceous tyrannosaurids. Thus, it appears that this behavior is convergent between the tyrannosaurs and this theropod-like archosaur, separated in time by some 140 million years. The Krasiejów and Lisowice coprolites yield information about the probable diet of *Silesaurus* and *Smok* that could not have been obtained by other means, and in the case of Krasiejów they also provide a concentrate of the (previously almost unknown) local beetle fauna. Although only two examples are presented here, it has been possible to link several more morphotypes to producers in both of these Triassic localities. Notably, a spiral coprolite from Krasiejów containing crushed clams and a partly articulated actinopterygian can be attributed to the lungfish *Ptychoceratodus*. Judging from these test cases, synchrotron microtomography of coprolites holds out great promise as a new tool for paleoecological research.

Grant Information
M.Q. is funded by the Department of Organismal Biology, EBC (Evolutionary Biology Centre) at Uppsala University, Sweden.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

DIRE WOLF FOSSIL RECORD IN MÉXICO

R. RAMONI, Damián, Universidad Nacional Autónoma de México, México City, Mexico; MONTELLANO, Marisol, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico

The dire wolf, *Canis dirus*, is one of the most emblematic and studied American Quaternary carnivorans. This species stands out among canids because of its wide geographic distribution and its abundance in some local faunas; it is also one of the largest members of the genus *Canis*. Its geographic distribution ranges from Alberta (Canada) to Tarija (Bolivia), but most of its record is concentrated in the United States, followed in abundance by México, where, until this study, 10 Pleistocene localities have documented its occurrence. We have undertaken a revision of the Mexican record and have updated the information that it contains. As a result, we can now count a total of 16 localities where *C. dirus* occurs: three are only mentioned in faunal lists, without reference to specimens or morphological information; nine are confirmed reports of cranial and dental remains; and finally, two new localities have yielded fragmentary material. So far, ten of the 32 Mexican states have yielded confirmed records of *C. dirus* of Rancholabrean age; three records are

in cave settings. In summary, the finds do not follow a pattern of occurrence (i.e., they come from different environmental settings), suggesting that México was part of the distribution of the dire wolf. Additionally, we performed a detailed dental and morphometric comparison between the Mexican and American materials, but found no significant differences between these samples. This refutes a previously proposed hypothesis that suggested morphometric differences exist between eastern and southwestern North American (including México) subpopulations of the dire wolf: clearly, the Rancholabrean Mexican specimens belong to a single, widespread North American species, *Canis dirus*.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

FORELIMB ANATOMY OF *EUROTAMANDUA JORESI* FROM THE MIDDLE EOCENE OF MESSEL, GERMANY, BASED ON COMPUTED TOMOGRAPHY: SYSTEMATIC IMPLICATIONS

RABENSTEIN, Renate, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt/Main, Germany; HABERSETZER, Jörg, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt/Main, Germany; LEHMANN, Thomas, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany; RUF, Irina, Senckenberg Forschungsinstitut und Naturmuseum, Frankfurt am Main, Germany; GUNNELL (†), Gregg F., Duke University, Durham, NC, United States of America; ROSE, Kenneth D., Johns Hopkins Univ, Baltimore, MD, United States of America

Fossils from the Messel Pit Fossil Site, Germany (MP 11, 48 Ma) are often preserved as articulated skeletons. Among them, the only known individual of *Eurotamandua joresi* was described as the oldest and most complete fossil anteater (Xenarthra, Myrmecophagidae) outside of South America. Since then its phylogenetic position has been debated (Palaeanodonta, Pholidota, Afredentata, or Xenarthra, as sister-taxon to Vermilingua or Pilosa).

Systematic and anatomical ambiguity mainly resulted from limited access to diagnostic features of the skeleton. After the water-containing sediment was removed and the fossil was embedded in a resin plate, only the bones of the right body side were visible and most joints were obscured. Using high-resolution computed tomography with extended field of view and virtual preparation (segmentation), complete forelimb bones and articulations are now visible for the first time—especially of the manus, which, except for the dorsal part of metacarpal III (Mc III), was not investigated before. The forelimb elements are completely preserved, but long bones are partly crushed and compressed. We compared them with extant specialized diggers (Dasypodidae, Manidae, the myrmecophagid *Tamandua tetradactyla*) and Palaeanodonta (*Metacheiromys dasypus*, *Palaeanodon ignavus*, *Alocodontulum atopum*). The segmentation of the phalanges, metacarpals, ulna, radius, and humerus revealed numerous features closely similar to those of palaeanodonts and manids, but unlike *Tamandua* and *Dasypus*.

The morphology of the humeral head, tuberosities, and shaft (deltoid tuberosity, deltopectoral and supinator crests) resemble those of palaeanodonts but are unlike *Tamandua*. The semilunar and the radial notches of the ulna are very similar in form and orientation to those of palaeanodonts, as is the radius.

In the manus, the proximal and intermediate phalanges are short; in digit III both are wider than they are long. The terminal phalanges of digits II to IV are slightly curved and strong; that of digit III is the largest. Confirming previous observations by one of us (KDR) the Mc III has a distinct dorsal extensor tubercle, whose ovoid shape is similar to that of palaeanodonts but unlike that of *Tamandua.* The CT data reveal in the distal joint a ventromedian keel and saddle-shaped proximal metacarpal joints as in palaeanodonts. Both contrast with the unique morphology of myrmecophagids.

In conclusion, our results provide substantial additional evidence that *Eurotamandua* is related to Palaeanodonta rather than to Xenarthra.

Grant Information
Humboldt Foundation Travel Grant (KDR)

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

ERQ EL AHMAR ELEPHANT SITE—A MAMMOTH SKELETON AT A RARE AND CONTROVERSIAL PLIOCENE SITE ALONG THE MAMMAL MIGRATION ROUTE OUT OF AFRICA

RABINOVICH, Rivka, The Hebrew University of Jerusalem, Jerusalem, Israel; HERZLINGER, Gadi, The Hebrew University of Jerusalem, Jerusalem, Israel; CALVO, Rani, Geological Survey of Israel, Jerusalem, Israel; BEINER, Gali, The Hebrew University of Jerusalem, Jerusaelm, Israel

Early sites along the Dead Sea Transform (southern Levant), among them the Erq el-Ahmar Elephant Site, are key points in understanding hominin and mammal migration out of Africa and into Eurasia. The late Prof. Tchernov had begun an intensive campaign to expose the faunal remains at the site, but unfortunately was unable to conclude his study. From interim reports and geomorphological description, we were aware of numerous elephant remains found and left in situ. In 2013, we returned to the site to complete the project and resolve the long-standing debate regarding the nature of the site and its role in understanding hominin and faunal dispersal.

The Erq el Ahmar Elephant Site is a controversial site. There are those who see it as the earliest archeological site in the area, while others consider it to be a 'mere' paleontological site. We returned to the site to finally resolve this controversy. In a controlled excavation, we succeeded in exposing the previously uncovered elements, exposed more material and currently better understand the deposition sequence. A series of elements were found partially superimposed. Several elements of the skull, an almost complete tusk, vertebrae, ribs, scapula, and limb bones were found in probable association. However, we faced a great challenge, because the bones and tusk were very fragile and required careful exposure and both in situ and laboratory conservation before they could be studied. Mammoth characteristics were identified in the teeth and tusk. However, very few skeletons of early mammoth are known from the region. Have we exposed the most complete *Mammuthus rumanus*? In addition, recent excavations have revealed the potential of the site to contribute to our understanding of the evolution and dispersal of proboscideanspecies out of Africa during the Pliocene, adding another focal point to southern Levant importance along this route.

Grant Information
Care Foundation, Stekelis Foundation, and Ruth Amiran Grant

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

MY HEAD HERTZ: HEARING ABILITIES IN AN EARLY SIMOCETID (CETACEA: ODONTOCETI) AS RECONSTRUCTED FROM MICROCT SCANS

RACICOT, Rachel, Claremont McKenna, Pitzer, and Scripps Colleges, Claremont, CA, United States of America; DARROCH, Simon, Vanderbilt University, Nashville, TN, United States of America; BOESSENECKER, Robert, W.College of Charleston, Charleston, SC, United States of America; GEISLER, Jonathan, NYIT College of Osteopathic Medicine, Old Westbury, NY, United States of America

Whales, in their transition from terrestrial to fully aquatic lifestyles, have profoundly modified the mammalian form to support living and feeding underwater. Toothed whales (odontocetes) are the most abundant group among modern whales, and originated sometime during the Eocene/Oligocene transition ~34 million years ago. Odontocetes are thought to have quickly, over the span of about 10 million years, evolved the ability to echolocate. The earliest transitions to fully aquatic biosonar usage are represented in early Oligocene odontocete members of the Simocetidae, Xenorophidae, and Agorophiidae. Simocetids exhibit unusual cranial and facial morphology compared with xenorophids and agorophiids, potentially related to suction feeding. Some aspects of their facial morphology, such as premaxillary sac fossae and expansion of the maxilla over the frontals, are consistent with biosonar capabilities. Here, we perform the first (to the best of our knowledge) in-depth investigation of simocetid inner ear labyrinth morphology. We use microcomputed tomography (microCT) to image and examine a petrosal belonging to a perinatal simocetid (CCNHM 1000; specimen includes a partial braincase and teeth) from the Pysht Formation (30.5–26.5 Ma). We obtain a wide variety of morphological measurements of the inner labyrinth; these are then added to an extensive dataset of cetaceans and other artiodactyls, to determine whether this individual had infrasonic or ultrasonic hearing. The semicircular canals and vestibule are also measured and described in detail as they relate to possible other aspects of ecology. These approaches provide a unique opportunity to better understand the evolution and ecology of simocetids, which occupy a crucial position in the evolutionary and ecological history ofodontocetes.

Technical Session I (Wednesday, October 17, 2018, 11:45 AM)

NOVEL POSTCRANIAL FEATURES IN A NEW SPECIMEN OF *HETERODONTOSAURUS* (DINOSAURIA, ORNITHISCHIA) REVEALED BY SYNCHROTRON X-RAY COMPUTED TOMOGRAPHY: IMPLICATIONS FOR ORNITHISCHIAN PHYSIOLOGY, EVOLUTION, AND SYSTEMATICS

RADERMACHER, Viktor, University of the Witwatersrand, Johannesburg, South Africa; CHOINIERE, Jonah, University of the Witwatersrand, Johannesburg, South Africa; CHAPELLE, Kimberley, University of the Witwatersrand, Johannesburg, South Africa; DE KLERK, William, University of the Witwatersrand, Johannesburg, South Africa; SANTUCCI, Vincent, University of the Witwatersrand, Johannesburg, South Africa

Heterodontosaurids were abundant ornithischian members of Early Jurassic Laurasian and Gondwanan ecosystems, with *Heterodontosaurus tucki* being the best represented taxon of this clade. Recent fieldwork in South Africa yielded an articulated and almost entirely complete specimen (AM4766) of this taxon. Propagation phase contrast synchrotron microtomography scanning at the European Synchrotron Radiation Facility (ESRF), France has revealed the presence of both novel and poorly known ornithischian features in AM4766. Based on these scans, and on the results of manual preparation, we describe the first unequivocal case of gastralia in an ornithischian dinosaur, the first occurrence of ossified clavicles outside of Marginocephalia, the presence of paired sternal plates and sternal ribs with a unique spatulate morphology in an early branching ornithischian, and the presence of a rare ossified suprascapular. Additionally, we present unambiguous evidence that gastralia were not only present in basal ornithischians, but that they potentially possess a morphology that differs from the saurischian condition, with crocodilian gastralia providing a closer analogue to the condition exhibited in *Heterodontosaurus*. When scored in two recent phylogenetic analyses, we illustrate that paired sternal plates and sternal ribs are plesiomorphic for Ornithischia, possessing markedly different morphologies basally. A hypothetical myological reconstruction is presented that seeks to provide a model for how gastralia would have functioned with the retroverted pubis of ornithischians and what their subsequent loss in this clade suggests about ornithischian respiratory physiology, and how it likely differed, fundamentally, from their sauropodomorph and theropod sister taxa.

Grant Information
This research was made possible by grants provided by the DST-NRF Centre of Excellence in Palaeosciences, and the Palaeontological Scientific Trust.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE FIRST PHYLOGENETIC SUPER-MATRIX OF THE ARMOURED DINOSAURS (ORNITHISCHIA, THYREOPHORA)

RAVEN, Thomas J., Natural History Museum, London, United Kingdom; MAIDMENT, Susannah C., Natural History Museum, London, United Kingdom; BARRETT, Paul M., The Natural History Museum, London, United Kingdom

The armored dinosaurs have been known since the early 1800s and include some of the most recognizable dinosaurs such as *Stegosaurus* and *Ankylosaurus*. The individual lineages, Ankylosauria and Stegosauria, have been studied thoroughly, but there has never before been a comprehensive whole-group cladistic analysis of Thyreophora. This has hindered efforts to understand the macroevolution of the group, and, in particular, has obscured character-state transformations at the base of Eurypoda (Stegosauria + Ankylosauria), making the identification of basal taxa and clades problematic, and the degree of convergence difficult to assess. Here, the first species-level phylogenetic super-matrix of the whole-group Thyreophora is presented, incorporating all previous known cladistic analyses of ankylosaurs, stegosaurs and basal thyreophorans and including all

valid species within Thyreophora, for a total of 89 taxa and 338 characters. Analyses were performed under both parsimony (in TNT) and Bayesian inference (under the Mk model in RevBayes) and the effects of reductive and non-reductive coding were investigated. *Hylaeosaurus* was recovered at the base of Ankylosauria, outside of both Ankylosauridae and Nodosauridae, and *Kunbarrasaurus* is found at the base of Nodosauridae. *Alcovasaurus* was found as the sister-taxon to *Tuojiangosaurus*, the first time the former has been recovered within Stegosauria by a phylogenetic analysis. Potential evidence for a 'polacanthine' clade was also found, with *Polacanthus, Hoplitosaurus, Mymoorapelta, Taohelong* and *Dongyangopelta* grouped at the base of the Nodosauridae, although symmetric resampling showed this to have weak support. Reductive character coding was shown to produce higher resolution results than non-reductive coding, despite the presence of a higher percentage of missing data in the former. The results of these phylogenetic analyses will become the framework for macroevolutionary studies ofThyreophora.

Grant Information
TJR is funded by a University of Brighton Science Scholarship.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE ABUNDANCE STRUCTURE OF LATE PLEISTOCENE MEGAFAUNA FROM NATURAL TRAP CAVE, WYOMING

REDMAN, Cory M., Drake University, Des Moines, IA, United States of America; MEACHEN, Julie, Des Moines University, Des Moines, IA, United States of America

Natural Trap Cave (NTC) is a well-known fossil locality located in Wyoming that has produced a diverse vertebrate assemblage from the late Pleistocene to early Holocene (34–3 ka). This study examines changes in the relative abundance structure of NTC's large-bodied (>10 kg) mammals, excluding horses, using rank abundance curves (RAC). RAC are a common ecological technique used to visually and quantitatively describe how species in an ecosystem partition resources and convert these resources into abundances. Abundance counts for 12 taxa were tallied from disarticulated, skeletal elements (N = 3256) over 50% complete, identifiable to the genus or species level, and collected from 1974–1979 by the University of Kansas. This study is restricted to NTC collections made by the University of Kansas from 1974–1979 because these collections have the most robust provenance data with the largest sample size. The floor of NTC was divided into 1.5 meter grids and each grid was excavated as a nearly horizontal surface in 7.6 or 15.2 centimeter intervals. Specimens were recovered from a maximum depth of 4 m and a 95 m^2area. Kurtosis and Wilcoxon Rank Sum tests were used to quantify changes in the shape of the RAC between four stratigraphic units.

Data analysis is currently being conducted on each grid, but analyses of grids that yield over 200 specimens show that RACs have a more peaked or convex-down shape (>3 kurtosis), reflecting a more stressed ecosystem, with no statistically significant change (p-value <0.05) in the shape of the RAC through the 4-m section. Sample size differences between the four stratigraphic units still need to be accounted for. Given the numerous glacial and interglacial periods that occur during the late Pleistocene–Holocene transition, these preliminary results are not unexpected. While the amount of time represented by each of the four stratigraphic units in NTC are different, RAC generated from fossil assemblages record the relative amount of perturbations that occurred over the represented time period. Detailed study of the late Pleistocene–Holocene transition is especially relevant to the modern ecological crises, given similarities in global climatic shifts, human disturbances, and faunal composition. NTC is an important fossil locality because it preserves a diverse fossil assemblage at a lower latitude (45°) in an arid basin environment, allowing the impact of long-term climate change to be examined on a landscape that is rarely captured in the terrestrial sedimentary record.

Technical Session I (Wednesday, October 17, 2018, 11:00 AM)

A REASSESSMENT OF THE PHYLOGENY OF BASAL SAUROPODOMORPHS THROUGH COMPARATIVE CLADISTICS AND THE SUPER-MATRIX APPROACH

REGALADO FERNANDEZ, Omar R., University College London, London, United Kingdom; UPCHURCH, Paul, University College London, London, United Kingdom; BARRETT, Paul M., The Natural History Museum, London, United Kingdom; MANNION, Philip, London, England; MAIDMENT, Susannah C., Natural History Museum, London, United Kingdom

Non-sauropodan sauropodomorphs have been intensively studied in recent years. Several hypotheses on the interrelationships within this group have been proposed, ranging from complete paraphyly (where the group represents a grade spanning early dinosaurs to Sauropoda), to a monophyletic 'core Prosauropoda'. Although a pectinate grade of taxa leading to sauropods has become the most widely accepted scenario, the interrelationships between Operational Taxonomic Units vary significantly among the different studies. These inconsistencies have been attributed to missing data and unstable (i.e., poorly preserved) taxa. To test these hypotheses, we conducted an extensive comparative cladistic analysis and assembled the largest and most comprehensive dataset compiled for this group of animals thus far. We sampled a total of 989 characters for 117 taxa (three outgroups, four silesaurids, 12 ornithischians, 11 theropods, and 87 sauropodomorph taxa). The resulting matrix was analysed in TNT (TBR, ratchet [10 iterations], drift [10 cycles], with 100 random additional sequences, and an implied weighting of 12) obtaining 420 MPTs, and also implementing Maximum Likelihood using MrBayes (we employed Lewis' Mk model). Our results, based on strict reduced consensus trees, indicate that these inconsistencies come from character coding and character selection, plus the strategies used when merging data sets (some previous studies have merged all the characters but not all the taxa, or others have worked on modifications done on one previous dataset). Partition analyses performed on this dataset (cranial, axial, and appendicular skeleton partitions; and continuous, discretised continuous, and continuous character partitions) found consistent interrelationships among early sauropodomorphs and cast doubt on the validity of several clades and taxa, such as Massospondylidae. The new topology supports the following groupings: Plateosauridae, Anchisauridae (*Aardonyx*, *Seitaad*, *Asylosaurus*, *Jaklapallisaurus*), Riojasauridae, Mussauridae, and the clade *Antetonitrus* +*Pulanesaura* + *Tazoudasaurus* + Sauropoda. The results of these analyses also suggest a new hypothesis of how quadrupedality evolved, with this stance originating twice independently within the group (in Riojasauridae and Sauropoda). This means that early sauropodomorphs represent a paraphyletic group comprised of several clades, and not a complete grade-like arrangement as proposed in the most recent phylogenies.

Grant Information
This project was funded by the National Council of Science and Technology (CONACYT) of Mexico.

Technical Session XIX (Saturday, October 20, 2018, 2:00 PM)

***VARANODON* AND THE EVOLUTION OF VARANOPID SYNAPSIDS**

REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada

Varanopidae is a clade of small to medium sized carnivorous synapsids whose fossil record spans the Late Pennsylvanian to late Permian, one of the longest known temporal ranges of any Paleozoic eupelycosaur clade. Varanopids have been recovered from a wide range of paleolatitudes, across much of the super-continent Pangea. The systematic position of Varanopidae within Synapsida has been discussed extensively, and various members of this clade have been originally identified as diapsid reptiles. It has also been recently suggested that this clade may not be part of Synapsida, but may instead nest within Diapsida.

The varanopid *Varanodon* is known from a single articulated skeleton, and includes a complete skull, vertebral column including anterior caudal, shoulder girdle and forelimbs. The excellent preservation of this skeleton, and the detailed information that it provides permit a reexamination of varanopid interrelationships, and their position among early amniotes. *Varanodon* provides more detailed cranial information than the other large varanopids. Notable among these is the unusual anatomy of the lacrimal bone and the associated increase in the posterior, post-septomaxillary portion of the external naris. The temporal region of *Varanodon* is greatly modified, with a reduced postorbital bone, and large, sheet- like squamosal bone that has ventrally a narrow groove for the dorsal edge of the anteriorly tilted dorsal process of the quadrate. This contact closes the adductor chamber and the adductor muscles apparently exited the lateral temporal fenestra and attached to the external surface of the squamosal bone. This unique arrangement, not readily observable in the other large varanopids, can be however inferred to be present in both *Aerosaurus* and *Varanops*, based on the anatomy of the temporal bones in these taxa. However, there is no evidence of a suborbital fenestra, or any evidence of an upper temporal fenestra, and the occipital surface of *Varanodon* has the typical synapsid configuration. A revised and expanded data matrix and phylogenetic analysis that integrates Permo–Carboniferous synapsids and reptiles does recover a monophyletic Varanopidae within Synapsida, with *Varanodon* and its varanodontine sister taxa, *Watongia, Varanops, Tambacarnifex,* as apex, gracile predators of the early Permian, contemporaries of the larger, more massively built sphenacodontid synapsids.

Grant Information
NSERC Canada Discovery Grant

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

ONTOGENETIC DEVELOPMENT OF AGAMIDAE (SQUAMATA) WITH IMPLICATIONS FOR FOSSIL SQUAMATA IDENTIFICATION

REJ, Julie, East Tennessee State Univ, Johnson City, TN, United States of America

Squamate fossil identification has long been challenging due to the poor understanding of their osteology and often inadequate comparative collections. Not only is species or even genus level identification a challenge but identifying adult and juvenile specimens is equally as difficult. For this analysis, I selected the family Agamidae (dragon lizard) and compared modern adult and juvenile specimens. I analyzed eight specimens of *Ctenophorus scutulatus*, four specimens of *Pogona vitticeps*, and two specimens of *Pogona minor*. For each species, there was at least one juvenile and one adult representative. Adult specimens were differentiated from juveniles by previously established snout-vent lengths. For this study, I examined the maxilla and the dentary since these are the bones commonly recovered from the fossil record. All specimens are from the Western Australian Museum and were on loan at the time of this study. When examining the teeth, juvenile specimens have fewer acrodont teeth compared to the adults. Additionally, juvenile acrodont teeth are proportionally larger then their maxilla or dentary and increase in size posteriorly down the tooth row. Adults have a more robust maxilla and dentary, and their acrodont teeth show wear, primarily in the anterior region. In the youngest individuals, anterior pleurodont teeth are absent, and in older juveniles, the present pleurodont teeth are more peg shaped compared to the pleurodont teeth of the adults. The dorsal maxilla process is thinner and more vertical in the juvenile specimens and gradually widens and slants posteriorly as specimen size increases. Other points of articulation within the maxilla appear under developed in the youngest individuals and become more robust and prominent in older individuals. These dental characteristics can be used to aid in the identification of fossil squamates with acrodont dentition and currently are in use for identifying fossil agamids from Western Australia.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A SECOND MAMENCHISAURID DINOSAUR FROM THE MIDDLE JURASSIC OF EASTERN CHINA

REN, Xinxin, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China; HUANG, Jiandong, Anhui Geological Museum, Hefei, China; YOU, Hailu, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

Huangshanlong anhuiensis was recovered from the Middle Jurassic Hongqin Formation in Anhui Province, eastern China. Here we report a new dinosaur from the same quarry and horizon. The new specimen consists of a complete left humerus, ulna and radius. Cladistic analysis including this new specimen and new forelimb characters recovers that the new specimen is a member of Mamenchisauridae and confirms previous assignment of *Huangshanlong* as a member of Mamenchisauridae. Within this clade, the new specimen is the sister taxon of *Huangshanlong*, and they together are more closely related to *Omeisaurus* than to the clade including all other mamenchisaurids. One character supports the new specimen as a member of Mamenchisauridae, which is the appearance of two cranial facing accessory processes on the craniodistal edge of humerus. The (new specimen+*Huangshanlong*+*Omeisaurus*) clade is supported by the stout ulna with high proximal breadth / proximodistal length ratio (below 0.68) and radius distal / mid-shaft

breadth ratio of 1.5–1.9. The new specimen shares with Huangshanlong the average of the greatest widths of the proximal end, mid-shaft and distal end / total length of humerus less than 0.27. The new specimen possesses a unique combination of characters such as the lateral edge of the deltopectoral crest turning posterolaterally, the lateral accessory process of humerus more robust than the medial one; ratio of the total length of radius to humerus of 0.50 (*Huangshanlong*: 0.58), ratio of the total length of ulna to humerus of 0.56 (*Huangshanlong*: 0.67); elliptical cross-sectional shape of ulna at mid-shaft (*Huangshanlong* is circular), and the nearly perpendicular orientation of the proximal end of the ulna relative to the long axis of ulnar shaft. This discovery indicates that Mamenchisauridae was already diverse in Eastern China during the Middle Jurassic, and the interrelationships within mamenchisaurids need to be further explored.

Grant Information
The research was financially supported by the National Natural Science Foundation of China (Grants No. 41472020 and 41688103).

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

FIRST DINOSAUR (ORNITHOPODA) FROM THE CRETACEOUS OF OREGON, U.S.A.

RETALLACK, Gregory J., University of Calgary, Eugene, OR, United States of America; THEODOR, Jessica M., University of Calgary, Calgary, AB, Canada; DAVIS, Edward B., University of California Berkeley, Eugene, OR, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America; BARRETT, Paul Z., University of Oregon, Eugene, OR, United States of America

A pedal phalanx is the first diagnostic non-avian dinosaur fossil from Oregon. It was found with ammonites and an ichthyosaur centrum in the marine Early Cretaceous Hudspeth Shale near Mitchell, in central Oregon. The dinosaur was above the local first appearance of the cosmopolitan ammonite *Mortoniceras inflatum*, and below the local first appearance of *Mortoniceras fallax*, or 102.5-103.0 Ma (late early Albian). The Mitchell ornithopod, like the Early Cretaceous (late Aptian) Ono ornithopod from California, was a fragment drifted out to sea and not identifiable beyond the Suborder Ornithopoda. Comparison of the size of the toe bone with that of other Cretaceous ornithopod dinosaurs show it to be larger than *Tenontosaurus tilleti*, smaller than *Iguanodon bernissartensis*, and about the size of *Brachylophosaurus canadensis*. The broad, short dimensions of the medial phalanx indicate a graviportal and subunguligrade stance. The Ono ornithopod in contrast was substantially smaller, more similar to *Hypsilophodon foxii* in size. The association of the Mitchell phalanx with conifer wood and shoots suggests life in a coastal redwood forest.

Technical Session V (Thursday, October 18, 2018, 9:30 AM)

WHAT IS A MAMMALIAN OMNIVORE? INSIGHTS INTO OMNIVORE DIET DIVERSITY, BODY MASS, AND EVOLUTION

REUTER, Dana M., University of Oregon, Eugene, OR, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America; PRICE, Samantha A., Clemson University, Clemson, SC, United States of America

Mammalian omnivory has primarily been studied in the context of human and primate dietary evolution. However, humans make poor analogues for many other omnivores because we eat a wide variety of foods at all trophic levels. Some specialist omnivores are more limited in their dietary diversity and are not generalists that eat any available food. Just like carnivory and herbivory, omnivory should come with its own suite of physical and ecological constraints. Body size, morphology, and phylogenetic history could be limiting the ability to access and digest wildly different kinds of food materials. To date, there has not been a comprehensive study of how mammalian omnivores combine different food materials and the relationship between omnivore body size and diet type. This diet information is imperative for paleodiet reconstructions and can inform how omnivory evolves through time. Using a previously published diet dataset of 1,500 mammalian species (including 426 omnivorous species), we looked at the frequency that vertebrate protein, invertebrate protein, fibrous plant material, and nonfibrous plant material are eaten together. In addition, we examined the body size distributions and phylogenetic history of the omnivores consuming these different diets using phylogenetically-informed t-tests. Using stochastic character mapping, we assessed whether certain diet strategies are constrained along the mammalian tree. We found that most mammalian omnivores focus on invertebrates and nonfibrous plant parts, while omnivores that consume vertebrate protein are much less diverse. Among rodents, there is also a large diversity of insectivore- granivore lineages. Body mass does not seem to constrain the type of plant material consumed by omnivores, but omnivores that consume invertebrates are smaller than omnivores that consume vertebrate protein. Our study shows that certain omnivorous strategies, such as frugivory-insectivory, are more common than others as a result of higher rates of transition into those diet strategies. By examining the macroevolutionary pattern of diet evolution, we find that omnivory among mammals is rarely a generalist strategy and tends to evolve in ways constrained by evolutionary history and ecological opportunity.

Grant Information
NSF grant (DEB-1256897) to SAP and SSBH

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

EXPANDING THE NORTHERN RANGE OF *SMILODON FATALIS* (CARNIVORA, FELIDAE): DESCRIPTION OF THE FIRST SPECIMEN FROM CANADA (LATE PLEISTOCENE; MEDICINE HAT, ALBERTA)

REYNOLDS, Ashley R., University of Toronto & Royal Ontario Museum, Toronto, ON, Canada; SEYMOUR, Kevin L., Royal Ontario Museum, Toronto, ON, Canada; EVANS, David C., Royal Ontario Museum & University of Toronto, Toronto, ON, Canada

In the late 1960s and early 1970s, C.S. Churcher of the University of Toronto and A. MacS. Stalker of the Geological Survey of Canada conducted a fieldwork program aimed at documenting the Pio-Pleistocene stratigraphy and vertebrate faunas of the Canadian prairies. Churcher included the sabre-toothed cat *Smilodon* in the late Pleistocene fauna near Medicine Hat, Alberta in several published faunal lists without any supporting documentation. This occurrence constitutes the only record of *Smilodon* from Canada, and the most northern occurrence of this iconic taxon by approximately 1000 km. The material has never been described or illustrated, nor is it included in any of the major palaeontological databases. Here, we describe this material for the first time and assess its taxonomic identification. The material consists of a left proximal ulna and right proximal metacarpal V, which were ascribed to Smilodon by Churcher. The length and gracility of the ulna are more consistent with the scimitar-toothed cat *Homotherium*, which has been previously reported from the Pleistocene of Alberta, and we can not support its referral to *Smilodon*. However, the size and morphology of the metacarpal are consistent with *Smilodon*; it has a longitudinally-oriented articular surface for metacarpal IV, a proximal origin of the muscle scar on the palmar surface, and overall robustness that resembles specimens of *Smilodon*. Previously published dates for associated fauna with these specimens suggest that *Homotherium* was present at this locality approximately 40,000 calendar years before present (cal. ybp), while the *Smilodon* remains were deposited at around 30,000 cal. ybp, closer to the Last Glacial Maximum. Additionally, recent reports of *Homotherium* from Wally's Beach, Alberta suggest it was present at nearly 12,000 cal. ybp. Other large Pleistocene carnivores, including the American lion *Panthera atrox*, the dire wolf *Canis dirus*, and the short-faced bear *Arctodus simus*, have been reported from Alberta. This indicates that the large carnivore guild of the Canadian prairies during the Pleistocene was more complex than today and comparable to the Rancholabrean fauna of more southern localities, including Rancho La Brea in California.

Grant Information
NSERC Discovery Grant to DCE (Grant File Number: RGPIN 355845) Preparators' Session (Thursday, October 18, 2018, 3:00 PM)

MAINTAINING DATA LABEL INTEGRITY: A REVIEW OF MATERIALS AND TECHNIQUES FOR AFFIXING LABELS TO VERTEBRATE FOSSILS, HOUSINGS, AND COLLECTION STORAGE AREAS

RHUE, Vanessa R., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America

In order to track the identification and disposition of vertebrate fossils, specimens are often assigned catalog or locality numbers before being organized into a systematic or geochronostratigraphic arrangement. Assigning numbers and placing objects within a standard system is a common practice in paleontology. Yet many of us have experienced the frustration of data loss due to poor labeling materials or techniques. Paper deterioration can occur due to absorption of pollutants, insect damage, fluctuations in relative humidity and temperature, as well as UV and fluorescent light. Custodial neglect can result in equivocal association of data labels with the specimen. While digital methods for tracking specimen data may continue to advance, the need to manually label specimens and their storage containers will remain. Each specimen has a labeling history involving a suite of labeling materials and techniques from the time it is discovered in the field to its preparation in the lab to its curation for research or public display. During these stages, people of various expertise may handle or move the specimen to different physical locations. Every person entrusted with handling a specimen should take care to maintain the physical association of any data labels with the specimen. Developing a consistent method of labeling and a tool kit of materials and techniques is important. Selecting durable, long-lasting materials will help maintain the longevity of the information, but consideration should also be given to how labels are attached to the object, as well as the storage environment in which the specimen and label will reside. Examples of durable materials include the use of archival pens with light fast India ink, acid free Bristol cardstock, Tyvek, titanium white acrylic paint, and metal tags affixed with engraved or stamped numbers. Examples of methods for associating labels with specimens include, inserting labels directing into cavity mounts, using solution adhesives to affix labels to various surfaces, placing extra labels inside field jackets, using wire rivets, writing numbers on nested containers, encapsulating paper labels in mylar or polyethylene zip bags, and the use of plastic label sleeves with magnetic or adhesive backing for metal cabinets and oversize storage racks. Awareness of the physical properties of materials and how they behave in different storage environments over time is essential to maintaining data label integrity.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

STRATIGRAPHIC REEVALUATION OF THE HISTORIC STOVVALL DINOSAUR QUARRIES OF THE UPPER JURASSIC MORRISON FORMATION IN THE WESTERN PANHANDLE OF OKLAHOMA

RICHMOND, Dean R., University of Oklahoma, Norman, OK, United States of America; HUNT, Tyler C., University of Oklahoma, Norman, OK, United States of America Sam Noble Museum at the University of Oklahoma (OU) expanded the historical Morrison Formation Stovall Quarry 8 during the 2017 field season to discover Jurassic-aged microvertebrate fossils. This pursuit has prompted the reassessment of the stratigraphic relationships of the Stovall dinosaur quarries and the geologic reevaluation of the Morrison Formation in the western Oklahoma panhandle. Exposed in Cimarron County, Oklahoma and surrounding states, the Morrison Formation is bounded by regional unconformities at its base and top. The J5 unconformity lies either at the contact with the Lower Jurassic Exeter Sandstone or the Triassic Sheep Pen Sandstone. The K1 unconformity is located at the contact with the overlying Cheyenne Sandstone, or when the Cheyenne Sandstone is absent, the Kiowa Shale. Correlation of the stratigraphy is complicated by listric normal faults and sediment slumping within the formation in the research area. Several faults are present along the southeastern front of Black Mesa. Quarries 5, 6, and 8 each reside in a separate fault block. Each has a minor degree of rotation, but the internal stratigraphy of each remains intact. Several regional sections were measured, and the formation thickness averages 60 m. Formation thicknesses derived from regional measured sections were compared to additional historical sections and correlated to well logs.Locally, the Morrison Formation can be divided into three stratigraphic units based on depositional facies. The lower Morrison section consists of red mudstones and ripple laminated sandstones. Laterally extensive Magadi-type chert beds mark the top of this unit. The middle Morrison section is comprised of green mudstones and lacustrine limestones and sandstones. The upper Morrison section is comprised of green mudstones and fluvial channel sandstones. The identified quarries are referenced in relation to the formation base since the K1 unconformity has a very irregular and undulatory surface. The revaluated stratigraphic order of the quarries is as follows. Quarry 9 is the lowest historical quarry at 31 m. Quarry 8 is located at 34 m. Quarry 1, known for its *Saurophaganax* and its juvenile and large adult *Apatosaurus*, and Quarry 6 are both at 38 m. Quarry 5 is 39 m above the base of the formation and stratigraphically is the highest quarry. Morrison and Cheyenne sediments are slumped adjacent to the more recently discovered Homestead Quarry. The stratigraphic position of this quarry is ascertained to be 23 m above the base, making it the lowest quarry in the Morrison Formation of Oklahoma.

Technical Session XIV (Saturday, October 20, 2018, 10:45 AM)

DEEP-BODIED RAY-FINNED FISHES (OSTEICHTHYES, ACTINOPTERYGII) FROM THE PEDRA DE FOGO FORMATION IN NE BRAZIL AND THEIR PHYLOGENETIC AND PALEOGEOGRAPHIC AFFINITIES

RICHTER, Martha, The Natural History Museum, London, United Kingdom; CISNEROS, Juan C., Universidade Federal do Piaui, Teresina, Brazil; KAMMERER, Christian F., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; PARDO, Jason, University of Calgary, Calgary, AB, Canada; MARSICANO, Claudia A., Universidad de Buenos Aries, Buenos Aires, Argentina; FRÖBISCH, Jörg, Museum für Naturkunde, Berlin, Germany; SMITH, Roger, University of the Witwatersrand, Cape Town, South Africa; ANGIELCZYK, Kenneth D., Chicago, IL, United States of America

Laterally compressed, deep body morphologies are often associated with modern teleosts living in marine reef environments. However, this body shape was also acquired independently by diverse lineages of stem-actinopterygians, stem-neopterygians, ginglymodans, and halecomorphs, and is also widespread among modern fish species inhabiting non-marine ecosystems. There is strong evidence that these forms were common in non-marine paleoenvironments as well. Here we report the recent discovery of two deep-bodied ray-finned fishes from lacustrine deposits of the Parnaíba Basin (PB), discuss their ecological niche and systematic affinities, and explore the paleogeographic implications of deep-bodied fishes in distinct distantly-separated Permian basins of western Gondwana. Isolated deep scales belonging to actinopterygians are ubiquitous at certain levels of the Pedra de Fogo Formation, but this is the firsttime articulated skeletons have been found. The new specimens share with the platysomiformes *Guildayichthys*, *Discoserra*, and *Ebenaqua* a remarkable combination of characters including pronounced beak-shaped jaws and terminal mouth. They also exhibit a dentigerous premaxilla, maxilla and dentary; small, conical marginal teeth; lack of maxillary postorbital plate; elongated pectoral fins; posteriorly inclined suspensorium; and very deep flank scales ornamented with fine vertical striae. The roof and cheek bones of the new fish are ornamented with parallel ridges. Preliminary results from a phylogenetic analysis including 43 characters coded for 17 deep-bodied fish fossils from Brazil, North America, China, South Africa, and Australia suggest a strong taxonomic affinity between the two PB specimens (possibly representing the same species). The occurrence of deep-bodied fishes in the PB mirrors the presence of a similarly shaped taxon, *Paranaichthys longianalis*, in the upper Permian of the Paraná Basin of southern Brazil. *Paranaichthys* is distinguished from the deep-bodied PB taxon by its bulbous snout and flank scales that are about half as deep and longer than those of the PB specimens, with longitudinal ganoin ridges. The fact that the two basins share another relatively common fish genus, the petalodont chondrichthyan *Itapyrodus*, suggests that they were once geographically interconnected, allowing selective faunalinterchange.

Grant Information
National Geographic (9601-14), Negaunee Foundation, Grainger Foundation to KA; Sofja Kovalevskaja Award/Alexander von Humboldt Found. to JF; CNPq (Brazil) to JCC.

Technical Session X (Friday, October 19, 2018, 10:30 AM)

ISOTOPIC GEOCHEMISTRY AS AN INDEPENDENT ECOLOGICAL PROXY IN EXTANT AND EXTINCT LIZARDS: DIET AND ARIDITY IN EARLY EOCENE SQUAMATES

RIEGLER, Mitchell, Virginia Tech, Blacksburg, VA, United States of America; GILL, Benjamin C., Virginia Tech, Blacksburg, VA, United States of America; ANEMONE, Robert L., UNC Greensboro, Greensboro, NC, United States of America; NACHMAN, Brett, University of North Carolina Greensboro, Greensboro, NC, United States of America; STOCKER, Michelle R., Virginia Polytechnic Institute and State University, Blacksburg, VA, United States of America

Understanding ecology through time must acknowledge the dynamic relationship between an organism and its environment on multiple scales. The paleoecology (e.g., preferences, tolerances) of lizards over their evolutionary history is largely unknown. This paucity of data is a problem today because of the drastic climate change living species are currently experiencing. However, understanding a 'snapshot' of fossil lizard ecology does provide a deep-time perspective. Early Cenozoic hyperthermals were comparable to today's perturbations, and many Paleogene deposits preserve squamate fossils. Ecological inferences can be based on form equaling function (i.e., ecomorphology), correlating certain features (e.g., leaf-shaped dentition) with certain behaviors (e.g., herbivorous diet). Though this applies to certain taxa, there are numerous confounding examples. Ecology can also be inferred through indirect means (e.g., LMA), but these methods are disconnected from the taxon of interest. Stable isotope geochemistry, however, provides an independent test for several ecological parameters (e.g., diet, rainfall). We developed a novel method examining isotopic ratios in enamel as a proxy for paleoecology and applied it to the teeth of extant lizards, providing new data testing the connection between squamate morphology, their diets, and the environments they occupy. We analyzed stable isotope ratios ($\delta^{18}O$, $\delta^{13}C$) in an extant collection of five lizard species representing a range of known diets. We found trophic separation in $\delta^{13}C$ values, and indications of aridity through $\delta^{18}O$ values. We applied this framework to extinct squamates from an early Eocene (Wa4) assemblage, a key time between two major global warming events (Paleocene– Eocene Thermal Maximum and Early Eocene Climatic Optimum). We identify xenosaurid and glyptosaurine squamates as well as alethinophidian snakes. The xenosaurid is one of the youngest representatives of *Restes rugosus*, and we provide the first testable hypothesis of its ecology. We performed geochemical analyses on the two extinct lizards, as well as on mammalian teeth and gar scales from the same locality to test for originality in the signal. The $\delta^{18}O$ values corroborate prior hypotheses of a wet, tropical environment, and the $\delta^{13}C$ values indicate an insectivorous or carnivorous diet for both lizard taxa. Our study provides an independent test of ecology for both extant and fossil squamates, with implications for differing survivorship throughout the early Cenozoic.

Grant Information
Funding was provided by the Geological Society of America, Virginia Tech, and NSF-BCS 1227329.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

NEW DATA ON THE ANATOMY OF *DIPLOCYNODON HANTONIENSIS*, A LATE EOCENE ALLIGATOROID FROM THE UNITED KINGDOM

RIO, Jonathan P., Imperial College London, London, United Kingdom; MANNION, Philip, Imperial College London, London, England; MARTIN, Jeremy E., University of Lyon, Villeurbanne, France; TSCHOPP, Emanuel, American Museum of Natural History, New York, NY, United States of America; DELFINO, Massimo, University of Turin, Turin, Italy

Diplocynodon is a basal alligatoroid known from abundant remains, representing nine species, spanning the late Paleocene to middle Miocene of Europe. Despite recent revisions of most *Diplocynodon* species, one of the earliest named and most complete, *Diplocynodon hantoniensis*, has not been redescribed for over 150 years. This species is known from the remains of numerous individuals from the Priabonian (late Eocene) Headon Hill Formation, which crops out at Hordwell Cliff in Hampshire, United Kingdom. Here we redescribe and diagnose *Diplocynodon hantoniensis*, for the first time presenting a detailed description of its axial and appendicular skeleton. The Hordwell Cliff collection comprises both juvenile and mature individuals, allowing an assessment of the morphological variability through ontogeny of the species. *D. hantoniensis* retains a pterygoid process (ectopterygoid-pterygoid flexure) into maturity, a feature previously unrecognised in the species and otherwise known only in Caimaninae. A discrete step in the frontal, anterior to the orbits, occurs in juvenile specimens, which is lost in ontogeny, and the 4thdentary tooth ontogenetically transitions from a closed pit to an open notch at the premaxilla-maxilla suture. We include *D. hantoniensis* in a phylogenetic analysis of 97 operational taxonomic units and 179 characters using parsimony in TNT. 18 revisions are made to existing character scores, and a large sample of *Diplocynodon* species is included. The strict consensus of the resulting 223 most parsimonious trees recovers a monophyletic *Diplocynodon*, with a topology consistent with previous studies. *D. hantoniensis* is distinguished from its congeners by a number of autapomorphies, including: (1) a deep notch posterolateral to the external naris, comparable to *Alligator mississippiensis*; (2) prominent pre-orbital ridges developed on the lacrimals; (3) placement of the quadraojugal-jugal suture at the posterior angle of the infratemporal fenestra; (4) presence of a prominent surangular spur adjacent to the posteriormost dentary alveoli; and (5) a surangular-angular suture which meets dorsal to the articular ventral tip. Our comprehensive revision of one of the most completely known *Diplocynodon* species facilitates comparisons within the genus, as well as with other basal alligatoroids, and for the first time presents a detailed description of its postcranial skeleton. The latter is frequently neglected in studies of crocodylomorph anatomy, and yet is a potentially rich source of new characterdata.

Grant Information
J.P.R. is funded by a NERC Ph.D. studentship.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

UNDERSTANDING ADULT EDUCATION: AN ANALYSIS OF THE DEVELOPMENT OF AN ADULT PROGRAM AT THE STERNBERG MUSEUM OF NATURAL HISTORY

RIVERS, Katharine M., Fort Hays State University, Hays, KS, United States of America

The Sternberg Museum of Natural History (FHSM) located in Hays, KS has a history of hosting successful educational events for children. However, attendance for adult programs has not been as strong. This study aims to add to the understanding, development, and implementation of adult education programs in order to improve FHSM's adult attendance. Previous studies have primarily investigated methods for developing programs qualitatively. This study creates a quantitative approach by: (1) investigating a previously hosted adult program by other natural history museums across the United States using surveys; (2) collecting and analyzing survey results. Additionally, the success of the surveyed event is quantitatively measured by: (3) the audience size in relation to the population of the surrounding region of the museum (attendees per capita), and profits from the event (in U.S. Dollars, if it is ticketed); (4) using survey results to develop a template for creating an adult program at FHSM; (5) implementing the template by hosting an event at FHSM; and (6) measuring the overall success of the event using attendance and ticket sales as metrics.

The surveys collected from other natural history museums facilitated the development of adult programs at FHSM by using information collected from previous events. Survey metrics include: event description, day and time it is held, if food/beverages are provided, intended target audience, and marketing efforts. Participating museums varied in size and location, which helped to model program success across diverse demographics. Based on the feedback of the surveys, this FHSM hosted event included a separate children's area, food, beverages, and a fun event theme to create a relaxing and enjoyable atmosphere for visitors. The separate children's event was added so that adults could forgo hiring a babysitter. The main event encouraged adults to use self-directed learning to interact with museum staff who explained the biology and ecology of the organisms within the Western Interior Seaway (WIS). Afterwards, visitors applied their new knowledge about the WIS to participate in a pirate themed "murder mystery" set in the Cretaceous. Various techniques were used to create a relaxed and welcoming environment and avoid a lecture or classroom setting. Success of the event was measured by the number of adults in attendance and the total profits from ticket sales.

Technical Session I (Wednesday, October 17, 2018, 10:45 AM)

EVOLUTION OF DINOSAUR AXIAL SKELETON DIVERSITY: EVOLUTIONARY DRIVERS AND DEVELOPMENTAL MECHANISMS

ROBERTS, Lucy E., University of Cambridge, Cambridge, England; HEAD, Jason J., University of Cambridge, Cambridge, United Kingdom

Dinosauria exhibits extraordinary axial skeletal diversity in the evolution of extreme body forms, ranging from gigantism in sauropods to powered flight in birds. Developmental mechanisms underpinning this diversity are unobservable outside of crown Aves, restricting our ability to understand their roles as evolutionary drivers of diversity. Osteological correlates to developmental processes in extant model taxa do permit inferences of the role of development in the evolution of dinosaur axial diversity when examined in a comparative phylogenetic context, however. In order to infer developmental

histories in dinosaurian axial skeletal evolution, we mapped discrete vertebral characters, including cervical, thoracic, and lumbar anatomies, as well as vertebral numbers, onto phylogenetic hypotheses and used Maximum Likelihood ancestral state reconstruction to estimate evolutionary histories. Among higher-order clades, sauropods show no distinct change in total vertebral number through their phylogeny, but cervical counts do increase across the group and dorsal numbers decrease, consistent with homeotic shifts in regional boundaries. Among ornithischians, ornithopods display an increase to absolute vertebral number as both cervical and dorsal counts increase in correlation with presacral counts. This pattern suggests changes in rates of somitogenesis, as opposed to homeotic transformations, underpin evolutionary changes in axial skeletal morphology. Theropods exhibit a less straightforward pattern of vertebral count evolution compared to sauropods and ornithichians. Cervical number changes very little across the non-avian theropod tree, whereas dorsal number increases and decreases variably. Basally crown birds exhibit an increase in cervical number and a decrease in dorsal number, similar to sauropods. This suggests a homeotic shift early in crown bird evolution. However, some clades, includingPasseriformes and Psittacidae, show decreases to both cervical and dorsal counts, indicating that changes in somitogenetic rate has driven change across these groups. Our results suggest that multiple developmental drivers generated axial diversity across Theropoda, including variable change to somitogenesis and homeotic shifts. These results offer insight into the underpinning causes of vertebral diversity, and provide a starting point for further study across Reptilia.

Grant Information
NERC ESS Studentship to Lucy Roberts

Technical Session XVIII (Saturday, October 20, 2018, 4:00 PM)

DENTAL MICROWEAR OF NORTH AMERICAN TAENIOLABIDOID MULTITUBERCULATES

ROBSON, Selina V., University of Calgary, Calgary, AB, Canada; SCOTT, Craig, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; THEODOR, Jessica M., University of Calgary, Calgary, AB, Canada

Multituberculates were among the most taxonomically diverse mammals of the Mesozoic and early Cenozoic, and comprise the longest-lived mammalian clade. Although most multituberculates are considered to have been omnivorous or insectivorous, one group, the Taeniolabidoidea, is characterized by a suite of dental adaptations that suggests a primarily herbivorous diet. Furthermore, recent work employing orientation patch count analysis (OPC), a measure of dental complexity, has confirmed that at least some of the larger taeniolabidoids may have been herbivorous. While dental complexity measures such as OPC are useful, they require three-dimensional dental reconstructions that can be difficult to obtain. An alternative approach is the study of dental microwear, which has been frequently used as a proxy for the diets of extinct animals. Microwear analyses examine the patterns of pits and scratches on the surface of a tooth to infer the physical properties of food items. We examined the dentitions of taeniolabidoids to determine whether microwear could be used to detect herbivory in multituberculates. Most North American taeniolabidoids (*Taeniolabis taoensis*, *Catopsalis calgariensis*, *Catopsalis fissidens, Catopsalis alexanderi*, *Valenopsalis joyneri*, *Catopsalis kakwa*) were included in the analysis, with the non-taeniolabidoids *Meniscoessus major* and *Cimolomys primaevus* included for outgroup comparisons. The sample was limited to cusps in the lingual cusp row of the lower first molars. All cusps with microwear were included, regardless of their position in the cusp row. Because of the small size of the teeth, scanning electron microscopy (SEM) was used to capture high-resolution images of the microwear. Two 0.1 x 0.1 mm regions of interest were circumscribed on each image, and microwear was categorized based on coarse and fine scratches, large and small pits, and gouges. A preliminary analysis indicates that there are no significant differences in microwear between taxa. However, a visual inspection suggests that there are differences in microwear, with larger taxa having more coarse features and fewer parallel scratches. The lack of statistical significance may be a result of a low sample size; a future analysis will include lower second molars as well as upper molars. Some of the microwear signal may also be obscured because the multituberculates were possibly ingesting large amounts of exogenous grit while feeding close to the ground.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE MICROVERTEBRATE FISH FAUNA OF THE HAYDEN QUARRY, GHOST RANCH, NEW MEXICO: IMPLICATIONS FOR PRESERVATIONAL ENVIRONMENT AND CHINLE BIOSTRATIGRAPHY

RODGERS, Samuel J., SUNY College at Oswego, Oswego, NY, United States of America; IRMIS, Randall, University of Utah, Salt Lake City, UT, United States of America; SMITH, Nathan, Natural History Museumof Los Angeles County, Los Angeles, CA, United States of America; STOCKER, Michelle R., Virginia Polytechnic Institute and State University, Blacksburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America; PRITCHARD, Adam C., National Museum of Natural History, Washington, DC, United States of America; OLORI, Jennifer C., SUNY College at Oswego, Oswego, NY, United States of America Microvertebrate fossils are an under-utilized resource for biostratigraphy and paleoecology. This is especially true in the early Mesozoic, where emphasis has been placed on macrovertebrates, leading to a poor understanding of wider community structure. The Upper Triassic Hayden Quarry (HQ) in northern New Mexico contains a dense assemblage of Norian-aged macro- and microvertebrate fossils of archosauromorphs, stem reptiles, early tetrapods, and fishes. Despite the utility of fish fossils for biostratigraphy and paleoecology, as with many Chinle localities, the HQ fish fauna is virtually unknown. We collected, described, and analyzed specimens from HQ in order to characterize taxonomic diversity and preservational context. We used scanning electron microscopy (SEM) to obtain detailed images of screenwashed specimens and electron diffraction spectroscopy (EDS) to investigate potential taphonomic differences between fish and tetrapod fossils. EDS revealed consistent general chemistry across all material, and barite and other minerals confirmed that HQ fossils, including tetrapods, were preserved within the fluvial deposits. Fish remains include abundant scales, isolated teeth, intact jaws with teeth, other skull bones, fin rays, and vertebrae. Following an apomorphic approach, identifiable remains include hybodontid shark teeth referable to *Polyacrodus* and *Reticulodus*; redfieldiid rostral and dermal material; other actinopterygian teeth; a partial braincase of the coelacanth *Chinlea*; phyllodont toothplates; and dermal bones and teeth from additional osteichthyans. The hybodontids, along with enigmatic, hexagonal, batoid- like teeth, represent rare occurrences of chondrichthyans, and the only known occurrence of *Reticulodus,* within the Chinle Formation in the Chama Basin. Pycnodont-like teeth, otherwise unknown from the Chama Basin, also were recovered, and may represent an unusual occurrence of pycnodonts in freshwater deposits. Taxonomic diversity and preservational context was similar to that of the nearby Snyder Quarry, and preliminary comparisons of biozones suggest that these quarries may be correlative. However, faunas from both sites require refined taxonomic resolution under an explicitly apomorphic approach. A revised taxonomic framework will be critical for revising other sites in northern New Mexico (e.g., Canjilon Quarry, Coyote Amphitheatre) that have poorly characterized microvertebrate assemblages and present long-standing problems for Chinle biostratigraphy.

Grant Information
NGS 9849-16 to JCO, NSF EAR 1349667 to SJN, NSF EAR 1349654 to AHT, NSF EAR 1349554 to NDS, NSF EAR 1349650 to RBI.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

INVESTIGATING DIETARY NICHE PARTITIONING IN THE EARLIEST NORTH AMERICAN EUPRIMATES *TEILHARDINA* AND *TETONIUS* (ANAPTOMORPHINAE), AND *CANTIUS* (NOTHARCTINAE) USING HIGH RESOLUTION PROFILOMETRY AND DENTAL TOPOGRAPHIC ANALYSES

RODWELL, Ben W., Colorado State University, Fort Collins, CO, United States of America; NICHOLS, Kimberly A., Colorado State University, Fort Collins, CO, United States of America; BOWN, Thomas M., Colorado State University, Fort Collins, CO, United States of America

Dental Topographic Analysis (DTA) provides a method for quantifying aspects of the gross morphology of teeth that correspond with functional processing of foods. In extant primates and other mammals these measures are accurate in distinguishing individual taxa based on primary dietary components. In this study, DTA is applied to examine niche partitioning among three contemporary genera belonging to two subfamilies of the earliest known North American euprimates (*Teilhardina* and *Tetonius*, Anaptomorphinae; *Cantius*, Notharctinae). Using a Nanovea high resolution white-light confocal profilometer, 3-D models of the lower second molars of *Teilhardina*, *Tetonius*, and *Cantius* were generated and analyzed using three dental topographic metrics: Dirichlet Normal Energy (DNE), Orientation Patch Count Rotated (OPCR), and Relief Index (RFI). DNE is a measure of curvature across the tooth surface, OPCR measures the relative complexity of the occlusal surface, and RFI provides a measure of the relative amount of topographic relief or relative amount of food processing surface of a tooth. Body mass estimates and shearing ratios were also calculated. A Kruskal-Wallis test with post hoc Mann-Whitney pairwise comparisons, principal coordinate analysis, and linear discriminant analysis were conducted between taxa. Results indicate that the adapoid *Cantius*, occupied separate dietary niche space from the Omomyoids *Teilhardina* and *Tetonius*, supporting early ecological divergence of North American euprimates.

Technical Session XVII (Saturday, October 20, 2018, 2:45 PM)

POSTCRANIAL MORPHOLOGY AND THE LOCOMOTOR ADAPTATIONS OF EXTANT AND EXTINCT CROCODYLOMORPHS AND LEPIDOSAURS

ROONEY, Laura A., East Tennessee State University, Deer Park, NY, United States of America; SAMUELS, Joshua X., East Tennessee State University, Johnson City, TN, United States of America

Studies have shown that the morphology of the postcranial skeleton reflects the locomotor behavior of extant vertebrate taxa. Morphometric analyses can also be used to infer the locomotor modes of extinct taxa based on their morphological similarity to extant groups. Such studies have been conducted on many groups of mammals, however studies on reptiles are less common. Because semi-aquatic, arboreal, and terrestrial locomotor specialists are seen in multiple groups of extant reptiles, among both crocodilians and lepidosaurs, the group provides the opportunity for examining potential convergent or parallel evolution within clades.

We have collected a series of linear measurements of the postcranial skeletons of 43 extant crocodilian and lepidosaur taxa to determine if those engaging in similar locomotor behavior display similar morphology despite phylogenetic differences. A stepwise discriminant function analysis using 22 osteological indices reveals reptile locomotor mode can be accurately predicted (over 80% correct) based on morphology. Semi-aquatic taxa are distinguished by a longer scapula relative to humerus length, a longer ischium relative to pubis length, and a broader acetabulum diameter than in terrestrial and arboreal taxa. These features may reflect adaptations to increase surface area for the attachment of muscles used in lateral undulations of the tail during aquatic locomotion and to support the mass of this tail during terrestrial locomotion. Arboreal taxa display a more elongate, gracile humerus and a smaller acetabulum. Semi-aquatic lizards from four families show parallel divergences from their terrestrial relatives, suggesting similar evolutionary responses in both lepidosaurs and crocodylomorphs. This morphometric data can potentially be used to predict the locomotor behavior of a wide range of extinct reptile taxa, including both archosaurs and lepidosaurs. Within this study, five extinct crocodylomorph taxa were examined including *Hyposaurus rogersii*, *Necrosuchus ionensis*, *Alligator* sp. of the Gray Fossil Site, *Crocodylus affinis*, and *Allognathosuchus mooki*, all of which were inferred to be semi-aquatic by the discriminant function analysis.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

PTEROSAUR REMAINS FROM THE LATE CRETACEOUS OF AFRO-ARABIA PROVIDE INSIGHT INTO PTEROSAUR DIVERSITY AND FLIGHT CAPACITY

ROSENBACH, Kierstin L., University of Michigan, Ann Arbor, MI, United States of America; WILSON, Jeffrey A., University of Michigan, Ann Arbor, MI, United States of America; ZALMOUT, Iyad S., University of Michigan, Ann Arbor, MI, United States of America

Pterosaurs are an extinct clade of Mesozoic flying archosaurs, the largest of which appeared in the Late Cretaceous and reached wingspans of up to 12 meters. These large, late-appearing pterosaurs have been grouped together within Azhdarchidae, which has been regarded as the predominant pterosaur lineage during the Late Cretaceous. However, recent phylogenetic studies have not recovered a monophyletic Azhdarchidae, and recent reports identify other groups present in the latest Cretaceous (pteranodontids, nyctosaurids). This raises questions about patterns of pterosaur diversity at the end of the Mesozoic. Additionally, despite having a fossil record characterized by several exceptional fossil deposits (e.g., Solnhofen, Yixian, Crato, Niobrara), pterosaur fossils are rarely preserved in three dimensions. This aspect of their fossil record has limited insights into pterosaur flight mechanics.

Here we discuss Late Cretaceous pterosaur diversity and flight capability in light of new pterosaur remains recovered from Maastrichtian sediments of Jordan. This material represents the giant pterosaur *Arambourgiania* (ca. 10 m wingspan) and a new, smaller species (ca. 5 m wingspan). Both specimens consist of wing elements that preserve the original three-dimensional geometry of the bone as well as internal bone structure. We used high-resolution micro-computed tomography (μCT) to create three-dimensional models of these wing elements for the investigation of flight capacity using birds as a modern analog. Birds exhibit adaptive remodeling of internal wing bone structure in the form of struts and ridges; this response to the mechanical stresses of flight correlates with flight style. μCT scans reveal that similar structures are also present in the wing bones of these pterosaurs. The humerus of *Arambourgiania* exhibits a series of helical ridges formed along the cortical bone, whereas the smaller species exhibits a denser pattern of hollow struts. These preliminary results suggest that the smaller species has internal morphology similar to that of flapping birds, whereas *Arambourgiania* has internal morphology similar to that of gliding or soaring birds.

Grant Information
American Chemical Society Petroleum Research Fund (PRF 46006-E8 to JAW)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ANALYSIS OF MIOCENE SHARK TEETH DISTRIBUTION: COLLECTION FROM THE CALAVERAS DAM SITE, CALIFORNIA

ROSS, Xena L., University of California, Berkeley, CA, United States of America; ROBINS, Cristina M., University of California, Berkeley, CA, United States of America; WALKER, James P., Applied Technology and Science, San Francisco, CA, United States of America

Shark teeth are commonly discovered in Neogene rocks of the eastern Pacific. The taxonomic composition can be used to provide important paleoenvironmental information, including water depth and salinity. The rebuilding of the Calaveras Dam in the San Francisco Bay Area revealed a large suite of Miocene fossils from previously un- and understudied strata, allowing us to examine a new collection found near the mouth of the inland sea that once filled California. The taphonomy of the area is convoluted, consisting of shallow- and deep-water taxa with terrestrial input. Calaveras has produced fossil material of thousands of organisms, and numerous shark teeth have been found throughout the fossil assemblage. The interaction between sharks and other marine creatures is still unclear, but the shark teeth have been discovered in association with many of these creatures, primarily with many of the whales that have been extracted from the site.

Thus far, over 175 teeth have been collected and identified. A faunal study shows representation of at least 13 genera, with 156 of the total teeth currently identifiable to species level. Over half of the specimen sample is composed of selachimorphan teeth belonging to the genera *Isurus* (mako sharks) and *Carcharhinus* (requiem sharks). The Identification method that was utilized most often to identify the teeth was comparative analysis between this site and other samples from California, primarily those from Shark Tooth Hill. The data indicates the majority of the teeth belong to sharks that are typically found in the euphotic zone, though there are small samples of deepwater shark species such as *Hexanchus microdon*, implying significant depth at certain areas of the Calaveras site. The shark teeth from the Calaveras site closely resemble the variety of species found at Shark Tooth Hill, as well as those found in Panama. The sample studied also bears similarity to teeth samples discovered in the Atlantic region at Calvert Cliffs, though Calaveras produced a different distribution of teeth, shown through a greater variation in *Isurus* shark teeth and less variation in other genera such as *Galeocerdo* and *Hemipristis*. The shark teeth collected from the Calaveras Dam site present valuable information pertaining to the zoological make-up of the Pacific region of Northern America. The variety of teeth allows us to better understand Miocene ecosystems and more accurately imagine what the earth looked like over 15 million years ago.

Grant Information
This research was supported by the San Francisco Public Utilities Commission.

Technical Session XV (Saturday, October 20, 2018, 10:45 AM)

COMMUNITY STANDARDS FOR 3D DATA PRESERVATION: OWNERSHIP OF 3D DATA

ROUNTREY, Adam N., University of Michigan, Ann Arbor, MI, United States of America; LEVINE, Melissa S., University of Michigan Library, Ann Arbor, MI, United States of America

We present background information, case studies, and issues that must be addressed as part of the growing use and re-use of 3D specimen data in paleontology. This discussion emerged as part of the Community Standards for 3D Data Preservation (CS3DP) project. CS3DP is a collaborative, interdisciplinary effort to develop standards for documentation, preservation, and dissemination of 3D data, including surface and volume data derived from natural history specimens. With the increasing availability and efficiency of scanning technologies, many institutions and labs find themselves at a transition point requiring managed repositories and standardized documentation for 3D data. Yet, our 2017 survey results indicated that most researchers/creators of 3D content are not using documented standards. If they do so at all, they are using standards developed as their own in-house systems. Nearly all survey respondents desired to collaborate to develop standards as a community, recognizing that the accreting number of incongruent customized solutions can present barriers to aggregation, access, and preservation. CS3DP began in 2018 with a national forum event and ongoing virtual meetings. Participants include researchers, librarians, metadata specialists, museum workers, 3D specialists, lawyers, and artists. Areas of interest include "best practices", management and storage, metadata, accessibility, and ownership. Here, we focus primarily on legal concerns like copyright, tensions between open data and the need for security in some cases, and ownership as a legal and ethical concept often shaped by professional practice. In most scientific disciplines utilizing 3D data, there is a need to share information openly with the scientific community or the public. However, researchers and institutions have an interest in the right of attribution, that is, they want to be recognized as the creator or source of the original data (and potentially not the source of versions modified by others). This attribution is also critical for end users in identifying "authoritative" data sets. While licenses, such as Creative Commons (CC), can be used to require attribution, a 3D data set derived from natural history specimens is generally not subject to copyright. Thus, CC licenses cannot be applied. We discuss alternatives that allow open-access while preserving attribution and other rights. Putting appropriate, meaningful protections in place should encourage researchers and institutions to be more open in sharing data, benefiting the field.

Grant Information
Institute of Museum and Library Services LG-88-17-0171-17

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

BIOMECHANICS OF JUVENILE TYRANNOSAURID MANDIBLES AND THEIR IMPLICATIONS FOR TYRANNOSAURID BITE FUNCTION

ROWE, Andre J., University of Wisconsin - La Crosse, La Crosse, WI, United States of America; SNIVELY, Eric, University of Wisconsin - La Crosse, La Crosse, WI, United States of America; RIDGELY, Ryan, Ohio Univ, Athens, WI, United States of America; WITMER, Lawrence M., Ohio Univ, Athens, OH, United States of America

The tyrannosaurids are renowned for their relatively large body size, robust skulls, and small forelimbs. The robustness (depth relative to length) of tyrannosaurid mandibles increased with body size. Based on previous 2D studies, we used 3D finite element analyses (FEA) to test the hypothesis that, scaled to equivalent mandible lengths or surface areas, younger tyrannosaurids would experience stress and strain comparable to adult tyrannosaurids. We included the small-bodied tyrannosaur *Raptorex kriegsteini* (LH PV18) with subadult (BMRP 2002.4.1) and adult (FMNH PR 2018) *Tyrannosaurus rex* as a proxy ontogenetic series.

With normalized muscle forces, von Mises and principal stresses diminished predictably in the larger tyrannosaurid specimens. Ligaments between the dentary and post-dentary bones experienced moderate strains, which decreased stress and strain at the teeth. This suggests that ligaments within mandibles consisting of several bones reduce stress on the alveolar ligaments, and facilitate high bite force in tyrannosaurids and other reptiles.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

TRACKWAY OF A SIDEWAYS-WALKING BASAL TETRAPOD IN THE PENNSYLVANIAN MANAKACHA FORMATION OF GRAND CANYON NATIONAL PARK

ROWLAND, Stephen M., University of Nevada Las Vegas, Las Vegas, NV, United States of America; CAPUTO, Mario V., San Diego State University, San Diego, CA, United States of America

A recent rockfall along the Bright Angel Trail in Grand Canyon National Park produced two blocks of fine-grained quartz arenite from the Pennsylvanian (Atokan) Manakacha Formation. The two blocks display part and counterpart surfaces containing a conspicuous vertebrate trackway consisting of 28 tracks, preserved as impressions on one block and natural casts on the opposing block. The trackway extends about 1.0 m across the width of the fallen blocks. Individual tracks are plantigrade, with round sole impressions and three forward-directed digits. Pes and manus tracks are approximately the same size, about 5 cm long. We tentatively assign this trackway to the ichnogenus *Chelichnus*, which is well known from the Permian Coconino Sandstone but has never before been reported from pre-Permian strata anywhere in the world. Based primarily on the age of the tracks, we infer that the trackmaker was a basal tetrapod of unknown taxonomic affinity.

The trackway-bearing interval is typified by a reddish-brown, regularly interbedded succession of: (1) tabular, cliff-forming, sandstones of well-sorted, rounded to subrounded, fine-to-medium-grained quartz in beds 2.0–4.0 m thick, comprised of 1–3 cross-bed sets with sandflow beds wedging down-dip into wind-ripple laminations; (2) recess-forming mudstone partings ≤ 0.1 m thick, and locally bioturbated mudstone, and (3) siltstone beds 0.5–2.0 m thick, loaded by and squeezed-up into overlying sandstones. Our tentative paleoenvironmental interpretation places the trackmaker along the margin of an eolian dune field that was periodically interrupted by fluvial overbank sedimentation.

This Bright Angel Trail trackway is unusual for two reasons. First, it is the first reported vertebrate trackway in the Manakacha Formation and the oldest in Grand Canyon. Several trackways have been reported from the overlying Wescogame Formation, but no vertebrate tracks have previously been reported from the Manakacha Formation. Second, the animal that produced this trackway had an unusual sideways-walking gait; individual tracks are pointed in a direction that differs by 40° from the trend of the trackway itself. The result is an unusual trackway consisting of a series of parallel rows of tracks; each row consists of four tracks, and each row is offset to the right approximately 20 cm, in comparison with the previous row. Our tentative interpretation is that this sideways-walking gait records the influence of a strong wind that was pushing this animal toward the right while it struggled to move forward.

Technical Session VII (Thursday, October 18, 2018, 1:45 PM)

FURTHER INVESTIGATION OF THE SOFT-TISSUE ANATOMY AND WING CONFIGURATION OF THE 'BAT-WINGED' PENNARAPTORAN DINOSAUR *YI QI*

ROY, Arindam, University of Hong Kong, Pokfulam, Hong Kong (CN); PITTMAN, Michael, University of Hong Kong, Pokfulam, Hong Kong (CN); KAYE, Thomas G, Foundation for Scientific Advancement, Sierra Vista, AZ, United States of America; WANG, Xiaoli, Linyi University, Linyi City, China; ZHENG, Xiaoting, Shandong Tianyu

Museum of Nature, Pingyi, China; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China
Yi qi is a scansoriopterygid theropod dinosaur represented by a single ~160 million year old specimen (STM 31-2; Shandong Tianyu Museum) that preserves several peculiar anatomies. STM 31-2 sports paintbrush-like filamentous feathers and forelimbs associated with elongated, rod-like 'styliform elements' thought to support patagial membranes. The strange membranous wings of this animal are highly disparate from the feathered wings of avian theropods and has earned *Yi qi* the moniker 'bat-winged dinosaur'. This iconic fossil was studied using Laser-Stimulated Fluorescence (LSF) for the first time to try and clarify the morphology of reported membranous patches as well as the configuration of the styliform element of the wrist. LSF has successfully revealed unseen soft-tissue anatomy in paravian fossils from similar localities through differential fluorescence under 405nm violet laser illumination. This typically reveals soft tissues in bright orange and 'backlights' feathering to uncover new detail. In this study, all previously identified textured membrane patches exhibited negligible fluorescence under LSF. However, for the first time, LSF revealed multiple patches of orange-coloured suspected soft tissue around the cranial bones as well as an ungual sheath. These results appear to have two alternative explanations that deserve further investigation: (1) differential, chemical replacement of the soft and hard tissues of the fossil; and (2) the reported membrane patches are poorly preserved clumped filamentous feathers. Through LSF backlighting, we also identified additional morphological details of the semilunate carpal and radiale. The radiale angle of *Yi qi* (angle between the proximal face of the radiale and the facet articulating with the semilunate carpal) is ~40–50°, similar to the ancestral condition in paravians, but smaller than in oviraptorosaurs. A larger radiale angle facilitates larger angles of abduction of the wing towards the ulnar side of wrist, as seen in the range of abduction angles along the pennaraptoran lineage to modern birds (~62–123°). The radiale angle and angle of wing abduction of *Yi qi*, when compared with orientations of the styliform element proposed in bat, pterosaur, maniraptoran and frog models, indicate that the maniraptoran wing model was least restrictive to bird-like folding of the wings and was probably the most likely configuration for *Yi qi*.
Grant Information
This project was supported by a Jurassic Foundation Award and a Hong Kong PhD Fellowship (both to AR).

Technical Session VI (Thursday, October 18, 2018, 11:30 AM)

RICH OCCURRENCES OF CAPITOSAUR AMPHIBIANS FROM THE MIDDLE TRIASSIC DENWA FORMATION OF CENTRAL INDIA
ROY, Pummy P., Geological Survey of India, Kolkata, India; SENGUPTA, Dhurjati P., Indian Statistical Institute, Calcutta, India; CHAKRAVORTI, Sanjukta P., Indian Statistical Institute, Kolkata, India
The Middle Triassic Denwa Formation of Satpura Gondwana Basin of India recently yielded a huge amount of temnospondyl remains belonging to the family Capitosauridae. Almost 13 complete skulls, 16 mandibles, and nearly 200 other postcranial bones of *Cherninia denwai, Paracyclotosaurus crookshanki*, and a new species of *Cherninia* have been recovered from Denwa. Three skulls represent *C. denwai*, six represent *P. crookshanki.* The new species has four skulls. The new species of *Cherninia*, like *C. denwai* and *C. megarhina*, is characterised by a parabolic snout with parallel lateral sides of the skull and flared cheek region. A longitudinal ridge starts from the anterior of the orbit of all those species of *Cherninia*, which bifurcates at the prefrontal. The new species is distinguished by straight, posteriorly protruded and pointed tabular horns, comparatively larger nasals and constricted parasphenoid and narrow palatine ramus of the pterygoid. *C. denwai* has a tabular horn which unlike the new species, is postero-laterally directed and re-curved distally. *P. crookshanki* has triangular skull and curved lappet-like tabular horns with semi-closed otic notches. The Denwa Formation can be broadly divided into three horizons based on the lithology. The basal part is unfossiliferous. The middle part with violet mudstone has *C. denwai* and the upper part has red mudstone with *P. crookshanki* and the new species. Thus, the Denwa capitosaurs show two distinct biozones that are lithologically distinct as well. Worldwide, *Cherninia* occurs in the Anisian and *Paracyclotosarus* in the Ladinian. In that sense *C. denwai* should occur in younger horizon than *P. crookshanki*. However, the presence of a new species of *Cherninia* along with *P. crookshanki* in upper Denwa is unusual. Thus, India becomes unique in having a species of *Cherninia* and *Paracyclotosaurus* each, in the upper part of the Denwa Formation. *Cherninia* is found in Gondwana while *Paracyclotosaurus* is both Gondwana and Laurasia. Hence, the upper part of Denwa has temnospondyls that are more Pangaean than the temnospondyls of the middle part. The capitosaurs of Denwa thus helps to understand the geological and paleontological history of the formation and becomes useful in correlating Denwa with the coeval beds around the world.
Grant Information
The authors are thankful to Indian Statistical Institute, Kolkata, for providing funds and infrastructural facilities for carrying out the research.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A JUVENILE BADGER, *MELES LEUCURUS*, FROM THE PLEISTOCENE–HOLOCENE OF KYRGYZSTAN
ROYER, Julien, University of Oregon, Eugene, OR, United States of America; MCLAUGHLIN, Win N., University of Oregon, Eugene, OR, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America
We describe a partial skeleton of a juvenile badger, the first described Pleistocene–Holocene carnivoran from the Tien Shan mountains. This specimen differs from the much older previously collected fossil record of Kyrgyzstan, with most previous and ongoing work concentrated on the Miocene–Pliocene, dominated by large ungulates. Russian geologists discovered this specimen while mapping regional faults and reconstructing uplift rates in the QIII terrace (the regional convention for naming uplifted terraces) of the Pleistocene sediments of Kochkor Basin in the Kyrgyzstan Tien Shan mountains. The carnivoran fossil was recovered from the QIII terrace, with a calibrated estimated age of 20,000–5,000 years BP through carbon dating of other QIII terraces. A vertebra, rib, and tibia, as well as an associated snail shell from the specimen were used for radiocarbon dating of the material. A CT scan of the fully formed adult encapsulated m1 in the lower right jaw is used for a positive morphological diagnosis. The morphology of the preserved bones and the incomplete formation of the epiphyses as well as a single deciduous tooth and the encapsulated m1 suggest the specimen is a juvenile. Bones and p4 tooth structure compared with a modern dog skeleton demonstrates an assignment to the Carnivora. Nevertheless, the robust proportions of the femur, humerus, and ankle bones are grounds for diagnosis as genus *Meles*. Evidence of evolutionary pattern distributions, ecological niche, and chronology indicates an assignment as *Meles leucurus*. As Kyrgyzstan is extremely seismically active, dating the fossils recovered from recent uplifts can give us information about future earthquake risks. My findings contribute to comparing modern species from the same area on the account of observing morphological and biogeographic changes happening through time.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

***JUNGGARSUCHUS SLOANI*: A TRANSITIONAL 'SPHENOSUCHIAN' AND THE EVOLUTION OF THE CROCODILIAN SKULL**
RUEBENSTAHL, Alexander A., The George Washington University, Washington DC, DC, United States of America; CLARK, James M., George Washington University, Washington, DC, United States of America
The beginning of the transition from the generalized skull of basal crocodylomorphs to the specialized, skull and extremely powerful jaws of extant crocodylians is observable in the group of crocodylomorphs informally known as 'Sphenosuchia'. The 'sphenosuchian' *Junggarsuchus sloani* is known from the anterior half of a skeleton from the early Late Jurassic of the Shishugou Formation of China and documents several of these transitions from basal to more derived forms. Initial analysis found *Junggarsuchus sloani* as the sister group of Crocodyliformes, and although some important transitional aspects of the anatomy were reported, such as the quadrates contact with the squamosal, study of the palate and braincase was limited by the specimen. Here we present CT segmentation of the skull of *Junggarsuchus sloani*, using Mimics 3D. We illustrate important transitional features identified earlier as well as new aspects of the morphology important in the evolution of the crocodylian skull including an expanded basisphenoid body, contact between the laterosphenoid and quadrate, contact between the quadrate and prootic, the absence of a depression for the tympanic recess and reduced contact between the prootic and paroccipital process, and a depression for the mastoid antrum on the dorsal surface of the prootic. In addition to braincase characters, we also identify a unique morphology in the palate and pterygoid of *Junggarsuchus*, which, although similar to the condition in other sphenosuchians, has several aspects that are unlike anything reported in any 'sphenosuchians', including a far reaching anterior process of the pterygoid. In addition to this analysis, a preliminary segmentation of the braincase of *Dibothrosuchus elaphros* demonstrates both characters that place *Dibothrosuchus* as a more basal crocodylomorph than *Junggarsuchus*, and highlight several unique aspects of its anatomy.
Grant Information
This work was supported by NSF grant EAR 1636753 to Clark

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE FIRST OCCURRENCE OF A SAUROPOD BODY FOSSIL IN CANADA, WITH IMPLICATIONS FOR THE "SAUROPOD HIATUS" IN NORTH AMERICA
RYAN, Michael J., Cleveland Museum of Natural History, Cleveland, OH, United States of America; EVANS, David C., Royal Ontario Museum, Toronto, ON, Canada
Sauropods reached their peak in numbers and diversity during the Late Jurassic, after which they went through a global decline, although they persisted until the end of the Cretaceous. Historically, the relative absence of Cretaceous sauropods in the northern hemisphere has been referred to as the great "mid-Cretaceous sauropod hiatus", although recent work suggests that the gap in North America is only between about 90 to 75 million years ago, and their absence in Europe is limited to two short intervals between 95 to 83 Ma. The hiatus can be interpreted as the product of a sampling bias pertaining to the rarity of their inferred preferred inland sediments and the dominance of coastal deposits in these two regions during that time period.
The globally-distributed Lithostrotia ('titanosaurs') have specimens referred to the clade ranging from the Early to the latest Cretaceous. In North America, *Alamosaurus* (~70–66 Ma) is a common member of the Late Cretaceous fauna of southern Laramidia and has been used to define, in part, the *Alamosaurus-Quetzalcoatlus* faunal zone that is representative of the semi-arid inland plains where these taxa are found. Despite their presence in most Jurassic and Cretaceous sediments of the United States, no sauropod body fossils are known from Canada, although footprints (*Brontopodus*) have been described from the Mist Mountain Formation (Tithonian/Berriasian) of BritishColumbia.
We report here the first occurrence of a sauropod body fossil (a caudal centrum) from Canada, collected from the late Santonian Deadhorse Coulee Member (~83 Ma) of the Milk River Fm of southern Alberta in exposures adjacent to Black Coulee. This member has previously produced the oldest diagnosable dinosaur body fossils from southern Alberta (i.e., *Acrotholus* and *Gryphoceratops*). Although the specimen was surface collected, no other formation exposed in the area, so we can infer that the specimen was probably derived from the fossiliferous lower 35 m of the ~70 m thick member. The specimen closely resembles a mid-caudal centum of a large titanosaur similar to *Alamosaurus*. In addition to being the most northerly occurrence of sauropods in the Late Cretaceous of North America, it also provides important evidence for the presence of North American sauropods during the "sauropod hiatus".

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

XENARTHRANS FROM THE GULF COAST OF TEXAS AND THE DISTRIBUTION OF *NOTHROTHERIOPS*
SAGEBIEL, James C., University of Texas at Austin, Austin, TX, United States of America
A Pleistocene, Rancholabrean-age fauna collected near Bluntzer in Nueces County, Texas, yielded a diverse xenarthran fauna including the first definite record of *Nothrotheriops* from the gulf coast of Texas. The Bluntzer Pit fauna was collected during the commercial excavation of gravel over a period of several years. A total of 121 fossils of xenarthran mammals were recovered from five species, including three ground sloths (*Paramylodon*

harlani, *Megalonyx jeffersonii*, and *Nothrotheriops shastensis*), a glyptodont (*Glyptotherium floridanum*), and a pampathere (*Holmesina*). These taxa were also recovered from the Ingleside fauna, collected from nearby San Patricio County; however, the occurrence of *Nothrotheriops* at Ingleside was not previously reported. Fossil remains of the extinct ground sloth *Nothrotheriops* have now been identified from more than 70 localities distributed throughout the western and southern United States and Mexico. However, *Nothrotheriops* fossils are only found in north Texas despite the abundance of Pleistocene-age fossil sites throughout south and central Texas. Because of its limited distribution (most often caves and mountainous areas), it has been posited that climate—specifically minimum winter temperature—was a limiting factor in the geographic distribution of *Nothrotheriops shastensis*. The milder climate along the Gulf of Mexico coast was probably ideal for these ground sloths.

Technical Session IV (Wednesday, October 17, 2018, 3:45 PM)

AROUND THE WORLD IN 129 DOGS: THE HISTORICAL PHYLOBIOGEOGRAPHY OF CANINAE, BASED ON A NOVEL CANID PHYLOGENY AND NOW DATABASE DATA

SAILA, Laura K., University University of Helsinki, Helsinki, Finland; MATZKE, Nicholas J., University of Auckland, Auckland, New Zealand

The phylogenetic relationships of North American fossil Canidae have been subject to many recent studies but canids from other continents have received less attention. We here present the results of the first ever combined evidence dating analysis (molecular and morphological characters) of global living and fossil Canidae, and use it to infer the biogeographical history of Caninae.

We used BEASTmasteR (a collection of R scripts to write Beast2 analyses) to conduct a Bayesian total evidence analysis (tip-dating) to produce a dated phylogeny of 222 extant and extinct Canidae (64 in subfamily Borophaginae, 29 in subfamily Hesperocyoninae, and 129 in subfamily Caninae). To maximise taxon coverage, fossil taxa with no character data were included a priori based on expert opinion and analysed together with extant and fossil taxa. Morphological characters were extracted from previous analyses, while molecular data was gathered from GenBank. We assigned the approximate positions of the additional fossil taxa based on expert opinion a priori because this allows the inclusion of their temporal information into the analysis; in tip-dating the dates of fossil taxa are used as the primary source of dating information, rather than traditional node-based dating. We used last occurrence dates for our tip-dating that were gathered from fossil databases (primarily New and Old Worlds [NOW] fossil mammal database, but also Paleobiology Database [PBDB]) and the literature. Our results are moderately consistent with previous studies by other authors but the inclusion of over 50 fossil taxa previously excluded resulted in differences in the clade topology and timings. We also included extant Caninae from Asia, Africa, and South America that were not included in the previous large-scale analyses.

We then conducted a historical biogeographical analysis only for subfamily Caninae because Borophaginae and Hesperocyoninae are almost entirely exclusive to North America. We assembled an occurrence database from NOW, PBDB, and the literature for geographic ranges, and compared the fit of many different models of biogeography using the R package BioGeoBEARS. Models that include jump dispersal gained over 99% of the AIC model weight. A newly developed detection model in BioGeoBEARS allowed us to estimate whether an absence of a fossil taxon from a certain region is a ‘true absence’ or just ‘absence of evidence’ based on the completeness of the fossil record (estimated from large mammal occurrences in the NOW database through time), resulting in more robust biogeographical models.

Grant Information

LKS: Academy of Finland Postdoctoral grant, Otto Malm Foundation grant; NJM: NIMBioS fellowship, DECRA fellowship (Australian Research Council), New Zealand Marsden grant

Romer Prize Session (Thursday, October 18, 2018, 11:30 AM)

MOLECULAR STABILITY AND MOBILITY: PROTEIN DIAGENESIS IN OPEN AND CLOSED TAPHONOMIC SYSTEMS

SAITTA, Evan T., University of Bristol, Bristol, United Kingdom

Paleontology has benefited from improved physiochemical and computational equipment. However, tremendous potential resides in organic geochemistry, the study of how organic molecules fossilize, to ultimately instill new ways of thinking about questions and underlying investigative approaches. Such molecular taphonomy is often employed in non-vertebrate paleontology (e.g., biomarkers) and paleoclimatology (e.g., temperature proxies), but these concepts can equally be applied to vertebrate fossils. Here, two important factors of molecular preservation are illustrated relating to vertebrate proteinaceous tissue: molecular stability through diagenesis and molecular mobility relative to the permeability of the surrounding matrix. Direct chemical analyses of fossil dinosaur feathers show that only diagenetically stable pigment and calcium phosphate components of keratin survive, while protein is lost. Anoxic, fine-grained sediment can retain organic fossil pigments that might otherwise be lost, with only phosphates preserving in coarser sediment. Inorganic components of biominerals themselves can act as open or closed systems, retaining diagenetically stable organics deposited within them. Chemical analyses of aseptically-collected dinosaur bone reveal apatite to be an open system, capable of hosting a unique, thriving subterranean microbiome, without evidence of original protein. Dinosaur eggshell calcite, however, follows expected patterns from younger avian eggshells and shows closed-system behavior, trapping the most thermally stable endogenous amino acids, fully hydrolyzed from their peptide chains. Molecular taphonomic experiments also deal with the concepts of open and closed systems. Under more traditional, sealed-capsule thermal maturation experiments, feather proteins hydrolyze into an organic, water-soluble fluid not seen in fossils. However, when thermal maturation is undertaken in an open system of compacted sediment, feathers and other vertebrate tissues evidence not only the diagenetic instability of protein and labile lipids, but also how degradation is coupled with molecular migration through sediment pore spaces to reveal organic stains consisting of exposed melanosomes that resemble exceptional fossils macro- and ultrastructurally. Directing investigation towards stable, insoluble compounds or closed systems offers much potential for vertebrate paleontology.

Grant Information

Geological Society of London’s Daniel Pidgeon Fund

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

TOOTH GROWTH AND REPLACEMENT RATES OF THE SAUROPOD *EUHELOPUS* REVEALED WITH SYNCHROTRON AND LAB MICRO-TOMOGRAPHY

SALAKKA, Seela S., University of Helsinki, Helsinki, Finland; POROPAT, Stephen F., Swinburne University of Technology, Hawthorn, Australia; CORFE, Ian J., University of Helsinki, Helsinki, Finland; KEAR, Benjamin P., Uppsala University, Uppsala, Sweden

Sauropod tooth morphologies and tooth replacement patterns can reveal important information on sauropod feeding habits and evolution. *Euhelopus* is an Early Cretaceous somphospondyl neosauropod, and belongs to the group Euhelopodidae, usually placed as a close relative of Titanosauria. *Euhelopus* is a key taxon in the evolution of sauropod teeth because it displays a conservative broad ‘spoon-shaped’ tooth morphology relative to titanosaurs, yet is a member of a group hypothesized to have independently evolved the derived state of narrow, peg-like teeth, separately found in the two major neosauropod groups Titanosauria and Diplodocoidea. The spoon-shaped teeth of *Euhelopus* resemble those of *Camarasaurus*, a more basal macronarian, as well as many non-neosauropodan taxa not closely related to *Euhelopus*.

We used, for the first time for Sauropoda, non-destructive high-resolution synchrotron X-ray micro-tomography to identify growth rate recording von Ebner growth increments in the dentine of *Euhelopus* teeth. In *Euhelopus*, these are spaced on average 14.5 µm apart, similar to reported spacings for the diplodocoid *Diplodocus* and the macronarian *Camarasaurus* (both 15 µm) but lower than those of unidentified titanosaurs (19–21 µm) from Late Cretaceous Argentina. We also used lab CT to identify replacement teeth in upper and lower jaws of *Euhelopus*. There are two or three replacement teeth per functional tooth, depending on jaw position. Using replacement rate estimates based on tooth length, we find an average rate of 38 days (upper teeth) and 55 days (lowers). These values are slower than the diplodocoids *Dicraeosaurus* (20 days for upper teeth and 50 days for lowers) and *Nigersaurus* (14 days for uppers), slightly slower than *Diplodocus* (34 days for uppers), but faster than *Camarasaurus* (62 days for uppers). This suggests that moderately fast tooth replacement had evolved for the robust, conservative tooth morphology of *Euhelopus* at a node on the lineage leading to Titanosauria, before the independent evolution of pencil-shaped teeth in both Euhelopodidae (*Phuwiangosaurus)* and elsewhere in Somphospondyli.

Although we show here that the evolution of tooth shape and tooth replacement rate was uncoupled in at least euhelopodid sauropods, the repeated evolution of pencil shaped teeth and fast replacement rates indicates that there was a strong evolutionary pressure in this direction for sauropods at varied places and times.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

SKULL MECHANICS AND FUNCTIONAL MORPHOLOGY OF BRASILODONTIDAE, THE SISTER CLADE TO MAMMALS

SALCIDO, Charles J., University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom; GILL, Pamela, University of Bristol, Bristol, United Kingdom; SOARES, Marina B., Museo Argentino Ciencias Naturales, Capital Federal, Argentina; MARTINELLI, Agustin G., Museo Argentino Ciencias Naturales, Capital Federal, Argentina

Triassic vertebrate assemblages of the Santa Maria Supersequence in Brazil have yielded many specimens of cynodont therapsids including members of the clade Brasilodontidae. Recent phylogenetic analyses place this clade as the sister clade to Mammaliaformes. While these specimens have been described in detail, little work has been done to quantify the skull mechanics. The skulls of the brasilodontids *Brasilodon*, *Brasilitherium*, and *Minicynodon* are analyzed to compare their functional morphology and biomechanics to the Early Jurassic mammaliaforms *Morganucodon* and *Kuehneotherium*, and any similarities could be interpreted in light of the ontogenetic status of the comparable brasilodontids. We here compare the results of biomechanical and finite element analysis (FEA) of the mandibles of *Minicynodon* and *Brasilodon*, both to each other and to those of *Morganucodon* and *Kuehneotherium* from a previous study.

Specimens were µCT scanned, segmented in Avizo 9.4.0, meshed in Hypermesh to prepare for FEA, and then imported into Abaqus for testing. Biomechanical analysis includes beam analyses such as second moment of area, polar moment of inertia, and section modulus results that were obtained from Moment Macro in ImageJ. Although the overall trends are the similar in *Minicynodon* and *Brasilodon*, the latter has higher resistance to torsion and bending strength than *Minicynodon*. Also, for *Brasilodon*, the posterior end has a near constant resistance to torsion, with a sudden drop between pc4 and pc3. These differences may support an ontogenetic relationship and niche partitioning between the different age groups. The polar moment of inertia results also show that the mandibles of the brasilodontids are able to resist torsion in a similar manner to *Morganucodon* and may indicate a similar mode of feeding. During segmentation, the postdentary bones of *Brasilodon* and *Minicynodon* were found to be preserved and are more similar to those of *Morganucodon* (thin and rod-like) than other nonmammalian cynodonts (e.g., *Probainognathus jenseni* and *Riograndia guiabensis*). This further supports the close connection between brasilodontids and mammaliaforms, displaying a transitional stage in the evolution of the mammalian jaw joint and middle ear right before the mammaliaform condition.

Podium Symposium (Wednesday, October 17, 2018, 8:30 AM)

MASS EXTINCTION AND HABITAT SHIFTS ENABLED THE MID-PALEOZOIC DIVERSIFICATION OF VERTEBRATES

SALLAN, Lauren, University of Pennsylvania, Philadelphia, PA, United States of America; KIM, Jisoo, University of Pennsylvania, Philadelphia, PA, United States of America; SANSOM, Ivan J., University of Birmingham, Birmingham, United Kingdom

Vertebrates are important components of global ecosystems past and present. Yet, apart from conodonts, vertebrate material is scarce in the 100 million years following their first appearance in the Chengjiang Lagerstätte during the Cambrian Explosion. Their comparatively minor contribution to Cambro-Ordovician communities suggests a divergent history and potentially different triggering factors for diversification of "fishes" than invertebrate phyla, and brings the fossil record into conflict with phylogenetic inferences of origins from ghost ranges and molecular studies. We assembled new occurrence, phylogenetic, and morphological databases to determine the timing, triggers, and tempo of the first diversification of vertebrates. We fit phylogenetic models to habitat data for early vertebrate occurrences, much of it based on environmental inferences and depositional details for invertebrate faunas in existing compendia (e.g., Paleobiology Database, Boucot and Lawson's 'Paleocommunities'). This revealed that vertebrate groups, jawed and jawless, were initially limited to shallow waters at the margins of ancient seas. Time-series of vertebrate occurrences showed that armored vertebrates, the relatives of living jawed forms, massively increased in abundance and diversity in the aftermath of the end-Ordovician extinction, following global losses of conodonts. We created multi-clade morphospaces by coding of functional aspects of body form in extinct and living fishes (via FishBase and descriptions in Google Scholar) and compared distribution of traits with occurrence in environmental zones along the marine depth gradient. This showed that modern relationships between form and habitat use were already established in the Silurian among jawless stem-gnathostomes. Following their initial appearance in nearshore environments, jawed fishes were limited to pelagic ecomorphologies resident in offshore zones rarely used by agnathans, and remained so into the Devonian "Age of Fishes." This result undermines assertions of a "Devonian Nektonic Revolution" and competition-induced extinction of jawless fishes, and might support a sea-level based control on agnathan diversity. Our results illustrate how new databasing efforts and quantitative approaches are completely rewriting the first half of vertebrate history.

Technical Session XVIII (Saturday, October 20, 2018, 2:45 PM)

THE STRUCTURE OF RODENT AND LAGOMORPH COMMUNITIES ACROSS THE CENOZOIC OF NORTH AMERICA: THE IMPORTANCE OF REGIONAL TOPOGRAPHY AND CLIMATIC DIFFERENCES

SAMUELS, Joshua X., East Tennessee State University, Johnson City, TN, United States of America; SCHAP, Julia, East Tennessee State University, Johnson City, TN, United States of America

Recent studies have demonstrated dramatic changes in North American rodent and lagomorph communities through the Cenozoic, with open-habitat specialists becoming common as open and arid habitats spread. Increased crown heights and burrowing, jumping, and cursorial adaptations appeared in rodents and lagomorphs millions of years before ungulates responded. Prior studies have primarily focused on continental scale analyses, but summation of geographically widespread faunas obscures individual community changes. Comparison of regional and local changes are key to understanding how communities have changed, which is expected to be strongly influenced by topography and local climate. Here, we use a database of fossil rodents and lagomorphs in North America to compare small mammal communities through time from eight distinct regions, and examine whether changes were synchronous across the continent or differed due to topography and vegetational history. The earliest mammals with hypselodont (ever-growing) cheek teeth appeared in the late Eocene of the Northern and Central Great Plains. Hypselodont taxa appeared later in other regions, in the early Oligocene of the Pacific Northwest, early Miocene of the Great Basin and California Coast, and late Miocene of the Gulf Coast. Shifts to communities dominated by taxa with high-crowned teeth were also regionally variable, starting in the early Oligocene in the Northern Great Plains and Pacific Northwest, early Miocene of the Central Great Plains and California Coast, middle Miocene of the Great Basin, and late Miocene of the Gulf Coast. Multiple regions showed increases in low-crowned taxa and declines in hypselodont taxa during the Middle Miocene Climatic Optimum. In the Pliocene, the Pacific Northwest and Northern Great Basin shifted to faunas dominated by hypselodont taxa. Burrowing and cursorial species became common in the late Oligocene of the Pacific Northwest and Great Plains, but not until the middle Miocene in the Great Basin and late Miocene on the Gulf Coast. These results help reveal important regional differences in the nature and timing of shifts within rodent and lagomorph communities through the Cenozoic.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

GEOMETRIC MORPHOMETRICS ON TREESHREW CRANIAL ENDOCASTS: A COMPARATIVE ANALYSIS OF SCANDENTIAN AND PLESIADAPIFORM BRAIN SHAPES

SAN MARTIN FLORES, Gabriela, University of Toronto Scarborough Campus, Scarborough, ON, Canada; NAGENDRAN, Lavania, University of Toronto Scarborough Campus, Scarborough, ON, Canada; SILCOX, Mary T., University of Toronto, Scarborough, ON, Canada

In order to better understand what is primitive in terms of brain shapes for the order Primates, it is essential to understand the brain morphology of their closest extant relatives: Dermoptera and Scandentia (treeshrews). Dermopterans are larger animals and, therefore, have gyrencephalic brains, making them problematic proxies for the form of the brain in smaller ancestral primates. Treeshrews have often been used as modern analogues for plesiadapiforms because they are small-bodied and have smaller, lissencephalic brains. Despite this, one of the biggest limitations in previous studies is that they were restricted in terms of their taxonomic range for scandentians, particularly excluding *Ptilocercus lowii*, which is the most primitive living treeshrew.

This study uses geometric morphometrics on the endocasts of a diversity of living treeshrews in order to better characterize the variation in their morphology, and to create a context to compare them to early primate endocasts. A new set of 21 endocranial landmarks were placed on endocasts derived from microCT data for three treeshrew genera: *Ptilocercus* (n = 5), *Tupaia* (n = 20), and *Dendrogale* (n = 2). Additionally, two plesiadapiforms were also landmarked: *Ignacius graybullianus* (n = 1) and *Microsyops annectens* (n = 1). The coordinate data were used in a Principal Component Analysis. The treeshrew-only plot shows that there is a lot of variation among the treeshrews, with two distinct groups: one largely composed of tupaiine treeshrews and the other including all the specimens of *Ptilocercus*. In the plot including the fossil endocasts with the scandentian specimens, it can be seen that in spite of sharing superficial similarities, the treeshrews did not group with the plesiadapiforms. These results would suggest that members of Scandentia share features that have evolved since their common ancestor with Primates.

Grant Information
Supported by an NSERC Discovery Grant to MTS

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE GIANT "MYSTERY BONES" FROM EUROPEAN RHAETIC BONE BEDS—A HISTOLOGICAL TEST OF COMPETING HYPOTHESES OF AFFINITY

SANDER, P. Martin, University of Bonn, Bonn, Germany; WINTRICH, Tanja, University of Bonn, Bonn, Germany

During the latest Triassic (Rhaetian), a rich and unique ecosystem is recorded. The historically important Rhaetic bone beds of Aust Cliff in England and the newly discovered bonebeds of Bonenburg in Germany contain one of the most peculiar finds from this ecosystem: giant bone shafts and broken parts of the outer cortex of such shafts. The most striking characteristic of these bones is their size, the minimal shaft diameter of the largest of the bones from Aust Cliff being 14 cm. Estimates of the original size of these bones and fragments suggested that dinosaur-like gigantism had already evolved in the Late Triassic. Based on the geological age and on bone size, these bones have been considered to belong to either sauropodomorphs or to giant pseudosuchian archosaurs in the past.

Since cortical bone histology carries a phylogenetic signal and is a mature technique, the controversial affinities of the "mystery bones" appear amenable to testing by histological comparison. The giant bone shafts exhibit a peculiar cortical histology of longitudinal primary osteons with secondary osteons inside. The primary osteoans are set in a coarsely fibrous matrix, indicating that this bone tissue type pertains to the fibrolamellar complex. Growth marks are common as either LAGs or annuli, indicating cyclical growth. Finally, there is an abundance of structural fibers. Thus, bone histology appears inconsistent with both previously suggested clades. All sauropodomorphs have fibrolamellar bone with a laminar vascular architecture. Pseudosuchians have well developed growth marks and longitudinal vascular canals but lack fibrolamellar bone. Neither does the bone histology of the Rhaetian "mystery bones" fit to the histology of any other dinosaur group.

A recently advanced hypotheses based on morphology is that the bone shafts and fragments from the Rhaetic bone beds belong to gigantic ichthyosaurs (>25 m long), representing the surangular of the lower jaw. Thin sections of the surangular and splenial of the giant Norian ichthyosaur *Shastasaurus sikanniensis* show longitudinally arranged vascular canals but they differ from the Rhaetian "mystery bones" in that the bone tissue is spongy. Finally, the abundance of structural fibers in cortical bone is not seen in any amniote but in temnospondyl amphibians. Among these, brachyopoids can be extremely large. To conclude, archosaurian affinities of the "mystery bones" are inconsistent with the histological evidence, but either ichthyosaurian or temnospondyl affinities remain a possibility.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

REVALIDATION OF THE GENUS *DROMOCERATHERIUM* (PERISSODACTYLA, RHINOCEROTIDAE) AND ITS KEY ROLE WITHIN RHINOCEROTINAE

SANISIDRO, Oscar, University of Kansas, Lawrence, KS, United States of America; DEMIGUEL, Daniel, Universidad de Zaragoza, Zaragoza, Spain; MADURELL MALAPEIRA, Joan, Institut Català de Paleontologia Miquel Crusafont, Cerdanyola del Vallès, Spain; JOVELLS VAQUÉ, Silvia, Institut Català de Paleontologia Miquel Crusafont, Cerdanyola del Vallès, Spain; CASANOVAS-VILAR, Isaac, Institut Català de Paleontologia Miquel Crusafont, Cerdanyola del Vallès, Spain

Dromoceratherium mirallesi is a fossil rhinoceros species originally described in the 1950s on the basis of scarce distal limb elements and lower cheek teeth from the early Miocene (early Aragonian, biozone MN4) locality of Can Julià (Vallès-Penedès Basin, Catalonia, NE Spain). We report recently recovered fossil remains of *D. mirallesi* from the contemporaneous Vallès-Penedès locality of Les Cases de la Valenciana including upper cheek teeth and elements of the skull, a complete femur, a partial humerus, phalanges and vertebrae amongst other elements. The new material allows for an adequate differential diagnosis of the species and reveals unknown details of its anatomy. Overall consensus regarded *Dromoceratherium* as a junior subjective synonym of *Plesiaceratherium* when *D. mirallesi*, the type and only known species within the genus, was transferred to *Plesiaceratherium*. The updated diagnosis of *D. mirallesi*, based on the re-description of the type material from Can Julià and the new recovered material, together with the meta-analysis of previously published cladistic hypotheses supports the distinction of the genus *Dromoceratherium* and confirms its pivotal placement in the diversification of the main clades of Rhinocerotinae.

Grant Information
CGL2016-76431-P, CGL2017-82654-P (AEI/FEDER,EU), RYC-2013-12470 to ICV, CERCA Prog., SGR 416, FI_B 00054 to SJV, NGS 9640-15 (Nat. Geo. Soc.), Handel T. Martin Endowm. Fund

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

UTILIZING MUSEUM COLLECTIONS IN COLLABORATION FOR EXPERIENTIAL LEARNING AND CITIZEN SCIENCE IN HIGHER EDUCATION

SANTOS, Gabriel-Philip, Raymond M. Alf Museum of Paleontology, Claremont, CA, United States of America; SCHMITZ, Lars, Claremont McKenna, Scripps, and Pitzer Colleges, Claremont, CA, United States of America

Recent studies have shown that experiential learning may aid students in higher education better retain information outside the classroom setting. In higher education, there has been an increase in the development of programs and learning spaces in which students become active participants in the scientific method. The Raymond M. Alf Museum of Paleontology and the W. M. Keck Science Department of the Claremont Colleges have begun a collaborative citizen project that provides undergraduate students in comparative anatomy

classes hands-on learning experiences in anatomy, paleontology, and museum science through research-based projects. Throughout the course, which has a typical enrollment of 18–22, students are provided Oligocene-aged fossil specimens from the Western Interior of the United States from the Alf Museum collection. Over the course of five lab periods (4 hrs each), students are then tasked with the identification, interpretation, and curation of specimens, working towards six main learning objectives: 1) improve understanding of mammalian osteology, highly relevant to human anatomy, by applying material covered in class to a set of unknown specimens; 2) document skeletal and dental material including photos and drawings (both detailed as well as interpretative); 3) analyze and interpret skeletal material (taphonomy, functional morphology, ecology, faunal composition); 4) learn about collection management and proper curation; 5) understand the importance of natural history museums for biodiversity and anatomical research; and 6) design posters for scientific presentations. In written, anonymous evaluations, students commented on the uniqueness of this experiential project and liked that they gained hands-on experience and an opportunity to explicitly test their knowledge. Other students noted that the project took time away from dissection, a very popular course component, and suggested to shorten the fossil project. Moving forward, we will develop a more formal assessment of the program and reduce the time allocated to the project, facilitated by adding well-trained teaching assistants and decreasing the number of specimens students work with.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

FUNCTIONAL MORPHOLOGY OF A REMARKABLY COMPLETE SKELETON OF *MIXODECTES PUNGENS*: EVIDENCE FOR ARBOREALITY IN AN ENIGMATIC EUTHERIAN FROM THE EARLY PALEOCENE

SARGIS, Eric J., Yale Peabody Museum, Yale University, New Haven, CT, United States of America; CHESTER, Stephen G., Brooklyn College, City University of New York, Brooklyn, NY, United States of America; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America; SILCOX, Mary T., University of Toronto, Scarborough, ON, Canada; WILLIAMSON, Thomas E., New Mexico Museum of Natural History, Albuquerque, NM, United States of America

Mixodectids are eutherian mammals from the Paleocene of North America that have been considered close relatives of the extinct plagiomenids, microsyopid plesiadapiforms, and/or dermopterans, making them relevant to better understanding euarchontan relationships. We analyzed a new dentally associated skeleton of *Mixodectes pungens* (NMMNH P-54501) from the late Torrejonian (To3) *Mixodectes pungens* zone of the Nacimiento Formation, San Juan Basin, New Mexico. It is the most complete skeleton of a mixodectid known, preserving a partial skull with all teeth erupted and previously unknown elements of the axial skeleton, forelimbs, and hind limbs, all with epiphyses fused. This skeleton of *M. pungens* was recovered mixed with partial skeletons of the palaechthonid plesiadapiform *Torrejonia* and the cimolestid *Acmeodon* but was easily distinguished from them based on its larger size. The NMMNH P-54501 humerus has a fairly spherical head that extends superior to the tuberosities, indicating a mobile shoulder. The humerus also has a spherical capitulum separated from the trochlea by a groove and a radius with a very rounded head, both indicating a mobile elbow. The innominate has an elliptical acetabulum and an articular surface that is expanded cranially, as in arboreal euarchontans. The femur has a large lesser trochanter oriented posteromedially and fairly shallow femoral condyles suggesting a habitually flexed knee. The astragalus has a trochlea that extends far distally onto the neck and a confluent sustentacular-navicular facet. The calcaneum has a sustentacular facet that extends distally onto the body, large peroneal tubercle, helical ectal facet, and concave cuboid facet. This combination of features indicates mobility in the ankle joints and is often present in arboreal taxa capable of pedal inversion. The humerus has a large medial epicondyle and the proximal phalanges have pronounced flexor sheath ridges, both indicating powerful flexion of the digits. In summary, the postcranial morphology of *Mixodectes* is very similar to that of arboreal euarchontans, including plesiadapiforms, supporting inferences based on less complete material that mixodectids were both arboreal and members of Euarchonta. There is continuing debate about relationships among euarchontan mammals. As possible stem euarchontans, mixodectids may be relevant to reconstructing plesiomorphic states for key features in this group, thereby improving our understanding of character polarity, as well as evolutionary relationships, within Euarchonta.

Grant Information
National Science Foundation EAR-0207750 and 1325544 to T.E.W. and PSC CUNY Award to S.G.B.C.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

TESTING MOLDING SEPARATORS FOR COLOR CHANGE AND EFFECTIVENESS

SATO, Tetsuya, Peking University, Beijing, China; FOX, Marilyn, Yale Peabody Museum of Natural History, New Haven, CT, United States of America

The matrix surrounding a fossil provides vital information, such as dating and depositional environment. To avoid any contamination, it is desirable to preserve its original status. It is, however, often necessary to use conservation materials to keep fossil specimens safe during preparation, in storage and on exhibit. Preparators are required to apply separators to the matrix when a specimen, especially a specimen in a slab, is molded. And yet, how different separators affect matrix or bone has not been clearly understood. Which separators are most effective at protecting the specimen from damage or infiltration by silicone oil? Which separators have the least long-term effect on the specimen in terms of permanent color change? Here we tested eight molding separators on three matrices to observe changes in color and texture pre- and post-molding.

Tested molding separators were conservation materials (Butvar B-76 at 5% w/v in acetone and Paraloid B-72 at 5% w/v in acetone), historically used materials (paste wax), commonly used molding separators (mold release spray and petroleum jelly), common lab supplies sometimes used as molding separators (talcum powder, dish soap, and their mixtures), as well as a control sample with no separator. These separators were applied on non-fossil-bearing rock slabs from well-known fossil localities: limestone from the Triassic Falang Formation and shales from the Cretaceous Yixian Formation and the Eocene Green River Formation. RTV, tin cure silicone rubber (Silicones Inc. G-1000) was poured on the prepared samples. The color and texture of the slabs was observed two hours after each cured mold was removed and again, after the separators were cleaned with acetone. Our results varied with the type of rocks. The limestone from the Falang Formation showed clear differences in color and texture between the separators; the silicone rubber peeled off the surface layer when the separators did not function. The shale from the Green River Formation exhibited the least difference; even on the control sample with no separator no damage was caused while molding. Overall, Butvar B-76 resulted in the least damage and color change in all three rocks, but we still recommend testing separators on small portion of any unknown matrix before molding the whole specimen.

Grant Information
SVP Hix Preparators Grant

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

***TOROSAURUS* OR *TRICERATOPS*? ASSESSING THE POSTORBITAL HORN CORE MICROSTRUCTURE OF THE HOLOTYPE OF *TOROSAURUS GLADIUS* REVEALS NEW INSIGHTS INTO CERATOPSID HORN GROWTH**

SCANNELLA, John B., Museum of the Rockies, Montana State University, Bozeman, MT, United States of America; HORNER, John R., Chapman University, Irvine, CA, United States of America

The ceratopsid specimen YPM 1831, initially designated the holotype of *Torosaurus gladius* in 1891, is a focal point for research regarding the proposed synonymy of the uppermost Cretaceous taxa *Torosaurus* and *Triceratops*. Despite its large size (parietal length ~ 134 cm), YPM 1831 is suggested to be a subadult *Torosaurus latus* due to unfused cranial elements including the epiossifications and occipital condyle. This would be inconsistent with the hypothesis that the expanded, fenestrated cranial frill morphology that has diagnosed *Torosaurus* actually represents the mature morphology of *Triceratops*.

In order to directly assess the relative maturity of YPM 1831, a postorbital horn core from this individual was thin-sectioned and its microstructure was compared to an expanded ontogenetic series of sectioned horn cores (n=12) from specimens referred to *Triceratops* or *Torosaurus*. Examination of the YPM 1831 horn core reveals multi-generational secondary reconstructions and evidence for erosion along the exterior border followed by development of metaplastic tissue. The interior of the horn core exhibits evidence of extensive tissue erosion. This is consistent with a relatively mature individual in which the postorbital horn cores were still changing at the time of death. The histology of YPM 1831 is comparable to that noted in other toromorph specimens in this study (n=3), though the relatively thick margin of metaplastic tissue may indicate a slightly younger individual. In late ontogeny, much of the interior of the horn core eventually eroded away leaving a network of metaplastic struts in the extended cornual sinus (exemplified by toromorph specimen MOR 3081). These struts and the remaining horn core contain acellular tissue, similar to that observed in late stage ontogeny of the frontoparietal domes of pachycephalosaurs.

Preliminary results of this study are consistent with YPM 1831 representing a toromorph-stage *Triceratops*. Ceratopsid horn core development, like that of the frill, was a dynamic process with growth and erosion sometimes co-occurring in different areas. We note the discovery of acellular tissue near the developing cornual sinus of a large non-toromorph (MOR 2551), which suggests advanced erosive processes or age without expansion of the cranial frill. Because MOR 2551 was collected from a different stratigraphic level than toromorphs in this study, and the relative position of YPM 1831 is undetermined, this emphasizes the importance of stratigraphic context in deciphering ontogenetic and evolutionary trends.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A NEW MIOCENE GERRHONOTINE FROM THE CALIENTE FORMATION, CALIFORNIA

SCARPETTA, Simon G., University of Texas at Austin, Austin, TX, United States of America

Gerrhonotinae (i.e., alligator lizards) is an extant lizard clade with a rich Cenozoic fossil record and a diverse assemblage of species still inhabiting regions of North and Central America. There are 55 extant species in six genera that inhabit a variety of ecosystems, including cloud forests, pine-oak forests, and deserts. Gerrhonotines are known from the Eocene through the present, but only two articulated fossilized skulls have ever been described. Here, I describe a new gerrhonotine lizard known from a partial skull housed at the University of California Museum of Paleontology (UCMP). The specimen is from the Caliente Formation in southern California and is 12.5–11.5 Ma old (Miocene, Clarendonian North American land mammal age). I used x-ray computed tomography (CT) scans to visualize the specimen and elucidate cranial anatomy that is inaccessible from the physical specimen alone. The specimen is unique among gerrhonotines in that it possesses cephalic osteoderms with tall, sail-like keels.

To place the fossil phylogenetically, I conducted phylogenetic analyses of Gerrhonotinae using molecular and morphological data. Molecular and combined-evidence analyses included previously published data for nuclear and mitochondrial genes of 38 extant species. I CT-scanned the skulls of 17 extant species of gerrhonotine to acquire morphological data. The morphological dataset includes 75 cranial characters that are new to the literature and 115 total characters for 24 taxa. I analyzed the data using Bayesian, maximum likelihood, and parsimony methods. The specimen represents a new taxon nested within a clade composed of the extant genera *Abronia* and *Mesaspis*, both of which are now found only in tropical Mexico and Central America. Apomorphies allying the new taxon with *Abronia* include heavily ossified osteoderms with a vermiculate texture, a frontal that is wide relative to its length, a narrow and subrectangular-shaped facial process of the maxilla, and a conch of the quadrate that is roughly cylinder-shaped. Ancestral state reconstructions indicate that the new taxon most likely inhabited cloud forests or pine-oak forests, similar to extant species of *Abronia* and *Mesaspis*. The presence of an *Abronia* and *Mesaspis* clade gerrhonotine lizard in southern California during the Miocene suggests that the climate and environment of that area was more tropical during the

Miocene, or that the ecological tolerances of *Abronia* and *Mesaspis* clade gerrhonotines have changed significantly over the past 12 Ma.
Grant Information
Geological Society of America
University of Texas at Austin Jackson School of Geosciences off-campus research grant
Lundelius Award in Vertebrate Paleontology

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

VARIED RESPONSES OF MAMMALS TO THE MIDDLE MIOCENE CLIMATIC OPTIMUM, NON-UNIFORM SHIFTS IN CROWN HEIGHTS OF RODENTS, LAGOMORPHS, AND UNGULATES

SCHAP, Julia, East Tennessee State University, Johnson City, TN, United States of America; SAMUELS, Joshua X., East Tennessee State University, Johnson City, TN, United States of America

Through the Cenozoic there were well-documented climate and habitat changes in North America. One of the most pronounced periods of change is the Middle Miocene Climatic Optimum (around 15 Ma, during the early Barstovian land mammal age), which showed substantial warming, comparable to the warming we see today. Study of community responses to this interval of warming could be informative and aid prediction of changing ecology and community structure if temperature continues to climb. Studies of ungulate crown heights have revealed a correlation between an increase in hypsodonty and a shift to more arid environments through the Cenozoic. Small mammals have also been shown to adapt to changing habitats, with specializations for life in open habitats appearing millions of years earlier than larger mammals. Few studies have examined regional changes in crown heights, but these have potential to better highlight community changes. In this study we focused on southern California, eastern Oregon, and western Nebraska, which all have relatively complete fossil records spanning from the Hemingfordian to the Clarendonian. Diversity of rodents, lagomorphs, and ungulates were analyzed through this time period, including examination of community structure as characterized by relative percentages of taxa with different crown heights. Diversity of low crowned taxa increased in Oregon early in the Hemingfordian, while Nebraska and California show an increase in low-crowned taxa through the early Barstovian, at the time of the Middle Miocene Climatic Optimum. A decline in hypselodont lagomorphs is also evident during the Barstovian in Nebraska and California. Oregon shows a different pattern, with an increase in high-crowned taxa during the Barstovian, possibly due to close proximity to the massive volcanic activity associated with the Columbia River Basalts and resulting ash-filled environments. Within all three regions, there is a sharp decrease in low-crowned taxa starting in the Clarendonian, as global and regional climates became cooler anddrier.
Overall, these findings help demonstrate geographic and temporal variation in how communities react to climate change and show that we can gain a more refined understanding of major climate shifts through small scale studies.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

MEDIPORTAL RHINOCEROSES FROM THE MIOCENE SANDELZHAUSEN LOCALITY (GERMANY)

SCHELLHORN, Rico, Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn, Germany

While horses are known for a cursorial mode of locomotion (adapted for running), elephants are the other extreme with a graviportal mode of locomotion (adapted for bearing weight). In general, cursorial mammals have elongated distal limb elements, while graviportal mammals have longer proximal limb elements. Intermediate locomotory categories are subcursorial (e.g., *Hyrachyus*) and mediportal (e.g., *Tapirus*). Very often, ratios using bone lengths are calculated to categorize the different modes of locomotion. Following such ratios (e.g., metatarsal III/tibia, or tibia/femur), 'running rhinos' like *Hyracodon* are often classified as subcursorial, while all living members of the Rhinocerotidae are seen as mediportal forms. In fossil rhinos, the carpal bones are also used to identify the mode of locomotion. Following this approach, some rhinos even show a graviportal locomotion (e.g., *Brachypotherium brachypus*). Within this study the hind limb long bones of the rhinos from the Miocene Sandelzhausen locality (Germany) are investigated to identify the mode of locomotion. Therefore, a dataset of extant and fossil mammals with known locomotion type is used. This dataset comprises rhinos, hippos, and proboscideans among others. A clear separation of three clusters (graviportal, mediportal, cursorial) can be seen in the graphs plotting ratios (length of metatarsal III/length of tibia vs. length of tibia/length of femur). Subcursorial forms, as categorized in the literature, plot within the mediportal cluster. The three rhinoceros species from Sandelzhausen (*Lartetotherium sansaniense*, *Plesiaceratherium fahlbuschi*, and *Prosantorhinus germanicus*) plot within the mediportal cluster, but *P. germanicus* is closer to the graviportal cluster. The placement of *P. germanicus* could be due to the disarticulation of the bones from the Sandelzhausen locality, or on the other hand, could be due to its possible semi-aquatic mode of life. Other semi-aquatic rhinos (e.g., *Teleoceras*) and extant hippos plot clearly within the mediportal cluster. A principal component analysis, performed here, does not show a placement of *P. germanicus* closer to the cluster of graviportal mammals.
Grant Information
This study is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation)—SCHE 1882/1-1.

Technical Session I (Wednesday, October 17, 2018, 11:15 AM)

GEOMETRIC MORPHOMETRIC ANALYSIS OF THE INNER EAR OF SAUROPODOMORPHA

SCHMITT, Armin D., University of Oxford, Oxford, United Kingdom; BENSON, Roger B., University of Oxford, Oxford, United Kingdom; GILES, Sam, University of Oxford, Oxford, United Kingdom; WITMER, Lawrence M., Ohio Univ, Athens, OH, United States of America; SANDER, P. M., University of Bonn, Bonn, Germany

Sauropods surpassed the body mass of any extant land animal by up to an order of magnitude. Furthermore, as giant, long-necked quadrupeds they show dramatic anatomical modifications compared to their smaller-bodied, bipedal ancestors. The vestibular system of the inner ear is the sensory system that controls the vestibulo-occular and vestibulo-colic reflexes, using information about head motion, and is central to gaze stabilization and therefore balance in vertebrates. Its shape and size vary in response to agility, head mass, changes in habitual head motion, and therefore locomotory and body plan changes. To investigate these factors among sauropodomorphs, we assembled a dataset of 32 digital models of the bony labyrinth using CT scan data. This was analysed using 3D geometric morphometrics of their semicircular canals (SCC) in phylogenetic context.
A strong correlation between inner ear size and the body mass has been documented among vertebrates. We find that the largest vestibular systems yet known to science belong to sauropods. In particular, the sauropod *Giraffatitan* has a vestibular system measuring 30 mm anteroposteriorly. However, the relationship between body mass and inner ear size is relaxed among sauropods: diplodocoids, which are hypothesised as low browsers and weighed in excess of 20 tonnes, have vestibular systems of similar size to early sauropodomorphs such as *Plateosaurus* which weighed about one tonne and had smaller head sizes. Differences in traits, interpreted as indicating low browsing, might explain this large variation in proportional size. 3D geometric morphometrics show substantial variation of the shape of the SCC in sauropodomorphs. Most sauropods have rounded SCC that are proportionally taller (dorsoventrally) than those of non-sauropods, which have a triangular or 'pyramidal' morphology. This difference may be explained by the large differences in overall body form. Nevertheless, the SCC of some sauropodomorphs, for example, *Plateosaurus* or *Europasaurus* have similar geometry to those of non-sauropodomorphs, possibly correlating to their shorter neck, albeit the correlation is imprecise and warrants further investigation.
Variation in SCC morphology among sauropodomorphs corresponds to inferred differences in browsing heights, and body mass variation and fewer constraints on relative size of the inner ear at the high end of the body mass scale of terrestrial vertebrates.

Technical Session V (Thursday, October 18, 2018, 10:15 AM)

INVESTIGATING IMPACTS OF NON-NATIVE SPECIES ON AUSTRALIAN MARSUPIAL DIETARY ECOLOGY ACROSS SPACE AND THROUGH TIME

SCHOLTZ, Elinor, Vanderbilt University, Nashville, TN, United States of America; DESANTIS, Larisa G., Vanderbilt University, Nashville, TN, United States of America

European arrival into Australia, more than 200 years ago, had large scale impacts on the local flora and fauna. Most notably, Europeans brought with them numerous non-native species, including the European red fox and rabbits. The introduction of these species had significant consequences on native Australian mammals, causing some small to medium-sized herbivores to exist largely on islands. Here, we examined the dietary ecology of two native marsupial herbivores (medium sized), *Setonix brachyurus* and *Petrogale lateralis,* which have restricted ranges in Western Australia. Pleistocene fossils from the Margaret River region in southwest Australia were compared to extant specimens, with additional comparisons between island and mainland populations in extant specimens (when possible). Dental microwear textures of *P. lateralis* are indistinguishable across space/time for both anisotropy ($p = 0.067$) and complexity ($p = 0.342$), and consistent with the consumption of a browse dominated diet. Similarly, *S. brachyurus* maintains a browsing diet through time on the mainland (from the Pleistocene to the present), but modern island populations demonstrate a significant increase in anisotropy values ($p = 0.038$) compared to modern mainland populations. This difference suggests that modern island *S. brachyurus* populations are potentially inhabiting less preferential habitats and eating drier, tougher foods. Stable isotope analysis of *S. brachyurus* shows significantly greater carbon and oxygen isotope values (from tooth enamel) on islands as compared to extant populations from mainland Western Australia ($\delta^{13}C$ $p = 0.002$, $\delta^{18}O$ $p = 0.006$). These data suggest that *S. brachyurus* feed in slightly more open and arid environments on islands where non-native predators are absent, consistent with reduced predation pressure and less access to fresh water on islands. Collectively, dental microwear textures indicative of a browse diet and highly negative carbon isotope values (all values range from -20.6‰ to -15.5‰) suggest that these dense forest/shrub browsers maintained similar dietary ecology across space and since the Pleistocene. Similarities in the dietary ecology of these taxa across space and through time, with a slight shift towards less favorable habitats in *S. brachyurus* when living on islands lacking foxes, suggests that restricted ranges of these taxa today are unlikely due to a lack of suitable habitat and instead are most likely a result of the predation of non-native carnivorans and/or other human influences.
Grant Information
NSF 1455198 (to DeSantis) and Vanderbilt University

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

DISTINGUISHING NORTH AMERICAN BLACK BEARS (*URSUS AMERICANUS*) AND BROWN BEARS (*URSUS ARCTOS*) WITH DENTAL MEASUREMENTS

BOGNER, Emily L., East Tennessee State University, Johnson City, TN, United States of America; SCHUBERT, Blaine W., East Tennessee State University, Johnson City, TN, United States of America; SAMUELS, Joshua X., East Tennessee State University, Johnson City, TN, United States of America

Researchers have noted Northern American black bears (*Ursus americanus*) and brown bears (*U. arctos*) are difficult to distinguish in the fossil record, because of similar dental morphologies and overlapping measurements. Further, little is known how dental characteristics differ among sympatric and allopatric populations of the two species. The ability to better distinguish *U. americanus* and *U. arctos* using modern specimens has potential to aid in fossil identification and help elucidate when *U. arctos* arrive in North America. A previous study by our group determined there is a clear separation between sympatric *U. arctos* and *U. americanus* of southeast Alaska based on length of cheek teeth. This study examines a large database of crown lengths (p4, m1, m2, and m3) to determine which teeth are most useful for distinguishing *U. arctos* and *U. americanus*. Two groups of *U. americanus* that are sympatric with *U. arctos* are also compared with two populations of allopatric *U. americanus* to examine potential character displacement within black bears.
Samples were compared using Analysis of Variance (ANOVA) and stepwise discriminant analyses (DA). A discriminant model based on modern specimens is used to classify fossil specimens from Pleistocene sites in California, Maryland, Missouri, Oregon, Texas, and Virginia. ANOVA results indicate that there are statistically significant differences ($P < 0001$) in individual molar crown length measurements (p4–m3) between the two species, *U. arctos* and *U. americanus*. When comparing sympatric and allopatric populations of *U. americanus*, ANOVA results indicate the only statistically significant difference is found

in m3 ($p < 0.001$) and there is substantial amount of overlap among groups. Results indicate the lengths of p4–m3 can be used to accurately distinguish between *U. americanus* and *U. arctos*, with a 99.2% successful classification of species. Allopatric and sympatric populations of *U. americanus* studied here are indistinguishable by molar crown length, with only a 55.8% successful classification of populations. These results suggest there is no substantial character displacement in black bears that occur in sympatry with brown bears. Fossil specimens from California, Maryland, Missouri, Oregon, and Virginia were identified by DA as *U. americanus*; the fossil specimen from Texas was classified as *U. arctos*, but originally identified as *U. americanus*.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

EXTENSIVE NEW TRACKWAYS OF *MEGALOSAURIPUS* AND *PARABRONTOPODUS* AT "DINOSAUR LAKE", THE PURGATOIRE VALLEY DINOSAUR TRACKSITE, MORRISON FORMATION, SOUTHEASTERN COLORADO

SCHUMACHER, Bruce A., United States Forest Service, La Junta, CO, United States of America

The Purgatoire Valley tracksite ('Dinosaur Lake') is among the most notable Jurassic dinosaur tracksites in the world, and continues to provide striking new evidence of gregarious and social behavior among dinosaurs, based upon multiple parallel sauropod trackways and overprinting.

First formal description of the site included 1300 individual dinosaur tracks preserved in a lacustrine limestone layer, naturally exposed on the south bank of the Purgatoire River. In recent years, U.S. Forest Service volunteer projects have re-revealed more than 600 additional prints from beneath Quaternary gravel deposits on the north bank. The 'new' area formed the channel floor of the Purgatoire River centuries ago, as evidenced by polishing of the limestone bedding plane and tracks. A new group of parallel sauropod trackways (*Parabrontopodus*) includes five individuals traveling roughly west in modern orientation, similar in trend to previously recorded sauropod trackways. The dominant westward trend of sauropod trackways at the entire site likely originated in a singular event. New sauropod trackway series (longest=54 successive pes prints) are significantly different in size. Pes prints of the smallest and largest individuals average 47 cm and 65 cm in maximum length, respectively, thus the Dinosaur Lake sauropod 'herd' was of mixed age class, with adults and juveniles traveling together. Other lone sauropod trackways traveling in north-south directions tend to be larger individuals (pes length>70 cm) with lower pace angulations values and much better defined manus impressions.

The 'new' area also contains numerous theropod tracks and trackways, with individual pes prints ranging from 25 to 40 cm in maximum dimension. A suite of morphologies accurately match collective observations for the ichnogenus *Megalosauripus*, particularly a large and rounded first phalangeal pad (metatarsal) of digit IV, a distinctive morphology recently described for *Megalosauripus transjuranicus*. None of the preserved tridactyl prints are identifiable as other noted Morrison theropod ichnotaxa (*Hispanosauropus* or *Therangospodus*, "wide-splay" morphotype). This marks the first attribution of the name *Megalosauripus* to the Morrison Formation. Other noteworthy discoveries include direct overprinting of *Megalosauripus* within *Parabrontopodus* tracks, and a particular *Megalosauripus* track series extending more than twenty successive footfalls. The site was photogrammetrically recorded by drone photography in 2017, and this information is pending publication.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A MAJOR EVOLUTIONARY TRANSITION—NEUROANATOMICAL ADAPTATIONS IN THALATTOSUCHUAN CROCODYLOMORPHS

SCHWAB, Julia A., University of Edinburgh, Edinburgh, United Kingdom; YOUNG, Mark T., University of Edinburgh, Edinburgh, United Kingdom; WALSH, Stig, National Museums Scotland, Edinburgh, United Kingdom; WITMER, Lawrence M., Ohio University, Athens, OH, United States of America; HERRERA, Yanina, División Paleontología Vertebrados, La Plata, Argentina; BRUSATTE, Stephen L., University of Edinburgh, Edinburgh, United Kingdom

Thalattosuchia was a group of globally distributed crocodylomorphs that lived from the Early Jurassic to the Early Cretaceous. They are an excellent example of a major evolutionary transition, in this case secondary adaptation to a pelagic marine environment. Thalattosuchians evolved from being semi-aquatic and superficially gharial-like (e.g., teleosauroids and basal metriorhynchoids) to being pelagic and cetacean-like (i.e., metriorhynchids). Although changes in their osteology during this transition are well known, how their sensory systems changed during their adaptation to living in the marine realm is not well understood. However, insight into sensory evolution is essential for understanding how extinct animals could have interacted with their environment, and in this case, how they adapted as they moved into the open sea.

We digitally segmented the endocranial structures (such as the brain cavity, bony labyrinth, and sinuses) from CT datasets of several thalattosuchians, enabling us to draw inferences about their behaviour and sensory capability. We hypothesized that thalattosuchians underwent a similar land-to-sea neuroanatomical transition as cetaceans, with regression of bone-enclosed sinuses and shifts in bony labyrinth shape. Our results thus far show that in basal thalattosuchians (e.g., *Pelagosaurus typus*, *Steneosaurus* cf. *S. gracilirostris*), the pharyngotympanic sinus system reduced and is poorly differentiated. The bony labyrinth and brain cavity are not dorsally enclosed by the pharyngotympanic sinus system (unlike in protosuchians and most other crocodyliforms, including extant crocodylians). In the pelagic metriorhynchids (e.g., *Cricosaurus araucanensis*), there is an even greater reduction in the pharyngotympanic sinus system compared to extant species, and the three semicircular canals and the overall bony labyrinth shape are considerably reduced. The extreme changes in the bony labyrinth are convergent with other secondarily aquatic vertebrates (such as cetaceans and various clades of pelagic marine reptiles), and is likely linked to reduced neck mobility—thereby potentially allowing the animal to better handle fast body rotations.

Our results hint that thalattosuchians quickly became specialised to a marine lifestyle prior to the teleosauroid-metriorhynchid split. It would appear that thalattosuchians quickly adapted to living in a pelagic marine environment, and that their neuroanatomical adaptations might underpin their extraordinary success.

Grant Information
This project is supported by a Leverhulme Trust Research Project grant (RPG-2017-167).

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

POPULATION ANALYSIS OF HADROSAUR TEETH FROM EGG MOUNTAIN QUARRY, UPPER CRETACEOUS, TWO MEDICINE FORMATION, NORTHWEST MONTANA

SCOFIELD, Garrett B., Montana State University, Bozeman, MT, United States of America

Egg Mountain locality as part of the Willow Creek Anticline in the Upper Cretaceous Two Medicine Formation of northwest Montana has become well known for its preservation of dinosaur eggs, eggshell, nesting traces, insect traces, and more recently described mammals and lizards. The diffuse micro-vertebrate locality also turns up an abundance of hadrosaur and theropod teeth. Population dynamics of dinosaurian taxa are known though analysis of long bone material and histology. Here we test the utility of hadrosaur teeth for the same means. Field excavations of a new Egg Mountain Quarry from 2010–2015 resulted in the collection of 564 hadrosaur tooth fragments presumed to belong to *Maiasaura peeblesorum* in addition to a variety of theropod teeth. The most complete *Maiasaura* teeth were measured and compared to *Maiasaura* specimens from museum collections. A subset of the Egg Mt. assemblage was subjected to histological analysis as means to understand tooth formation and shedding rates. Unique factors were developed and applied to the assemblage translating tooth abundance into an abundance of individuals and ultimately mortality and survivorship.

Analysis of museum collections and Egg Mt. hadrosaur teeth revealed highproportions of juvenile individuals as part of the abraded and largely incomplete Egg Mt. specimens. High mortality rates occur within the first year of life followed by a marked decrease until adult age and size is attained. Seasonal nesting grounds and a seasonal and semi-arid environment proposed for the Egg Mt. area is supported by high proportions of young individuals. Shed and disarticulated teeth generated from *Maiasaura* roaming the alluvial plain, were subjected to alluvial processes allowing the rather abraded and broken assemblage to be put in conjunction with autochthonous theropod teeth as well as mammal, lizard, and dinosaur nesting material. Ontogenetic changes in hadrosaur teeth and the conditions of the Egg Mt. assemblage complicate what an individual tooth represents; however, shed and disarticulated hadrosaur teeth appear to show effectiveness in paleoecological population studies. Continued work on abundant dinosaur tooth assemblages would hone these new techniques and potentially provide insight into similar microsite assemblages around the world.

Grant Information
National Research Foundation; NSF (EAR) grant nos. 0847777 and 1325674 to Dave Varricchio (D.J.V.)

Technical Session IX (Friday, October 19, 2018, 8:00 AM)

RE-EVALUATING THE EVOLUTION AND PHYLOGENETIC SIGNIFICANCE OF THE PASSIVE STAY APPARATUS IN EQUID SHOULDERS

SCOTT, Eric, Cogstone Resource Management, Inc., Riverside, CA, United States of America

Living horses (genus *Equus*) share the remarkable ability to drowse while standing, a capability enabled by an arrangement of ligaments and tendons termed the passive stay apparatus. Part of this apparatus is located in the shoulder, where the tendon of the biceps brachii extends from the scapula to the proximal radius. In modern horses, the biceps tendon is broad, and exhibits a ventral depression or pocket that fits over the intermediate tubercle of the proximal humerus. When the animal is standing, the tendon locks onto the intermediate tubercle, preventing the forelimb from collapsing during stance with little or no required muscular exertion.

Previous studies have proposed that the presence of a well-developed intermediate tubercle in fossil equid humeri can be used to infer the presence of the passive stay apparatus in the shoulders of extinct forms. The feature is reported in incipient form in the North American equid genus *Dinohippus* (c. 5 Ma), and is more thoroughly developed in Pliocene and later *Equus*. The passive stay apparatus is thus interpreted to be a synapomorphy uniting this monophyletic clade.

To test this hypothesis, fossil humeri of the endemic African hipparionine genus *Eurygnathohippus* from the Hadar region in the Afar Depression, Ethiopia, were examined to determine if humeral intermediate tubercles were present. Hipparionine horses first appeared in the African fossil record in the early late Miocene, about 10.5 Ma, and subsequently remained evolutionarily distinct from North American equids. Given this prolonged evolutionary and geographic separation, any true synapomorphy uniting Neogene and later equids in North America would not be expected to occur in African hipparionines. However, every examined proximal humerus of *Eurygnathohippus* from Hadar ($N = 6$) bears a moderate to strongly developed intermediate tubercle, indicating the presence of a passive stay apparatus in these animals. Either this anatomical structure evolved more than once in separate lineages, or the stay apparatus has a temporally deeper origin that is not reflected in the bony anatomy in older, smaller forms. It is noted in this context that intermediate tubercles are also present on humeri of the Pleistocene equid genus *Hippidion* from South America—a third distinct horse lineage possessing this feature. The presence of an intermediate tubercle in equid humeri is likely of more limited phylogenetic significance than previously proposed.

Technical Session X (Friday, October 19, 2018, 11:45 AM)

PALEOENVIRONMENTS IN THE WIND RIVER BASIN DURING THE EARLY EOCENE CLIMATIC OPTIMUM—INFERENCES FROM STABLE CARBON ISOTOPES IN MAMMALS

SECORD, Ross, University of Nebraska Lincoln, Lincoln, NE, United States of America

During the Early Eocene Climatic Optimum (EECO), tropical conditions prevailed at mid-latitudes based on botanical evidence and the marine climate record. Euprimate species diversity peaked during the EECO, due largely to high omomyoid diversity. The presence

of these arboreal mammals, along with tropical plants, has led many to think of ecosystems during the EECO as akin to modern, closed-canopy tropical rainforests. However, other lines of evidence, such as well-developed red paleosols with pedogenic carbonates, suggest that these forests may have been seasonally dry and open. Here we use stable carbon isotopes in mammal teeth to infer vegetation structure in the late Wasatchian (biozones Wa6, Wa7) and early Bridgerian (Br1a) of the Wind River Basin (WRB). The EECO begins in Wa7 when mean annual temperature increased by ~5° C from Wa6. A model was used to estimate expected enamel carbon isotope values for different biomes in the early Eocene. The model is based on carbon isotopes in modern plants, corrected for diet-to-enamel enrichment, latitude, altitude, and changes in atmospheric $\delta^{13}C$ values. Carbon isotope values for all three biozones fall in the range predicted for dry, open C_3 habitats before and during the EECO. The pantodont *Coryphodon* (Wa6, Wa7, Br1a) has the lowest mean $\delta^{13}C$ values, the equid "*Hyracotherium*" (Wa6, Wa7, Br1a) has middle to high values, and the brontothere *Lambdotherium* (Wa7) has the highest values. Both "*Hyracotherium*" and *Lambdotherium* have significantly higher values than *Coryphodon*. No significant changes in either carbon or oxygen occur in this sequence, implying that open habitats prevailed before and during the EECO. Although the common presence of arboreal primates may seem at odds with an open habitat interpretation, some small and large strepsirrhine primates do live in open, dry habitats today. Thus, an open forest interpretation is plausible. However, it is possible that $\delta^{13}C$ values in the WRB teeth have been influenced by diagenesis or by an underestimate of atmospheric $\delta^{13}C$ values for the Eocene. Although neither can be entirely discounted, a consistent and significant separation in $\delta^{13}C$ values among taxa demonstrates that at least a partial primary signal is preserved. Additionally, a correction in atmospheric $\delta^{13}C$ values large enough to push the WRB faunas into a closed forest would force the contemporaneous Wa6 Bighorn Basin fauna, for which mean $\delta^{13}C$ values are ~3‰ lower, into an unreasonably low range. Thus, the WRB fauna, which samples a peak in euprimate diversity, appears to have been occupying an open forest.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A NEW CAMARASAURID SPECIMEN FROM THE LATE JURASSIC MORRISON FORMATION OF WYOMING, U.S.A.

SEKIYA, Toru, Fukui Prefectural Dinosaur Museum, Katsuyama, Japan; SHIBATA, Masateru, Fukui Prefectural University, Eiheiji-Town, Japan; AZUMA, Yoichi, Fukui Prefectural University, Eiheiji-Town, Japan

A nearly complete sauropod skeleton (FPDM-V-8509) is recovered from the Late Jurassic Morrison Formation of Shell, Big Horn County, Wyoming, U.S.A. FPDM-V-8509 is articulated and includes a complete skull and postcranial skeletons, representing one individual. FPDM-V-8509 likely belongs to the genus *Camarasaurus* based on the following diagnostic characters: massive lower and upper jaws; metacarpal III to humerus length ratio ~0.33; pubis massive with short shaft; very slender ischium, especially the distal end; and tibio-femoral length ratio ~0.60. Although previous studies erect multiple species of *Camarasaurus* from the Morrison Formation, recent analyses validate only four (possibly three) of them, *C. supremus, C. grandis, C. lentus,* and *C. lewis*. It is noted that some authors argue *C. lewisi* belongs to a closely related genus, *Cathetosaurus*. Based on the emended diagnosis of those species by previous researches (low neural arch of anterior dorsal vertebra and narrow neural spine of anterior caudal vertebra), FPDM-V-8509 is assignable to *C. lentus*. To analyze the congeneric phylogenetic relationships, we created a species-level data matrix based on the character description from previous research on sauropods, and FPDM-V-8509 constitutes a clade within the basal member of Macronaria. The strict consensus tree finds *C. lentus* as the most basal member of the clade, and FPDM-V-8509 closely related to *C. lewisi*. However, in contrast to one of the diagnostic characters of *C. lewisi*, dorsal neural spines being bifid until the 11th dorsal vertebra, the dorsal neural spines of FPDM-V-8509 are bifid only until the 8th dorsal vertebra. This topology results from the lack of derived character states in the juvenile holotype specimen of *C. lentus*. These characters include, for example: anteroposteriorly shortened axis (#121); development of cervical pleurocoels (#127); absence of middle single fossa on the dorsal neural sine (#166); distal expansion of radius (#314); and development of the tibial condyle of femur (#350). In future analyses, a revised dataset may provide a better insight into the taxonomic position of FPDM-V-8509.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THREE-DIMENSIONAL GEOMETRIC MORPHOMETRIC ANALYSIS OF TREESHREW LOWER MOLARS: DENTAL MORPHOLOGY OF THE EXTINCT *PRODENDROGALE YUNNANICA* (SCANDENTIA, TUPAIIDAE)

SELIG, Keegan R., University of Toronto Scarborough, Toronto, ON, Canada; SARGIS, Eric J., Yale Peabody Museum, New Haven, CT, United States of America; CHESTER, Stephen G., Brooklyn College, City University of New York, Brooklyn, NY, United States of America; SILCOX, Mary T., University of Toronto Scarborough, Scarborough, ON, Canada

Scandentia (treeshrews) is an order of small-bodied, Southeast Asian mammals considered to be closely related to primates and colugos, united within Euarchonta. Compared to other euarchontans, the intraordinal relationships among treeshrews are only partially understood. Although previous work has begun to clarify species-level relationships using molecular and morphological data, dental morphology has contributed little to our understanding of these relationships, in part due to low variability among treeshrew dentitions. Understanding how treeshrew molar morphology relates to phylogeny is imperative to understanding the evolutionary history of Scandentia as virtually all known treeshrew fossils are dentognathic. Here, we compare the morphology of the extinct treeshrew species *Prodendrogale yunnanica* from the late Miocene of China to that of extant treeshrew species using 3DGM methods.

We captured 18 landmarks on the lower second molars of 43 specimens representing 15 extant treeshrew species and three of four extant genera, as well as a single specimen of *P. yunnanica.* Our analysis of extant taxa show that this method can characterize the subtle differences between treeshrew families (Tupaiidae and Ptilocercidae) and among less inclusive tupaiid clades. When plotted in morphospace, the tupaiids and ptilocercids form separate clusters, and the tupaiid *Dendrogale* plots among the species of *Tupaia*. *Prodendrogale* plots among the tupaiid group as well, falling near the specimens of *Dendrogale*, particularly along principal components 1, 4, and 5. Euclidean distances of the PC scores suggest that *Prodendrogale* is more like *D. melanura* from Borneo than the latter is to *D. murina* from mainland Southeast Asia. In light of a recent phylogenetic analysis that supports *Prodendrogale* as the sister to *Dendrogale*, our results are consistent with the hypothesis that *Prodendrogale* should be classified in Tupaiidae and shares a close relationship with or could even be the ancestor of *Dendrogale*. These results also suggest that the molar bauplan of the Tupaiidae has long been established, at least since the late Miocene. Although more specimens of extant and extinct taxa are needed to fully characterize the morphospace occupied by treeshrew molars through time, our results suggest that 3DGM methods could serve to clarify our understanding of morphological transformations in treeshrew lineages known from both fossil and extant taxa. Hence, this quantitative approach provides insights into scandentian systematics and dental evolution in this group.

Grant Information

This research was supported by a NSERC Discovery Grant and a UTSC International Research Collaboration Fund award to MTS and a PSC-CUNY Award to SGBC.

Podium Symposium (Wednesday, October 17, 2018, 2:15 PM)

CRANIAL JOINTS AND THE EVOLUTION OF EXTREME FEEDING PERFORMANCE IN CROCODYLIFORMES

SELLERS, Kaleb C., University of Missouri, Columbia, MO, United States of America; MIDDLETON, Kevin, University of Missouri, Columbia, MO, United States of America; CLARK, James M., George Washington Univ, Washington, DC, United States of America; HOLLIDAY, Casey M., University of Missouri, Columbia, MO, United States of America

Modern crocodylians generate immense forces during feeding and have key features that enable the skull to generate and resist such forces. Early crocodylian ancestors lack many of these features, and so the evolution of crocodylians and their fossil relatives (the crocodyliforms) involved a substantial reorganization of the feeding apparatus. This transformation saw changes to a number of cranial joints: the expansion of the pterygoid buttress, reorientation of the jaw suspension, and the suturing of the quadrate and palate to the braincase. The jaw muscles that load cranial joints were also reorganized: the flat crocodylian skull led to mediolateral orientation of temporal and pterygoid muscles, the pterygoideus ventralis muscle began attaching laterally on the mandible, and the depressor mandibulae muscle expanded and reoriented. Once this suite of changes was in place, crocodylian ancestors radiated into forms with derived diets and craniodental modifications, and so these modifications are linked with the radiation of the crocodyliforms. Although the pattern of morphological change is recorded by fossils, the biomechanical performance of these structures in transition is less understood.

To assess the changing relationships between muscles and cranial joints, we used CT data to create 3D models of individuals of three extant crocodylians and four fossil suchians that represent the stepwise acquisition of the modern crocodyliform skull. We used dissections and osteological correlates to reconstruct muscle attachments. Muscle forces were distributed with the computational package, Boneload, and used as input for finite element analysis and 3D lever analysis.

With this dataset, we found that the pterygoid buttress is loaded to a similar magnitude as the jaw joint in crocodyliforms, but not in basal suchians. Our results also show that as the quadrate changes orientation during evolution, jaw joint force aligns with the structural axis of the quadrate despite changes in its linkages. We also show that working side joint force decreases in caudal bite locations, and it is likely that in extreme feeding events such as shaking bites or death rolls, the jaw joint is loaded in tension. Our results reveal a feeding apparatus that defies traditional understanding, and suggest that a suite of changes to cranial joint loading represents a key innovation in crocodyliform evolution. The combination of dual craniomandibular joints and jaw joints loaded in tension is unknown from other groups of tetrapods.

Grant Information

National Science Foundation (IOS 1457319 and EAR 1631684)

University of Missouri Research Board, Research Council, and Department of Pathology and Anatomical Sciences

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

WHAT CAN ENAMEL MICROWEAR REVEAL ABOUT THE DIETARY BEHAVIOR OF *MOERITHERIUM* AND *PHIOMIA* FROM THE FAYUM REGION OF EGYPT?

SEMPREBON, Gina M., Baypath College, Enfield, CT, United States of America; UTTECHT, Lily M., Bay Path University, Longmeadow, MA, United States of America; SANDERS, William J., University of Michigan, Ann Arbor, MI, United States of America

The Fayum region of Egypt has produced a rich Paleogene mammalian fauna including basal proboscideans from the genera *Phiomia* and *Moeritherium*. The goal of this study was to analyze molar teeth of *Phiomia serridens*, *Moeritherium lyonsi*, and *Moeritherium trigodon* from these deposits using enamel microwear and then to compare these results to those of extant proboscideans (*Loxodonta africana*, *Loxodonta cyclotis*, and *Elephas maximus*) and to a wide array of ungulates to reconstruct dietary behavior in the fossil proboscideans and to test the hypothesis that species of *Moeritherium* were semi-aquatic hippo ecomorphs. Quantitative variables (i.e., scratch and pit numbers) and qualitative variables (i.e., gouging, large pitting, puncture-like pitting, and scratch textural differences) were assessed. All three fossil taxa have low average scratch results consistent with browsing ungulates and within a narrower range than results of all three extant elephant species, although fossil scratch results are closer to those of the extant forest elephant (*L. cyclotis*) than to less closed habitat extant forms (*L. africana* and *E. maximus*). Although *Moeritherium* species lack the high scratch grazing type results found in the extant *Hippopotamus amphibious,* both species have finer microwear features than *P. serridens*, which is consistent with the consumption of a relatively soft diet. *Phiomia serridens* is unique in having considerably higher average pit results than those of *M. lyonsi*, *M. trigodon*, and extant elephants as well as numerous deep puncture-like large pits typical of extant fruit consumers, the relative sizes of which are similar to those found in the extant tapirs studied. All fossil taxa show less gouging and finer scratch textures than extant elephants indicating less abrasive diets and the occupation of more closed habitats than the

latter. Results are congruent with prior reconstructions suggesting that *Moeritherium* consumed soft, aquatic vegetation, whereas, a more terrestrial, forest, or woodland existence for *Phiomia* is indicated.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

ASSESSING THE IMPACT OF THE EOCENE–OLIGOCENE CLIMATE TRANSITION ON THE RODENT FAUNAS OF THE WHITE RIVER GROUP

SENN, Megan B., University of New Mexico, Albuquerque, NM, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America

The Eocene and Oligocene boundary occurs at the same time as a distinct global cooling event (the Eocene–Oligocene Climate Transition, or EOCT) that has been associated with the formation of permanent ice caps on Antarctica. The biotic effect of this cooling and whether it is causally associated with the faunal transition across the Eocene–Oligocene boundary has yet to be completely resolved. To obtain a better understanding of the effect of this climatic shift on the vertebrate paleontological record at mid-latitudes, we assess changes in the ecology of the rodent faunas preserved in the White River Group of Nebraska across the EOCT. Rodents are an abundant member of the White River microfauna, and have been shown to be sensitive to shifts in climate in the modern, so are an ideal taxon for quantitatively assessing response to events like the EOCT. The specific environmental preferences of White River rodents are relatively little studied, so we were not able to generate a priori hypotheses of taxonomic response. Instead, we suggest that EOCT-driven faunal shifts would be concentrated between the two localities bracketing the transition, whereas faunal response driven by regional processes would be more widely temporally distributed.

Over 600 rodent specimens representing at least 20 species were collected from four microsites spanning the EOCT at Toadstool Geologic Park (Chadronian to Orellan NALMAs), and changes in the richness, composition, and abundances of the preserved taxa between sites were quantified. While absolute fossil abundance varies among sites, the proportional abundances of the most common species (such as *Eumys elegans* and *Eumys parvidens*) show only minor changes through the study interval. Similarly, while there are compositional differences among the study sites, these are driven by a few very rare taxa (represented by < 3 individuals in any sample) and so much of the compositional difference among sites could be an artifact of sampling, rather than climate-driven ecological change. The EOCT cooling appears to have had little to no effect on the most common White River Group rodents, suggesting that the magnitude of environmental change experienced by this region was insufficient to significantly impact this key component of the White River ecosystems.

Grant Information
This research was funded through UNM RAC Grant 2018-10.

Technical Session XIII (Friday, October 19, 2018, 4:00 PM)

A NEW CHASMOSAURINE HIGHLIGHTS EXTRAORDINARY CERATOPSID RICHNESS IN THE UPPER CRETACEOUS (CAMPANIAN) KAIPAROWITS FORMATION OF SOUTHERN UTAH, U.S.A.

SERTICH, Joseph J., Denver Museum of Nature & Science, Denver, CO, United States of America; LOEWEN, Mark A., Natural History Museum of Utah & University of Utah, Salt Lake City, UT, United States of America; GETTY, Michael A., Denver Museum of Nature & Science, Denver, CO, United States of America

During the middle to late Campanian, the Western Interior foreland basins of the North American landmass of Laramidia, extending from northern Alaska to central Mexico, preserved rich non-marine biotas characterized by tyrannosaurid, hadrosaurid, and ceratopsid dinosaurs. Ongoing work in the Kaiparowits Formation (upper Campanian, ~76 Ma) of southern Utah has revealed a vertebrate assemblage significantly different from contemporaneous northern assemblages hinting at ecologically- or latitudinally-influenced regionalism on Laramidia during this interval. Of particular note is sympatric Kaiparowits Fm ceratopsid diversity that includes both centrosaurine (*Nasutoceratops*) and chasmosaurine (*Utahceratops*, *Kosmoceratops*) taxa from a well-constrained 'middle unit' interval. Remarkably, recent work has recovered significant cranial and postcranial remains from six individuals of a previously unrecognized chasmosaurine ceratopsian from this same stratigraphic interval. Individuals of this new chasmosaurine include a range of life stages, from juvenile to adult, demonstrating consistency in characters through ontogeny that clearly distinguish the new form from previously recognized Kaiparowits taxa. The new taxon is characterized by an anteroposteriorly shortened rostral region, a small sub-pyramidal epijugal, ten episquamosals, and large, dorsally directed, medially curving postorbital horns. The posterior margin of the parietal possesses a strong medial embayment with a dorsally directed first epiparietal confluent posteriorly with a dorsally curved second epiparietal. In many respects, the parietal is similar in overall morphology to *Pentaceratops sternbergii* with the exception of being anteroposteriorly shorter, the frill approximately equal in length to the rest of the skull, and in having an anteroposteriorly broad posterior bar across its entire width. A comprehensive phylogenetic analysis recovers the new taxon as sister to a *Utahceratops*+*Pentaceratops* clade. The presence of three sympatric chasmosaurine taxa is unprecedented in any Upper Cretaceous unit and underscores other observed differences between northern and southern faunas from this interval. While northern assemblages were typically centrosaur-dominated, southern assemblages appear to have been chasmosaur-dominated, sometimes with multiple representatives more closely related to *Pentaceratops* than to *Chasmosaurus*.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

COMPARING DIETARY NICHE PARTITIONING AMONG THE HORNLESS ARTIODACTYL RUMINANTS *HYPERTRAGULUS*, *HYPISODUS*, AND *LEPTOMERYX* FROM THE EARLY OLIGOCENE (ORELLAN) BRULE FORMATION, TOADSTOOL GEOLOGIC PARK, NEBRASKA

SEYLER, Holly C., University of Colorado Museum of Natural History, Boulder, CO, United States of America; EBERLE, Jaelyn J., University of Colorado Museum of Natural History, Boulder, CO, United States of America

The early Oligocene (Orellan) in the North American Western Interior is marked by a cooler and dryer climate than the late Eocene (Chadronian). New mammalian taxa appeared while other groups already present began to diversify. This study takes a closer look at the diversification of hornless ruminant artiodactyls present in the latest Orellan *Merycoidodon bullatus* Interval Zone through an analysis of 71 specimens from three closely related species: *Hypertragulus* (27), *Hypisodus* (18), and *Leptomeryx* (26) from a single locality in Toadstool Geologic Park, Nebraska. Specifically, we took a closer look at the hypsodonty index, mesowear, and tooth volume, which have been used as proxies for paleodiet. Using a Keyence VHX-2000 Digital Microscope©, the lingual, labial, and occlusal view of the m3 of specimens was imaged and a series of up to 24 measurements were performed on each image. These measurements include length, width, and height of both the overall molar as well as the individual selenes and posterolophid. Values were then analyzed using JMP Statistical Software©, running an analysis of variance test. Results show the three artiodactyls are more distinct from each other in dietary niche than previously thought. Specifically, and while this data is preliminary, we found the values group through a combination of hypsodonty index and tooth volume. More so, the difference in the average hypsodonty index may be enough to categorize them into different feeding behavior groups. Furthermore, a new formula to calculate the volume was derived to provide a more accurate value of tooth volume specific to the unique shape of the selenodont teeth possessed by ruminant artiodactyls. Part of this formula [$A = (2W_1L_1)/3$] focuses on the occlusal surface area where W_1 and L_1 represent the width and length, respectively, of any selene or posterolophid; values are summed together for a total occlusal surface area. This study both explores how new technology and techniques can provide more accurate means of gathering measurements for non-destructive analysis and takes a closer look at dietary niche partitioning of these artiodactyls that occurred in the same place at the same time.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

IMPLIED VOCALIZATION BASED ON THE MORPHOLOGY OF THE HYOID APPARATUS IN THE SABERTOOTHED CAT, *SMILODON FATALIS* (MAMMALIA, FELIDAE, MACHAERODONTINAE) FROM RANCHO LA BREA, LOS ANGELES, CALIFORNIA

SHAW, Christopher A., Idaho Museum of Natural History, Pocatello, ID, United States of America

Rancho La Brea has recorded the most complete terrestrial biota from the late Pleistocene of North America. One of the many unique qualities of the fossiliferous asphalt deposits is the preservation of bones that are rarely found elsewhere in the fossil record. The complete structure of the hyoid apparatus has been recovered from several extinct species found at Rancho La Brea, including over 150 elements representing the basihyal, thyrohyal, and stylohyal of *Smilodon fatalis*. These bones are morphologically distinct in size and shape when compared to large feline cats, including the extinct American lion (*Panthera atrox*) and extant African lion and leopard (*Panthera leo* and *Panthera pardus*). The structure of the hyoid apparatus is most similar to these large feline cats than to any other carnivoran clade. This form of hyoid structure entails a reduction of total elements through loss and fusion of the bony elements, with an elastic ligament that stretches from the ventral ends of each stylohyal to the dorsolateral ends of the basihyal. This structure is associated with the ability to enlarge the cavity of the throat enabling living large feline cats to roar, which has been shown to be an important communication ability. The similar condition of the hyoid apparatus in *Smilodon fatalis* implies that this extinct species could roar. Vocalizations of various kinds are important communication abilities, and roaring may have been as important in a social group of*Smilodon fatalis* as it is today in *Panthera leo*.

Technical Session XIV (Saturday, October 20, 2018, 11:00 AM)

FISH FOOD: AN ANALYSIS OF CONVERGENT EVOLUTION IN THE FEEDING STRUCTURE OF *XIPHACTINUS AUDAX* AND *MEGALOPS ATLANTICUS* USING LANDMARK-BASED GEOMETRIC MORPHOMETRICS

SHELBURNE, Edward C., Fort Hays State University, Hays, KS, United States of America

Convergent evolution, a phenomenon in which distantly related organisms independently evolve similar functional or morphological features due to similar environmental pressures, often confounds phylogenetic analyses. A better understanding of convergence and the ecological and physiological constraints that drive it is important for understanding both the phylogeny and ecology of fossil organisms. Current assessment of convergent evolution relies on well-resolved phylogenetic analysis, which can be difficult to develop in fossil taxa due to lack of molecular data. In this study, we used two dimensional (2-D) landmark-based geometric morphometrics (GM) as a novel technique for investigating convergent evolution between the ichtyodectiform fish *Xiphactinus audax*, and the elopiform fish *Megalops atlanticus*.

Xiphactinus audax was a large teleost that inhabited the epicontinental Western Interior Seaway (WIS) during the Late Cretaceous. *M. atlanticus* (Atlantic tarpon) is a large, extant teleost that inhabits the east and west coasts of the Atlantic Ocean, as well as the Gulf of Mexico. These two fish species are phylogenetically distant, but independently converge on a similar feeding structure – most evident in the form of a strongly supraterminal mouth. Landmark-based GM is a series of statistical procedures that analyze shape data through the comparison of axial landmarks placed at homologous points between multiple specimens. These landmark-based GM procedures were applied to the cranial material of a series of *X. audax* and *M. atlanticus* specimens, with emphasis on the jaws and other cranial elements related to feeding. Photographs of specimens were taken and converted to line-drawings for analysis. *X. audax* specimens were un-deformed in order to adjust for diagenetic alteration to the fossils before carrying out statistical analysis. Preliminary

results indicate morphological differences in the feeding structure of these two fish, suggesting a lack of convergence on a functional phenotype. This is corroborated by ecological information regarding the feeding strategies of both species. However, landmark-based GM analysis may be overly sensitive to minor differences in shared phenotypes. Alternatively, these results may suggest a re-assessment of what constitutes convergent evolution is a necessary next step in better understanding this phenomenon. These results also provide insight into the ecology of *X. audax* as a major marine predator of the WIS, and the usefulness of *M. atlanticus* as a valid modern analog.

Grant Information
Geological Society of America (GSA); Western Interior Paleontological Society (WIPS)

Technical Session XI (Friday, October 19, 2018, 2:00 PM)

RESOLVING THE PHYLOGENY OF PALEOCENE MAMMALS: THE PERIPTYCHIDAE

SHELLEY, Sarah L., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America

In the wake of the end-Cretaceous mass extinction, the Paleocene saw the proliferation of many so-called 'archaic' placental mammals, which exhibit an idiosyncratic mosaic of primitive and derived anatomies and whose phylogenetic affinities within Placentalia remain contentious. Consequently, the nature and timing of the placental radiation remains controversial, hindered, in part, by our lack of knowledge of the mammals that thrived during this interval. The Periptychidae are a distinctive 'condylarth' family and were among the first placental mammals to appear after the end-Cretaceous mass extinction. As such they constitute an excellent empirical case study towards resolving the evolutionary history of Paleocene mammals.

I undertook extensive anatomical and multivariate analyses to understand the anatomy and variability within Periptychidae. Multivariate analyses of teeth reveal fluctuating trends in body size and tooth proportions, providing useful taxonomic clarification. Analyses of postcranial elements show that periptychids and other Paleocene taxa exhibit a distinct and constrained range of locomotor ability, defined by their prevalent robust morphology, compared to extant mammals. I conducted an inclusive cladistic analysis to determine the phylogenetic affinities of Periptychidae and other key Paleocene groups within Placentalia. I scored 194 taxa for 693 characters, including 40 periptychids alongside 85 additional Paleogene taxa, incorporating new morphological and taxonomic data.

Salient results of this analysis are a monophyletic Periptychidae excluding several purported periptychids from the earliest Puercan (Pu1). Periptychidae is nested within a group of 'condylarths' positioned at the base of Laurasiatheria and closely related to Artiodactyla, indicating their importance in understanding the origins of the modern orders. Within Periptychidae, the major subfamilial divisions were established by Pu1, indicating that Periptychidae evolved exceptionally rapidly after the extinction, and diversity remained high through the middle to late Puercan (Pu2–Pu3). The Puercan–Torrejonian boundary is marked by a substantial faunal turnover, with only a few species continuing into the Torrejonian. These Torrejonian periptychid species were among the most enduring Paleocene mammal taxa known and reiterate the importance of the Periptychidae in understanding the recovery and radiation of Placentalia following the end-Cretaceous mass extinction.

Grant Information
This work was funded by a U.K. NERC Ph.D. studentship.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

EVIDENCE OF A LARGE BIPEDAL TETRAPOD FROM THE EARLY PERMIAN TAMBACH FORMATION PRESERVED AS NATURAL BONE CASTS DISCOVERED AT THE BROMACKER QUARRY (THURINGIA, GERMANY)

SHELTON, Christen D., Midwestern State University, Wichita Falls, TX, United States of America; WINGS, Oliver, Martin-Luther-Universität Halle-Wittenberg, Halle, Germany; MARTENS, Thomas, Drei Gleichen, Germany; SUMIDA, Stuart S., California State University San Bernardino, San Bernardino, CA, United States of America; BERMAN, David S., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America

The earliest bipedal reptile *Eudibamus cursori* (Bolosauridae) as well as a variety of other early tetrapods (e.g., microsaurs, dissorophoids, seymouriamorphs, amphibamids, diadectids, synapsids) have been found in the Tambach Formation (upper Rotliegend, early Permian) of the Bromacker Quarry near Gotha, Germany and the village of Tambach-Dietharz of Thuringia. Here, we report rare evidence of the largest known vertebrate remains ever to be discovered from the same locality preserved as natural bone casts. The morphology of the elements, suggested by the casts, is most closely comparable to the remains of the much smaller *E. cursori* of the Bromacker assemblage. On the surface of the sandstone slab (2.25 m x 1.65 m) containing the bone casts there are other trace fossils, like *Tambia spiralis*, which is found in abundance at the Bromacker Quarry. At least 30 bone casts were identified from the slab, a majority of which are ribs and long bones (10-24 cm in length). Additionally, recent taphonomic experiments revealed a possible mechanism for the formation of these unique ichnofossils. Given this evidence, we hypothesize that either there was an additional bipedal species that existed sympatrically with *E. cursori,* or these bone casts represent a later ontogenetic stage of *Eudibamus* with the type specimen being a juvenile.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

EARLY CRETACEOUS IGUANODONT PALEOBIOGEOGRAPHY IN ASIA

SHIBATA, Masateru, Institute of Dinosaur Research, Fukui Prefectural University, Eiheiji-Town, Fukui Prefecture, Japan; AZUMA, Yoichi, Institute of Dinosaur Research, Fukui Prefectural University, Eiheiji-Town, Fukui Prefecture, Japan

Recent discoveries of iguanodont dinosaurs in Asia give new information on iguanodont paleobiogeography in the Early Cretaceous. In particular, the Lower Cretaceous of east and southeast Asia provides well-preserved late Early Cretaceous iguanodonts, and new investigations are helping to expand our understanding of the evolutionary process toward the Hadrosauria. Here I review the Early Cretaceous sedimentary basins in East and Southeast Asia where dinosaur fossils have been known, in order to reconstruct their paleoenvironment and paleogeography and compare compositions of each dinosaur fauna from those basins to comprehend faunal transitions. I redescribe four iguanodonts from Japan and Thailand to add new information and describe a new well-preserved iguanodont skull from China, which shows each disarticulated cranial bone including undescribed elements for iguandonots. New phylogenetic analysis on the Early Cretaceous iguanodonts indicates that almost all Early Cretaceous Asian taxa belong to a derived group, Hadrosauroidea. *Lanzhousaurus* and *Fukuisaurus* are exceptionally recovered as basal positions from this clade. As a result, the iguanodont paleobiogeography in East and Southeast Asia is reconstructed as follows. From the Late Jurassic to the beginning of the Cretaceous, basal iguanodonts were prevalent in Europe, North America and Africa, whereas no iguanodont taxa appeared in Asia until the Hauterivian–-early Barremian. The most-primitive Asian iguanodont (*Lanzhousaurus*) from China might be related to European taxa based on the dinosaur faunal comparison. During the Barremian, primitive taxa (non-styracosternan Ankylopollexia) were predominant in North America and derived taxa (Hadrosauriformes) existed in Europe. Cosmopolitan distribution of iguanodonts had not occurred until the Aptian when European hadrosauriforms migrated into Asia. During the Aptian–Albian, hadrosauroids were prevalent and diversified only in Asia. The late Early Cretaceous diversification in Asia led to the emergence of derived hadrosauroids in North America after the occurrence of the connection between Asia and North America in the beginning of the Late Cretaceous.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ONTOGENETIC GROWTH PATTERN OF THE LATE CRETACEOUS LAMNIFORM SHARK, *CRETODUS 'CRASSIDENS*,' BASED ON A SKELETAL REMAIN FROM KANSAS, U.S.A.

SHIMADA, Kenshu, DePaul University, Chicago, IL, United States of America; EVERHART, Michael J., Sternberg Museum, Derby, KS, United States of America

FHSM VP-17575 is a largely disarticulated partial skeleton of a large Late Cretaceous lamniform shark, *Cretodus 'crassidens*,' from the Blue Hill Shale (middle Turonian) of central Kansas, U.S.A. It is housed in the Sternberg Museum of Natural History, Hays, Kansas, and consists of at least 134 teeth, 61 vertebrae, and 23 placoid scales as well as multiple fragments of calcified cartilage. The crown height (CH) of the presumed second lower anterior tooth is 41.0 mm, and when the quantitative relationships between the CH and total body length (TL) of extant lamniform sharks, such as *Mitsukurina owstoni*, *Carcharias taurus*, *Lamna nasus*, *Isurus oxyrinchus*, and *Carcharodon carcharias*, are used, the *Cretodus* individual is extrapolated to be about 515 cm TL. This length is comparable to large individuals of *Cretoxyrhina mantelli* that lived contemporaneously in the Late Cretaceous Western Interior Seaway of North America.

The vertebrae in FHSM VP-17575 are found to exhibit growth bands presumed to have formed annually. The total band number (BN; i.e., equivalent to the number of years) of the specimen is 22, indicating that the shark is assumed have died at age of 22 years old. The TL of the shark when each band formed was back-calculated based on a large vertebra by treating its centrum radius (37 mm) at BN 22 as 100% and assuming that the shark was 515 cm TL when BN 22 formed. The von Bertalanffy growth function (VBGF) experimentally fitted to the BN-TL data gives the following growth parameter estimates with high statistically significance (non-linear regression: $R^2 = 99.9\%$; $p < 0.001$): 118.196 cm TL for the length at birth (L_0), 684.427 cm TL for the theoretical maximum length (L_∞), and 0.055 yr^{-1} for the rate constant with units of reciprocal time (k; i.e., the time it takes for the shark to reach near its theoretical maximum length). In addition, these VBGF parameter estimates give an estimated longevity of 51.021 years for the shark. These estimates are considered reasonable especially because the L_∞ value is close to the estimated TL of a previously described, large skeleton of *Cretodus* sp. from the middle Turonian of Italy (i.e., slightly over 650 cm TL).

Technical Session III (Wednesday, October 17, 2018, 3:30 PM)

AN UNEXPECTED NORTHERNER WITH BURROWED BONES: A NEW MAMMALODONTID (MYSTICETI) FROM THE PACIFIC NORTHWEST WITH *OSEDAX* BORES PROVIDES INSIGHT INTO OLIGOCENE MARINE TAPHONOMY AND MYSTICETE EVOLUTION

SHIPPS, Brenlee K., Smithsonian, Washington, DC, DC, United States of America; PEREDO, Carlos M., George Mason University, Fairfax, VA, United States of America; PYENSON, Nicholas D., Smithsonian, Washington, DC, DC, United States of America

The Mammalodontidae (Cetacea, Mysticeti) from the late Oligocene of Australia and New Zealand are a family of toothed stem mysticetes. Their phylogenetic position relative to other stem mysticetes makes them valuable for understanding the origin of crown mysticetes. Extreme ecological adaptations in crown mysticetes, such as infrasonic hearing and bulk filter feeding, represent significant deviations from their stem cetacean ancestors. Understanding the feeding and hearing adaptations of mammalodontids offers valuable insight into the evolution of modern mysticetes, yet the exact relationship between mammalodontids and other stem mysticetes remains unclear.

Here, we describe a new mammalodontid from the late Oligocene of the Pacific Northwest (Pysht Formation, Washington, United States). This represents the first documented mammalodontid from the Northern Hemisphere, substantially expanding the range of the family. The skull and teeth of this specimen bear boreholes from bone-eating *Osedax* worms, providing valuable information on the taphonomy of the specimen. Critically, this specimen preserves intact ear bones and several teeth. The phylogenetic position of this specimen—as the basal-most known mammalodontid—makes it informative for understanding the origins of both hearing and feeding adaptations. CT scans of the ear bones reveal a greater range of hearing than expected, and complexity analyses on the teeth suggest a simplified dentition relative to other stem mysticetes.

The Oligocene preserves a myriad of stem mysticetes, each with unique morphologies that hint at notably disparate ecologies. Our research enhances our understanding of stem mysticete diversity, adds context for the origin of stem mysticetes, and continues to inform the origins of their ecological innovations.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

BIG CONCEPTS, SMALL STUDENTS: CONVEYING COMPLEX PALEONTOLOGICAL IDEAS TO STUDENTS AGES 4–12

SHIPPS, Brenlee K., Makoshika State Park, Glendive, MT, United States of America

Selling young students on dinosaur paleontology is an easy task; dinosaurs engage the imagination and encourage students to explore a world completely unlike their own. Dinosaurs and other extinct organisms are common mascots and stars of movies and TV shows aimed at children, yet much of what students learn at a young age is detached from the real world of paleontology and divorces the animals studied from the science behind them. In museums, parks, and education centers, the goal is not only to present science in a way that children understand, but to engender a lasting interest in the subject being presented.

At Makoshika State Park, I created new, paleontology-focused educational programming to engage students who are 4–12 years old. This new content was followed by surveys of the students to gauge retention of information and engagement with the content. The educational content of these programs focused on three topics: the size and scale of Hell Creek Formation dinosaurs, the paleoecology of the Hell Creek Formation, and the techniques paleontologists use when examining and preparing fossil specimens. I conducted surveys to test whether students retained key concepts and if they wanted to learn more about paleontology after visiting Makoshika State Park.

Results gained from these surveys will be used to support the creation of new programs on the Montana Dinosaur Trail and to improve existing programs. When working with primary-school-aged students, the main goal of interpretive staff is to increase student interest in the subject presented and encourage students to continue exploring the subject on their own. Results demonstrate that paleontology continues to resonate with young students, and that paleontological concepts students have not been exposed to in fiction are more easily understood and accepted than anticipated.

Technical Session V (Thursday, October 18, 2018, 9:45 AM)

COMPARISON OF INFERENCE APPROACHES FOR ECOMETRIC ANALYSES: USING HYPSODONTY TO ESTIMATE PRECIPITATION

SHORT, Rachel A., Texas A&M University, College Station, TX, United States of America; LAWING, A. M., Texas A & M University, College Station, TX, United States of America

Ecometric analyses provide a method for quantifying assemblage-level functional trait responses to environmental change through time and, therefore, allow for estimating paleoclimates from assemblages of fossils. Ecometrics may also be used to investigate assemblage level functional responses to impending climate change by reversing the inference with a forward modeling approach. Given the potential of ecometrics to produce informative tools, it is important that we understand the analytical methods used in developing the models. Here, we compare two ecometric approaches, polynomial regression and maximum likelihood, to estimate annual precipitation from mean tooth crown height in communities of extant North American herbivores (Artiodactyla, Perissodactyla, Rodentia, and Lagomorpha). Communities were summarized using range maps from the International Union for Conservation of Nature and resampled to community lists at 50 km equidistant points. Tooth crown height was scored as a hypsodonty index of 1-brachydont, 2-mesodont, and 3-hypsodont. Brachydont dentition is an indicator of wet, closed environments, whereas hypsodont dentition is an indicator of arid, open environments. We compared the observed annual precipitation to each method's estimate of annual precipitation based on community hypsodonty. Anomalies calculated between the log annual precipitation and the estimation from the polynomial regression ranged between -3.73 and 3.09, where precipitation was underestimated in the desert southwest and tundra and overestimated in the Pacific Northwest, the entire eastern portion of the continent, and throughout Mexico and Central America. Anomalies from the maximum likelihood approach ranged between -2.39 and 2.54, where precipitation was overestimated in the arid southwest and underestimated in the Pacific Northwest and along the Appalachians. Smaller difference values from the maximum likelihood approach indicate a more reliable prediction when compared to the polynomial regression. Further development and use of the maximum likelihood approach will allow researchers to better compare and combine their ecometric analyses into a larger multiproxy framework. Because ecometrics provide an approach for comparing communities across space and through time, regardless of taxonomic composition, it is important that this promising approach be developed further.

Technical Session II (Wednesday, October 17, 2018, 12:00 PM)

A MULTITAXIC BONEBED FEATURING A NEW SHUVOSAURID (ARCHOSAURIA, POPOSAUROIDEA) FROM THE SONSELA MEMBER OF THE CHINLE FORMATION AT PETRIFIED FOREST NATIONAL PARK

SIDOR, Christian A., University of Washington, Seattle, WA, United States of America; PEECOOK, Brandon R., Field Museum, Seattle, WA, United States of America; BEIGHTOL, Charles V., Petrified Forest National Park, Petrified Forest, AZ, United States of America; KAYE, Tom, Foundation for Scientific Advancement, Sierra Vista, AZ, United States of America; KULIK, Zoe T., University of Washington, Seattle, WA, United States of America; LIVINGSTON, Gary, Burke Museum, Seattle, WA, United States of America; PARKER, William G., Petrified Forest National Park, Petrified Forest National Park, AZ, United States of America; OLROYD, Savannah L., University of Washington, Seattle, WA, United States of America; WHITNEY, Megan R., University of Washington, Seattle, WA, United States of America

For over a century, the rocks of Petrified Forest National Park (PEFO) have yielded important insights into Late Triassic terrestrial ecosystems in western Pangea. A large variety of tetrapod species are known, including temnospondyls, basal archosauromorphs, pseudosuchians, and rarer avemetatarsalians and synapsids. The vertebrate record encompasses two biozones, the Adamanian and overlying Revueltian, but historically most fossils occur as isolated elements or parts of individuals. In 2014, a collaborative PEFO-University of Washington Burke Museum team discovered a bonebed in the Sonsela Member (Jim Camp Wash Beds), within meters of the purported Adamanian-Revueltian transition. This rich deposit preserves several hundred disarticulated elements pertaining to at least 13 taxa, including: the aetosaur *Paratypothorax*, the archosauromorphs *Trilophosaurus dornorum* and *Vancleavia campi*, as well as material referable to Drepanosauromorpha, Metoposauridae, Phytosauria, Silesauridae, and Tanystropheidae. Dinosaurs are relatively rare, but postcranial material suggests the presence of three morphotypes: cf. *Chindesaurus*, a *Tawa*-like form, and a neotheropod (coelophysoid). Of special note are a probable new species of shuvosaurid and a possibly novel azendohsaurid. The shuvosaurid is the most abundant species in the quarry, with a minimum of 21 individuals recorded. Based on the size distribution of elements preserved, we suggest that most bones represent juveniles (~12 cm femur length), although much larger and smaller individuals also occur. The PEFO shuvosaurid is similar to *Effigia okeeffae* in its limb morphology, particularly in details of the pelvic girdle, femur, and metatarsus. Three sedimentary layers produce fossils within the quarry: a dull reddish-brown mudstone with sand-filled mudcracks, a massive mottled purple mudstone with sporadic quartz pebbles, and a greenish-white pebbly sandstone that includes mud rip-up clasts. The layers have a complex arrangement, and the pebbly sandstone down-cuts into the underlying muds in places. We interpret the sequence as a crevasse-splay deposit, but detailed taphonomic work is needed. The shuvosaurid quarry is somewhat isolated and thus difficult to correlate to the surrounding outcrops. Still, it is important as either latest Adamanian or earliest Revueltian and can thus provide key information on faunal transitions in this interval. However, the lack of diagnostic phytosaur material makes a more definitive biostratigraphic statement challenging.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

DESCRIBING THE LOWER JAW OF THE STEM TETRAPOD *TIKTAALIK ROSEAE* (LATE DEVONIAN, FRASNIAN) THROUGH COMPUTED TOMOGRAPHY DATA

SIEVERS, Kevin N., Academy of Natural Sciences of Drexel University, Philadelphia, PA, United States of America; DAESCHLER, Ted, Academy of Natural Sciences of Drexel University, Philadelphia, PA, United States of America

Describing the morphology of stem tetrapods is essential to understanding the evolutionary transition between finned and limbed animals. In particular, the lower jaw can be useful to reconstruct musculature and potential feeding behavior. This element is well studied in certain taxa of significance to the fin-to-limb transition such as the finned *Eusthenopteron foordi* and the limbed *Acanthostega gunneri*, but has received almost no attention in important transitional forms such as *Tiktaalik roseae*. Here we describe the lower jaw of *T. roseae* through computed tomography data and map out the individual bones within it for the first time, using the left jaw of a large individual recovered from fluvial deposits of the Upper Devonian (Frasnian age) Fram Formation of Ellesmere Island, Nunavut in 2004. Both primitive features, such as the nature of the coronoid fossae, and derived characters, such as extensive "scarf"-jointed sutural morphology, can be observed in this specimen. These characters appear to support a specialization for feeding in a shallow water setting proposed in other recent studies of stem tetrapods. Finally, we constructed a three-dimensional digital model of the jaw to compare to those of similar organisms, in order to track anatomical change through the evolutionary history of this lineage.

Grant Information
This work was supported by the Office of Undergraduate Research at Drexel University.

Technical Session XI (Friday, October 19, 2018, 2:15 PM)

BIOGEOGRAPHY AND BIOSTRATIGRAPHY OF EUTHERIAN MAMMALS DURING THE PUERCAN NORTH AMERICAN LAND MAMMAL AGE (PALEOCENE, EARLIEST DANIAN)

SILVIRIA, Jason, University of New Mexico, Albuquerque, NM, United States of America; WILLIAMSON, Thomas E., New Mexico Museum of Natural History & Science, Albuquerque, NM, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America; MYERS, Corinne, University of New Mexico, Albuquerque, NM, United States of America

The Puercan Land Mammal Age (Paleocene, earliest Danian; ~66–65 Ma) is the earliest North American faunal stage of the Cenozoic era, immediately after the end-Cretaceous (K–Pg) mass extinction event. It is typified by the adaptive radiation of eutherian mammals, including placentals, following the annihilation of the non-avian dinosaurs. Unfortunately, the spatiotemporal scale of Puercan eutherian diversification remains elusive, and controversy remains whether there was any basin-level faunal provincialism, as is documented below the K–Pg boundary. The traditional biogeographic scenario involves a more pronounced north-south dichotomy in the later Pu2 and Pu3 intervals compared to the earlier Pu1 interval, although Pu1 sites in Colorado and Wyoming have been interpreted as part of a 'transition-zone' with endemic taxa, as well as an early range expansion of 'southern' faunal components. Here we evaluate Puercan eutherian biogeography and biostratigraphy in western North America, relying on specimen records in the published literature and in museum collection catalogs. Trends in spatiotemporal ordination were examined in R using DCA, PCA, and NMDS clustering, as well as agnes hierarchial dendrograms. We recover four broad clusters of Puercan eutherian faunas. The three most robust clusters are a northern/transition-zone Pu1 fauna, a southern Pu2/Pu3 fauna, and a northern Pu3 fauna. A fourth cluster of 'oddball' Pu1 and Pu2 sites, united by the presence of two basal periptychians (*Ampliconus* and *Baioconodon*), is more tentatively resolved. Overall, the analyses indicate increased geographic differentiation in the later Puercan, with early expansion of the derived Pu2/Pu3 southern fauna. However, we found no significant basin-level endemism. Ongoing studies are using multiple regression analyses of spatiotemporal and taphonomic variables, along with geospatial plots of taxon distribution, to clarify patterns and processes in Puercan eutheriandiversification.

Grant Information
J. Silviria is funded by the GSA Graduate Student Research Grant and the Paleontological Society Stephen Jay Gould Award.

Technical Session XIV (Saturday, October 20, 2018, 10:15 AM)

NEW RAY-FINNED FISH (ACTINOPTERYGII) TAXA FROM THE LATE DEVONIAN OF EASTERN NORTH AMERICA EXPOSE UNEXPECTED DIVERSITY OF EARLY FRESHWATER FORMS

SIME, John A., University of Pennsylvania, Philadelphia, PA, United States of America; FRIEDMAN, Matt, University of Michigan, Ann Arbor, MI, United States of America; SALLAN, Lauren, University of Pennsylvania, Philadelphia, PA, United States of America

A sparse fossil record plagues the early history of the ray-finned fishes (Actinopterygii), following their inferred origination by the Late Silurian (418 million years ago). This rarity is taken to reflect a lack of abundance and morphological diversity for actinopterygians in most Devonian ecosystems, and implies they occupied minor ecological roles. New actinopterygian fossils collected from the Late Devonian (Famennian) Catskill Formation of Pennsylvania and re-evaluation of a misattributed, poorly-studied taxon from the similarly-aged Berea Sandstone of Ohio may help clarify regional morphological disparity and niche partitioning among freshwater, ray-finned fishes. A nearly complete fish and a partial second specimen, preserved on part-counterpart slabs, represent a new taxon. These fish belong to the rich vertebrate assemblage found at the Red Hill road cut locality, which includes an acanthodian, placoderms, chondrichthyans, sarcopterygians (including several tetrapods), and a single, previously described actinopterygian, *Limnomis delaneyi*. Specimens of the new fish preserve much of the skull, fins, and squamation. Taxonomically relevant characters include the presence of dermohyals, pectoral fins with fringing fulcra, and pelvic fins. In addition, micro-CT scans of the most complete specimen reveals an articulated gill skeleton, which is known in only a handful of Devonian actinopterygians. A large fish specimen discovered at another Catskill road cut represents a third, potentially ecologically divergent actinopterygian. However, the poor condition of the skull precludes precise assessment of its affinities. A fourth, very large taxon, *"Gonatodus" brainerdi*, is known from multiple, superficially degraded specimens recovered from the terrestrial river valley sediments of the Berea Sandstone, Ohio in the 1800s. However, these deposits were laid on top on the marine basinal Cleveland Shale during extreme sea-level regression at the end-Devonian Hangenberg event. This species may have originally resided in Deltas nearer to the Acadian mountains inland. Continued sampling of well-studied fossil localities in Pennsylvania and Ohio has improved the early actinopterygian freshwater fossil record. If early ray-finned fishes prove to be more ecologically diverse than was previously understood, then new discoveries may force a revision of hypotheses for the subsequent diversification of these fishes.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

ASSESSING HABITAT PARTITIONING IN NON-AVIAN THEROPOD DINOSAURS USING PEDAL MORPHOLOGY: A CASE STUDY OF THE CAENAGNATHID OVIRAPTOROSAUR *MACROPHALANGIA CANADENSIS*

SIMON, Jade, University of Toronto & Royal Ontario Museum, Toronto, ON, Canada; EVANS, David, Royal Ontario Museum & University of Toronto, Toronto, ON, Canada

Oviraptorosaurs are a diverse group of edentulous maniraptoran theropods from the Cretaceous of Laurasia. Although well-preserved and nearly complete oviraptorid specimens are relatively abundant, caenagnathid oviraptorosaurs remain enigmatic due to a paucity of complete specimens. The long legs and odd phalangeal proportions of caenagnathids have led to ecological reconstructions varying from cursors to arboreal perchers to fluvial waders and are suggested to reflect habitat partitioning between caenagnathids and the shorter-toed oviraptorids. One of the first caenagnathids described, *Macrophalangia canadensis* (synonymous with *Chirostenotes pergracilis*) comprises a complete articulated hind foot from the Dinosaur Park Formation of Alberta. As the only known complete caenagnathid pes, the *M. canadensis* holotype (CMN 8538) is crucial for evaluating morphological disparity in oviraptorosaurs. Here we redescribe *M. canadensis* and quantitatively assess pedal disparity across coelurosaurs.

Originally described in articulation, CMN8583 was prepared in three dimensions, allowing for more detailed description and comparison. This specimen illustrates the unique phalangeal morphology characteristic of caenagnathids, in which the penultimate phalanges of DIII-IV are elongated and non-ungual phalanges of DII are nearly subequal in length. Principle components analysis across coelurosaurs—restricted to digit III for the current study—indicates *M. canadensis* is separated from oviraptorids and other maniraptorans primarily by the relative length of PIII-3. Penultimate phalangeal elongation is often associated with arboreal perching or grasping ability in theropods; however, the animal's large size (~45 kg) and long PIII-1 seem inconsistent with perching behavior. Comparisons with extant birds suggest these differences instead correlate with foraging or substrate characteristics. Phalangeal proportions of *M. canadensis* are comparable to that of some reed marsh dwelling rails, which may reflect adaptation to moist or loose substrates, while oviraptorids are most similar to terrestrial birds that utilize drier, more consolidated substrates. These results support the hypothesis that observed disparity in foot morphology between caenagnathids and oviraptorids reflects niche segregation. Our ongoing ecomorphological modeling of birds and morphological comparison of coelurosaurs will further clarify the paleoecology of extinct theropods beyond the dichotomy between arboreal perching and ground dwelling.

Grant Information
NSERC Discovery Grant to DCE (RGPIN 355845); Dinosaur Research Institute Student Research Grant to DJS

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

HERPETOFAUNAL AND BOTANICAL ESTIMATE OF PRECIPITATION AND TEMPERATURE ANNUAL AVERAGES AT GRAY FOSSIL SITE, TENNESSEE

SIMPSON, Emily M., East Tennessee State University, Johnson City, TN, United States of America

When active in the early Pliocene, the Gray Fossil Site in east Tennessee was a flooded sinkhole complex surrounded by a temperate *Quercus-Carya* forest. Flora and fauna from the site include taxa, such as *Alligator*, whose modern distribution is limited by winter severity (i.e., a minimum temperature in the coldest month no lower than 5.5° C). *Trachemys*, *Chelydra*, and *Alligator* also require a permanent water source. However characterization of the GFS climate using a variety of available materials and methods have yet to be quantified. Temperature and precipitation are estimated using a paleoprecipitation index, based on herpetofaunas, and compared to results of leaf margin analysis (LMA) and climate leaf analysis multivariate program (CLAMP). Estimates are then compared to modern averages in the region. The estimated mean annual temperature using LMA and CLAMP is 13°–24° C, with seasonal variation estimated by CLAMP to be from 10° C in the coldest month to 23° C in the warmest month. CLAMP and the herpetofaunal paleoprecipitation index estimate the annual average precipitation to be 69–122.28 cm. These values are supported by the physiological needs of many taxa present at the site, and the higher estimated limits of the mean annual temperature support suggestions that the environment was warmer in the Pliocene. However, the average precipitation may have been less than modern conditions. As the precipitation herpetofauna model is recalibrated to the region, the estimate based on this is preliminary and may be revised.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

TURNING OVER A NEW LEAF: HERBIVOROUS TETRAPOD TROPHIC MORPHOLOGY REVEALS THE ECOLOGICAL DYNAMICS OF THE TERRESTRIAL FAUNAL TURNOVERS THROUGH THE EARLY MESOZOIC

SINGH, Suresh, University of Bristol, BRISTOL, United Kingdom; ELSLER, Armin, University of Bristol, Bristol, United Kingdom; STUBBS, Tom, University of Bristol, Bristol, United Kingdom; RAYFIELD, Emily J., University of Bristol, Bristol, United Kingdom; BENTON, Michael J., University of Bristol, Bristol, United Kingdom

Terrestrial ecosystems underwent significant changes through the early Mesozoic. Early Triassic faunas were populated by survivors from the Permo–Triassic mass extinction and dominated by therapsids. A series of faunal turnovers across the Triassic saw new (diapsid) clades supersede the Palaeozoic holdovers, establishing dinosaur supremacy through the remainder of the Mesozoic, and the structural basis for modern ecosystems via the earliest emergence of many key extant clades. Despite extensive study, the principal drivers of these turnovers remain hotly debated, with competition, increased volcanism, and bolide impacts suggested as possible triggers. A lack of data and imprecise chronostratigraphy has hampered efforts to understand macroevolution across this interval. Nonetheless, recent work is helping to resolve these issues, revealing a wealth of new taxa and focusing attention on extrinsic pressures such as the Carnian Pluvial Event (CPE) and Central Atlantic Magmatic Province (CAMP) eruptions. Consequently, fresh investigations are now warranted. Here we present a quantitative morphometric and functional study of herbivorous tetrapods through the early Mesozoic, using mandibular feeding functionality to infer patterns of trophic ecology and evolution. Herbivores are acutely linked to their environments as a result of their diets, thus we use changes in their trophic ecology to assess the impact of prospective extrinsic and intrinsic pressures. Our results support the macroevolutionary significance of the CPE, and reveal a complex narrative of ecological (and potentially intrinsic) interactions within early Mesozoic herbivores, shedding further light on the dawn of the dinosaurs.

Technical Session V (Thursday, October 18, 2018, 11:15 AM)

COMMUNITY DENTAL MORPHOLOGY OF PLIO-PLEISTOCENE CERCOPITHECID PRIMATES: COMPARISONS WITH

SMAIL, Irene E., Arizona State University, Tempe, AZ, United States of America

Cercopithecid primates are found in a variety of habitats across Africa and Asia today, where populations of sympatric species partition resources based on differences in body size, locomotor behavior, and dietary resource use, among other things. Plio-Pliestocene deposits across eastern and southern Africa also preserve a rich fossil record of potentially co-occurring cercopithecid species, raising the question of how these communities were structured in the past. This project examines the dental morphological niches of living and fossil cercopithecid primates to address whether communities exhibit similar niche areas or positions across varied spatial and temporal scales.

Premolar and molar metrics were collected from wild-shot museum specimens and from the literature for extant African ($n > 700$) and Asian ($n > 250$) cercopithecid species and African Plio-Pleistocene fossil cercopithecids ($n > 90$). Extant community comparisons focused on a subset of known localities for which the museum sample was representative of reported community composition (23 modern sites in Africa, 12 in Asia, and 10 fossil African sites). Isometric shape ratios were calculated separately for the maxillary and mandibular dentitions of individual specimens to account for differential fossil preservation, and principal component analyses were performed on these trait ratios. The first two components (~90% of the total variation) were subsequently used to calculate community niche sizes (two-dimensional area), pairwise niche overlap, and relative niche position (pairwise centroid distance).

Comparisons of community niche sizes using ANOVA revealed no significant differences ($p > 0.05$) between modern African, modern Asian, and fossil African cercopithecid communities. However, pairwise comparisons of community niche overlap and centroid distances did reveal differences between the fossil and modern sites. These results suggest that compared with Plio-Pleistocene communities, modern cercopithecids have undergone a dental morphological niche shift, rather than niche contraction. Ongoing and future research will examine the environmental context of modern and fossil cercopithecid community variation to better understand how and why this niche shift may have occurred. Future analyses will also incorporate resampling techniques to address issues of temporal averaging and incomplete sampling in the fossil record.

Grant Information
Data collection by IES was funded by a student research grant from the School of Human Evolution and Social Change at Arizona State University.

Technical Session IX (Friday, October 19, 2018, 11:30 AM)

WERE MOUNTAIN PASSES HIGHER IN THE MIDDLE MIOCENE?

SMILEY, Tara M., Oregon State University, Corvallis, OR, United States of America; TERRY, Rebecca C., Oregon State University, Corvallis, OR, United States of America; BADGLEY, Catherine, University of Michigan, Ann Arbor, MI, United States of America; BAHADORI, Alireza, Stony Brook University, Stony Brook, NY, United States of America; HOLT, William E., Stony Brook University, Stony Brook, NY, United States of

America; RASBURY, Troy, Stony Brook University, Stony Brook, NY, United States of America

Janzen's classic paper, "Why mountain passes are higher in the tropics," hypothesized that low temperature seasonality in the tropics leads to narrow thermal tolerances of organisms and strong effective thermal zonation, thereby limiting species' elevational ranges to a greater degree than in temperate montane regions. In this way, mountain passes in the tropics are effective barriers to dispersal, resulting in higher allopatric speciation over evolutionary timescales and ultimately contributing to the latitudinal diversity gradient. We expand on Janzen's hypothesis to test drivers of the species-richness peak in western North American mammals during the middle Miocene (17–14 Ma), a period with elevated global temperatures and rapid tectonic extension in the Basin and Range Province. Specifically, we 1) quantify faunal similarity among six fossil- rich regions from 17 to 6 Ma, 2) assess whether elevated spatial turnover contributed to peak diversity, and 3) test which landscape variables best explain the dynamics of faunal similarity over geologic time. To do so, we estimated regional paleotopography through quantitative temporal integration of crustal kinematic and deformation models in the western U.S. through the Neogene. We then produced elevational profiles between each fossil region for 1-million-year bins and calculated four landscape variables: paleo distance, maximum elevation, relief (maximum–minimum elevation), and a relief index (topographic distance/paleo distance). We find a strong signal of decay-by-distance in faunal similarity between regions today and during the middle Miocene, but not from 13 to 6 Ma. Furthermore, the best-fit model for the middle Miocene (explaining 82% of the variance in similarity) included paleo distance, maximum elevation, and relief-index variables. These results suggest that physical barriers and corresponding temperature and precipitation gradients were key to structuring mammal turnover in the tectonically active Basin and Range Province. However, we find no evidence that absolute elevation or relief between regions was higher during this time. We thus conclude that mountain passes were more effective barriers from 17 to 14 Ma during the warm Miocene Climatic Optimum. Future paired topography and climate models will help distinguish the relative influence of relief versus thermal gradients on faunal patterns. Initial results suggest that high rates of tectonic extension and barriers that are young features of the landscape promoted high mammalian turnover in the middle Miocene.

Technical Session XVI (Saturday, October 20, 2018, 9:45 AM)

APPENDICULAR MUSCLE RECONSTRUCTIONS IN THEREZINOSAURS WITH MUSCULAR CHANGES IN THE MANIRAPTORAN OPISTHOPUBIC PELVIS

SMITH, David K., Northland Pioneer College, Show Low, AZ, United States of America; WOLFE, Douglas G., White Mountain Dinosaur Exploration Center, Springerville, AZ, United States of America; SANDERS, Richard K., North Canyon Medical Center, Gooding, ID, United States of America

Appendicular musculature has been reconstructed for selected theropods scattered along the lineage, including *Tawa*, dromaeosaurs, *Tyrannosaurus*, and *Struthiomimus*, among others. Therizinosaurs were a highly modified clade of maniraptoran theropods. We present a reconstruction of therizinosaur appendicular musculature based mainly on *Nothronychus*. Casts and descriptions of *Nothronychus mckinleyi*, *N. graffami*, *Segnosaurus galbinensis*, and *Alxasaurus elisitaiensis* are incorporated because taphonomic alteration prevents precise identification of all muscle scars in any one specimen. The proposed musculature of our composite therizinosaur was derived principally from previous work on theropods, the non-theropod *Maiasaura,* pigeons, and alligators.

In many respects, *Nothronychus* forelimb muscles and function were typical for maniraptorans. The humerus could not be protracted beyond the base of the neck or extended above the vertebral column, but considerable lateral movement was possible. Maximum ulnar/humeral movement would permit considerable flexion as has been proposed typical for maniraptorans. Unlike typical theropods, pronation and supination of the radius/ulna was possible.

The pelvic girdle of therizinosaurs has frequently been described as opisthopubic. This configuration would result in an extensive reorganization of hindlimb musculature. We find that an avian musculature model more closely fits the observable muscle scars than crocodilians or that proposed for *Tyrannosaurus*. Therefore, this alteration must have evolved in concert with the development of an opisthopubic pelvis. The associated changes are convergent with the postpubic bar in the pelvis of ornithischians.

Therizinosaur appendicular muscle geometry represents a mosaic pattern of evolution. Generally, hindlimb musculature approaches an avian grade, but the forelimb is more plesiomorphic. This result supports functional separation of the two regions into discrete modules.

Podium Symposium (Wednesday, October 17, 2018, 12:00 PM)

THE INFLUENCE OF HOMININS ON PATTERNS OF MAMMAL DIVERSITY

SMITH, Felisa A., University of New Mexico, Albuquerque, NM, United States of America; ELLIOTT SMITH, Rosemary E., University of California San Diego, La Jolla, CA, United States of America; LYONS, S. Kathleen, University of Nebraska, Lincoln, NE, United States of America; PAYNE, Jonathan L., Stanford University, Stanford, CA, United States of America

Since the late Pleistocene, large-bodied mammals have been extirpated from much of the Earth. While all habitable continents once harbored giant mammals, the few remaining species are largely confined to Africa. Here, we employ several databases to examine patterns of mammal biodiversity loss over time. First, we use a late Quaternary database of taxonomy, distribution, body mass, trophic affiliation, conservation status, and last occurrence date for all mammals across the globe (MOM v10), to quantify the patterns of extinction selectivity, continental body size distributions, and taxonomic diversity over five time periods spanning the last 125,000 years and stretching ~200 years into the future. We demonstrate that size-selective extinction was already underway in the oldest interval, occurred on all continents, within all trophic modes, and across all time intervals. This 'body size downgrading' was coincident with the global expansion of hominins over the late Quaternary. Second, we employ a global database of Cenozoic mammals with associated age range and body sizes taken from the Paleobiology Database, literature, and specimen measurements. We compute mammal turnover and extinction selectivity in 1-million-year intervals for the entire Cenozoic and compare with temperature proxies. We find no influence of temperature on the rate of mammal turnover, or on the selectivity of extinction for the Cenozoic. However, the degree of body size selectivity at the late Quaternary was unprecedented when compared to the previous 65 million years of mammalian evolution. The distinctive selectivity signature of the late Quaternary implicates hominin activity as a primary driver of taxonomic losses and ecosystem homogenization. Because megafauna have a disproportionate influence on ecosystem structure and function, past and present body size downgrading is reshaping Earth's biosphere.

Grant Information

Funding was provided by NSF DEB-1555525 (F.A. Smith, PI; S.K. Lyons, S. Newsome, co-PIs).

Romer Prize Session (Thursday, October 18, 2018, 10:45 AM)

COUPLING PALEOECOLOGICAL PROXIES TO INFER THE DIETARY ECOLOGY OF EXTINCT MEGAHERBIVORES

SMITH, Gregory J., Vanderbilt University, Nashville, TN, United States of America

Megaherbivores (i.e., animals over 1000 kg in body mass) are extremely efficient resource consumers that play a significant role in the lateral transport of nutrients, often moving them from areas of high to low abundance. Because of this, modern megaherbivores, including Asian and African elephants, sustain high ecological diversity and productivity in their environments. Given their disproportionate impacts on regional ecology, modern elephants are a critical component of conservation strategies. However, a full understanding of how modern elephants might respond to anthropogenic stressors such as habitat loss due to farming or climate change is limited without a better appreciation for how their relatives responded to similar biotic and abiotic stressors in the past. Pleistocene North America offers an excellent natural laboratory for assessing such responses, as it hosted three proboscideans that likely competed with one another for resources during periods of dramatic climatic and ecologic change.

To reconstruct the ecology of these megaherbivores, I utilized three dietary proxies that record information about the properties of foods consumed—stable isotopes, dental mesowear, and dental microwear. I then coupled these data with biological data including geographic distribution and relative abundance across North America. I highlighted two disparate examples of ecological response to resource limitation in the late Pleistocene—niche partitioning in southern California and competition for resources in the Gulf Coastal Plain of Florida and Texas. Results demonstrate that southern California populations were capable of co-existing by specializing on disparate resources, and that this strategy resulted in one of the largest and most diverse assemblages of megaherbivores in late Pleistocene North America. However, in the Gulf Coastal Plain populations, *Cuvieronius*, a generalist, competed for resources with *Mammut* and *Mammuthus*, two end-member dietary specialists. Specifically, the stable isotope values of *Cuvieronius* shift from grazing to mixed feeding following the arrival of *Mammuthus* ~1.8 Ma while textural attributes are indistinguishable amongst all three taxa. *Cuvieronius* was likely competitively excluded during a period where climate change already bottlenecked resources. Modern elephants experience similar stresses—competition for resources with a more efficient consumer and dramatic climatic change—and are likely to respond similarly without contingency plans to provide relief from one or both stressors.

Grant Information

Geological Society of America Student Research Grant, Paleontological Society Stephen Jay Gould Award, Theodore Roosevelt Memorial Grant, Larry D. Agenbroad Legacy Fund

Poster Session III (Friday, October 19, 2018, 4:15 – 6:15 PM)

A NEW SPECIES OF THE NANHSIUNGCHELYIDAE TURTLE *BASILEMYS* FROM THE ARLINGTON ARCHOSAUR SITE, WOODBINE FORMATION, TEXAS, U.S.A.

SMITH, Heather F., Midwestern University, Glendale, AZ, United States of America; ADRIAN, Brent, Midwestern University, Glendale, AZ, United States of America; NOTO, Christopher R., University of Wisconsin-Parkside, Kenosha, WI, United States of America; GROSSMAN, Aryeh, Midwestern University, Glendale, AZ, United States of America

The Nanhsiungchelyidae is a family of large-bodied, primarily terrestrial t rionychoid turtles from the Early to Late Cretaceous. While primarily an Asian radiation, one genus from this family, *Basilemys*, has been discovered in North America and is considered endemic. The five species currently known are distinguished primarily by plastral features, as cranial and cervical material of the genus is rare. Here we present the initial description of *Basilemys* sp. nov. from the Cenomanian (early Late Cretaceous, 93–99 Mya) of the Arlington Archosaur Site (AAS) of Texas. This record marks the earliest appearance of the genus and its easternmost extent in North America. The new species is represented by a partial cranium, lower jaw, and plastral and carapacial elements. The caudal half of the cranium is complete, but the face and dermal neurocranium are mostly absent. We assign the specimen to *Basilemys* on the basis of a closed incisura columella auris, rounded tympanic openings, and outwardly radiating striations on the cranial roof. This specimen is unique in having large, rounded processus trochlearis oticum with minimal parietal contribution, and large tubercula basioccipitale that project caudally and are bounded by deep fossae superiorly. The lower jaw has a complex triturating surface that is divided into distinct posterior and anterior dentary pockets. It has a pronounced symphyseal hook, and the labial ridge of the dentary is serrated with a distinctive series of tooth-like denticles. The shell has the characteristically pitted sculpture of *Basilemys,* marked with large, coalesced pits separated by rounded ridges. It displays the single autapomorphy of *Basilemys,* a rectangular cervical scale. However, the cervical scute is substantially wider than other species of *Basilemys,* approximately twice as wide as it is long, and its lateral and posterior aspects are concave.

The Nanhsiungchelyidae had many functional adaptations similar to the Testudinidae, such as heavy armor, elephantine feet, enlarged gular projections, and extensive triturating surfaces, and have been reconstructed as at least semi-terrestrial. The presence of *Basilemys* sp. nov. at AAS expands the geographic range of *Basilemys* to southwestern Appalachia, and its temporal range back more than 10 Ma, so the new species represents

the earliest morphology of the genus. This finding adds to the terrestrial herpetofauna of AAS, further supporting environmental reconstructions of the site as a complex coastal ecosystem with highly diverse terrestrial and aquatic fauna.
Grant Information
The research was funded by Midwestern University intramural research funds (HFS).

Technical Session XIII (Friday, October 19, 2018, 3:00 PM)

NEW MATERIAL OF *DROMOMERON ROMERI* (ARCHOSAURIA, DINOSAUROMORPHA) FROM THE UPPER TRIASSIC CHINLE FORMATION OF NEW MEXICO PROVIDES INSIGHT INTO THE EVOLUTIONARY MORPHOLOGY OF EARLY DINOSAUROMORPHS

SMITH, Nathan, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; IRMIS, Randall, University of Utah, Salt Lake City, UT, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America

The Hayden Quarry (HQ) from the Petrified Forest Member of the Chinle Formation (Norian, ~212 Ma) has yielded unprecedented insight into dinosauromorph evolution. Discovery of the non-dinosauriform dinosauromorph *Dromomeron romeri* from the HQ established that early dinosauromorphs were contemporaries with dinosaurs for a substantial part of the Late Triassic, refuting hypotheses of rapid transition to dinosaur-dominated faunas. This discovery was based on hindlimb elements, which diagnosed *Dromomeron* as a member of Lagerpetidae, the sister group to all other dinosauromorphs. Despite a flurry of new discoveries, the anatomy of lagerpetids remains poorly known. We describe new specimens of *Dromomeron romeri*, including an articulated post-cranium, further revealing lagerpetid anatomy. The articulated *Dromomeron* specimen has a humerus/femur ratio of ~88%, higher than the lagerpetid *Ixalerpeton* (~78%), and dinosauromorphs like *Marasuchus* (~69%) and *Silesaurus* (~67%). Estimated forelimb/hindlimb ratio of *Dromomeron* is ~67%, higher than most dinosaurs, but within the range of non-dinosaurian dinosauromorphs. The deltopectoral crest apex extends nearly 30% the length of the humerus, as in *Ixalerpeton* and similar to the condition in Dinosauria. However, a smaller *Dromomeron* humerus has a more proximally-restricted deltopectoral crest, complicating interpretations of the distribution of this classic dinosaur synapomorphy. The medially directed internal tuberosity differs from the posteriorly deflected condition in dinosaurs. A partial manus, a first for any non-dinosaur dinosauromorph, has a metacarpal I ~50% the length of MCII. MCI has asymmetric distal condyles, a trait long considered a saurischian synapomorphy. Manus length is ~35% of the inferred humerus+ulna length, longer than other non-saurischian ornithodirans. An articulated metatarsus is short relative to the tibia, in contrast to the elongate metatarsus of *Lagerpeton chanarensis* and most dinosauromorphs. MTIII is the longest, with subequal MTIV/MTII, and MTI 50% the length of MTII. This configuration differs starkly from the highly modified metatarsus of *Lagerpeton*. These data provide new insight on the anatomy and limb proportions of *Dromomeron* and lagerpetids, highlighting variation within the group. *Dromomeron* skeletal elements solidify the phylogenetic position of Lagerpetidae as the earliest branching clade within Dinosauromorpha, but introduce character conflict that questions several diagnostic features of Dinosauria and major subclades.
Grant Information
NSF EAR 1349554 (NDS), 1349667 (SJN), 1349650 (RBI), 1349654 (AHT)

Technical Session XIX (Saturday, October 20, 2018, 4:00 PM)

END-PERMIAN ECOSYSTEM COLLAPSE IN SOUTHERN GONDWANA: EVIDENCE FROM SOUTH AFRICA AND ANTARCTICA

SMITH, Roger M., University of the Witwatersrand, Johannesburg, South Africa; BOTHA-BRINK, Jennifer, National Museum, Bloemfontein, South Africa; SIDOR, Christian A., University of Washington, Seattle, WA, United States of America; TABOR, Neil J., Southern Methodist University, Dallas, TX, United States of America

The southern part of the Karoo Basin of South Africa and the central Beacon Basin of Antarctica contain stratigraphic records of the terrestrial Permo-Triassic boundary (tPTB). These two basins were originally part of a NW-SE trending series of foreland basins along the landward side of the Gondwanide orogenic belt that, during Permo-Triassic times, spanned 50–70 degrees South. Comparison of the tPTB sequences at different latitudes tests the 'drought-induced phased die-off hypothesis' previously proposed for the main Karoo Basin.

We have logged ~700 in-situ vertebrate fossils from strata immediately above and below the tPTB at four widely-separated sections in the southern Karoo Basin. Biostratigraphic ranges of tetrapod taxa reveal three separate phases of die-off within a 75 meter-thick stratigraphic interval displaying the same sequence of sedimentary facies, which we interpret as indicative of a ~120 kyr-long interval of climatic drying, extreme seasonality, and the onset of an unpredictable monsoon-like rainfall regime.

Time equivalent strata of the Beacon Supergroup outcrop in the Central Transantarctic Mountains where several widely spaced tPTB sections have also been identified. We have logged 97 in situ tetrapod fossils from strata 4.5–90 m above the boundary, but no vertebrates have yet been found in the upper Permian beds. Shared Early Triassic taxa such as *Thrinaxodon*, *Lystrosaurus maccaigi*, *L. murrayi*, *Prolacerta*, and *Procolophon* indicate that breeding populations connected the two basins during the immediate post-extinction ecosystem recovery.

tPTB sequences in both basins record progressive climatic drying with lowering of the floodplain water tables. The South African record is accompanied by a general rubification of the mudrocks co-incident with the disappearance of glossopterid leaf flora and numerous tetrapod genera, whereas the Antarctic section remains drab green and the boundary is marked by the disappearance of coal beds and the appearance of distinctive branching root networks in siltstone beds coincident with the first Triassic tetrapod fossils.

We conclude that evidence of floodplain drying coinciding with faunal and floral extinctions in two Gondwanan basins separated by 20 degrees of paleo-latitude strongly favors climatic rather than tectonic control. Additionally, a ~120 kyr-long interruption of global rainfall regimes following a rapid increase in atmospheric aerosols and greenhouse gasses from extensive basaltic eruptions in northern Pangaea were the most likely cause of such aridification.
Grant Information
Funding for Antarctica through National Science Foundation Polar Research Program and for South Africa through DST/NRF African Origins Platform

Technical Session XI (Friday, October 19, 2018, 3:15 PM)

NEW DATA ON THE EARLY EOCENE MAMMALS AND OTHER VERTEBRATES FROM THE CAMBAY SHALE FORMATION EXPOSED IN LIGNITE MINES OF GUJARAT, WESTERN INDIA

SMITH, Thierry, Royal Belgium Institute of Natural Sciences, Brussels, Belgium; RANA, Rajendra S., H.N.B. Garhwal University, Srinagar, India; KUMAR, Kishor, Wadia Institute of Himalayan Geology, Dehradun, India; FOLIE, Annelise, Royal Belgium Institute of Natural Sciences, Brussels, Belgium; DUNN, Rachel H., Des Moines University, Des Moines, IA, United States of America; SOLÉ, Floréal, Royal Belgium Institute of Natural Sciences, Brussels, Belgium; ZACK, Shawn P., University of Arizona, Phoenix, AZ, United States of America; ROSE, Kenneth D., Johns Hopkins Univ, Baltimore, MD, United States of America

Excavations since 2004 in the early Eocene Cambay Shale Formation at Vastan, Mangrol, and Tadkeshwar open-cast lignite mines in Gujarat, western India, have yielded thousands of vertebrate specimens of terrestrial mammals, lizards, snakes, frogs, and birds as well as elasmobranch and teleost fishes. Here we report new fossils from the currently active Tadkeshwar mine discovered from several layers intercalated at different heights between the two major lignite seams. Most of them belong to taxa already described from the nearby Vastan and Mangrol mines, such as the adapoid primate *Marcgodinotius indicus*, the hyaenodontan *Indohyaenodon raoi*, the tillodont *Anthraconyx hypsomylus*, the perissodactyl-like mammal *Cambaytherium thewissi,* the agamid lizard *Tinosaurus indicus*, the palaeophiid snake *Palaeophis vastaniensis*, the caenophidian snakes *Procerophis* and *Thaumastophis*, and the bird *Vastanavis*. The presence of these taxa in the three mines and at different levels suggests that the deposits between the two major lignite seams represent a relatively short time span and a single mammal age. Among the new specimens from Tadkeshwar are well-preserved jaws of a new condylarth-like mammal, a new adapoid primate, and a small tapiroid perissodactyl. Most vertebrate taxa of the Cambay Shale Formation are of west European affinities; some of them seem to be endemic to India, and a few are of Gondwanan affinities, such as mesoeucrocodylians and the giant madtsoiid snake *Platyspondylophis*, attesting that the early Eocene was an important period in India during which Laurasian taxa coexisted with relict taxa from Gondwana before the India-Asia collision.
Grant Information
Funded by Leakey Foundation, National Geographic Society, Wadia Institute of Himalayan Geology, and Belgian Science Policy Office (project BR/121/A3/PalEurAfrica)

Technical Session XVI (Saturday, October 20, 2018, 8:00 AM)

TYRANNOSAURIDS WERE ABLE TO TURN MORE RAPIDLY THAN OTHER LARGE THEROPODS

SNIVELY, Eric, University of Wisconsin-La Crosse, La Crosse, WI, United States of America; O'BRIEN, Haley, Tulsa, OK, United States of America; HENDERSON, Donald M., Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; ROWE, Andre J., University of Wisconsin- La Crosse, La Crosse, WI, United States of America

The Tyrannosauridae were the only large (>400 kg) toothed theropods across Laramidia and central Asia during the closing stages of the Cretaceous. Tyrannosaurids appear shorter anteroposteriorly and had larger ilia than other theropods of similar body mass, suggesting both lower rotational inertia (resistance of an object to turning) and leg muscles that could exert greater torque (force times a lever) to turn their bodies. We tested the hypothesis that tyrannosaurids could turn more quickly, at greater angular acceleration, than other theropods of similar size, under two scenarios potentially important for preycapture.

To compare turning ability in theropods, we divided relative musculoskeletal torques by rotational inertia for an index of angular acceleration. Muscle forces were derived from ilium area and m. caudofemoralis longus cross-sections, and lever arms scaled by mass$^{1/3}$. We estimated theropod rotational inertias and masses with 3-D mathematical slicing, accounting for lungs and other air spaces; results converged precisely with independent ranges from skeletal mounts. PGLS regression of agility index versus body mass, and phylogenetic ANCOVA, enabled us to compare trends in agility amongst tyrannosaurids (juvenile and adult) and large non-tyrannosaurid theropods.

Tyrannosaurids had two to five times the agility index values of other theropods at equivalent masses, with greater discrepancies at smaller body sizes. Phylogenetic ANCOVA revealed definitively greater agilities in tyrannosaurids as a group with continuous biomechanical trends through ontogeny, and phylogeny explaining nearly all variance. Group differences hold with both feet planted on the ground, or with the body and swing leg pivoting over one stance leg. Results therefore indicate more rapid angular acceleration in tyrannosaurids whether in close quarters or intercepting prey during pursuit. Tyrannosaurids matched the agility of much smaller allosauroids, suggesting greater predatory scope for pursuing smaller, quicker, and/or more well-defended prey at a given body size.

Technical Session VI (Thursday, October 18, 2018, 11:15 AM)

UNUSUAL FOSSORIAL STEREOSPONDYL FROM THE TRIASSIC OF WYOMING WITH IMPLICATIONS FOR ORIGINS OF GYMNOPHIONA

SO, Calvin University of Wisconsin-Madison, Madison, WI, United States of America; KUFNER, Aaron M. University of Wisconsin-Madison, Madison, WI, United States of America; HUTTENLOCKER, Adam K. University of Southern California, Los Angeles, CA, United States of America; PARDO, Jason University of Calgary, Calgary, AB, Canada; LOVELACE, David UW-Madison Geology Museum, Madison, WI, United States of America

Recent efforts to study the paleobiology of fossil assemblages in the Late Triassic Popo Agie Formation of Wyoming led to the discovery of an unusually productive vertebrate locality in a discrete stratigraphic horizon near the base of the unit. Excavation of the bed—named the Serendipity Bed—yielded several dozen partially to fully articulated skeletons of a small (estimated body size range: 6–30 cm) brachyopoid stereospondyls preserved in situ in vertically oriented burrows. Several of these burrows have been scanned with both medical-grade and micro-CT instruments. Close examination of one individual (UWGM 2164) has yielded affinities with the stem-caecilian lineage including *Chinlestegophis*, but also retains many stereospondyl plesiomorphies such as a narrow cultriform process, a quadrate-articular joint level with the occipital surface, lateral line sulci, palatal fangs, and parasymphyseal dentary tusks. Among the synapomorphic characters shared between this new taxon and *Chinlestegophis* are: laterally-oriented orbits and a second row of lower teeth on the coronoid elements. The specimens preserve additional autapomorphic features, including a distinctly upturned snout—a possible specialization for fossoriality and, particularly, head-first burrowing. The preliminary results of our phylogenetic analysis using a recently published phylogenetic dataset and Bayesian posterior probability find that this new taxon resolves within the stem-caecilian lineage that also includes the latiscopid *Rileymillerus* and *Chinlestegophis*. The morphology of this new taxon further refines the stepwise acquisition of gymnophionan characters within Stereospondyli and suggests that some steps in the assembly of the caecilian body plan may have occurred at moderate body size.

Grant Information
We would like to thank the David B. Jones Foundation for funding the excavation and preparation of these specimens.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

REFINEMENT OF CHRONOLOGY OF KENNEWICK ROADCUT (WASHINGTON, U.S.A.) ALLOWS COMPARISON OF IRVINGTONIAN FOSSIL LOCALITIES ACROSS NORTH AMERICA

SOCKI, Francesca, Ohio Wesleyan University, Delaware, OH, United States of America

The chronology of Kennewick Roadcut (KRC) in south-central Washington has been difficult to refine. The original description of the chronology of this locality was based on the presence of four-triangle forms of *Lemmiscus curtatus*. At the time of description, *L. curtatus* was inferred to be approximately 30,000 years old. Previously, we documented variation in a sample of *Microtus* specimens that were found concurrently with specimens of *L. curtatus* within the KRC stratigraphic section. Now, we have been able to identify these specimens as belonging to *Microtus meadensis*. *Microtus meadensis* has a last known occurrence in the middle Pleistocene of North America (300,000 years ago) and a first known occurrence at roughly the middle Irvingtonian (780,000 years ago). This species is not present in the lowest level or highest level of KRC, allowing us to refine the chronology of the KRC stratigraphic sequence in-between. We now recognize that KRC has a potential minimum age of 300,000 years and a potential maximum age of 780,000 years ago, between stratigraphic levels A–I. This sequence is capped by an ashfall dated at 5,000 years ago. Our refinement allows us to place KRC into the context of other Irvingtonian-aged localities such as Porcupine Cave (Colorado) and San Antonio Mountain Cave (New Mexico), where the small mammal assemblages appear similar. We now have the ability to refine our understanding of faunal turnover in northwestern North America during the middle Pleistocene.

Technical Session XI (Friday, October 19, 2018, 2:30 PM)

CRITICAL ANALYSIS OF CARNIVORAN MAMMAL SUCCESS IN EUROPE DURING THE PALEOGENE

SOLÉ, Floréal, Royal Belgian Institute of Natural Sciences, Brussels, Belgium; MENNECART, Bastien, Natural History Museum Basel, Basel, Switzerland; LE VERGER, Kévin, Museum National d'Histoire Naturelle, Paris, Belgium; FISCHER, Valentin, Université de Liège, Liège, Belgium; SPEIJER, Robert P., Katholieke Universiteit Leuven, Leuven-Heverlee, Belgium; SMITH, Thierry, Institut Royal des Science Naturelles de Belgique, Brussels, Belgium

Why are we surrounded by only one group of placental carnivorous mammals (Carnivora: the present-day lions, dogs, bears, and seals among others) today, while at least three other groups of placental mammals (Hyaenodonta, Mesonychia, Oxyaenidae) were in competition with carnivorans 50 million years ago?

Since the 1990s, palaeontologists have investigated the success of carnivoraform mammals (including Carnivora) and their crucial adaptations in detail. Analysis of the taxonomic and morphological diversification of these groups in the North American fossil record clearly showed that carnivoraforms outcompeted hyaenodonts and oxyaenids during the Eocene, specifically from around 50 Ma when carnivoraforms began to dominate. It has been suggested that the evolutionary success of carnivorans may have resulted from the broad range of dental adaptations (i.e., a broad variety of diets) conferred by the particular position of their carnassialteeth.

Here we document the evolutionary history of the taxonomic diversity as well as the evolution of the body mass of carnivorous mammals that lived in Europe during the Paleogene (66–23 Ma). The results suggest that this competition was diametrically opposed in North America and Europe. Carnivoraforms actually did not become diversified in Europe during the Eocene and thus were not as taxonomically successful in Europe as in North America during that period. Moreover, when one considers body mass, the European hyaenodonts were distinctly more diversified than the carnivoraforms. The situation dramatically changed during the 'Grande Coupure' (around Eocene–Oligocene boundary; ca. 33.9 Ma). This transition corresponds to a major faunal turnover in Europe: during the earliest Oligocene global cooling (Oi-1) event, the Eocene endemic carnivorous fauna were replaced by immigrant taxa (hyaenodonts and carnivorans), mainly from Asia. The Oligocene fossil record shows a diversification of the carnivorans, whereas hyaenodonts were almost only represented by the hypercarnivorous genus *Hyaenodon*. However, two distinct periods can be discriminated in the Oligocene: the Rupelian was dominated by the Nimravidae and feliforms, while the Chattian was dominated by the caniformians (especially the Amphicyonidae and Ursidae). This turnover seems to be concomitant with the Latest Oligocene Warming and *Microbunodon* Event. Based on these results, onecan hypothesize that the evolution of the European carnivorous mammals might have been profoundly driven by climate modifications (abiotic factors).

Grant Information
This abstract is a contribution to the Belspo Brain Pioneer project BR/175/PI/CARNAGES funded by the Belgian Science Policy Office.

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

IMPROVING PHYLOGENETIC INFERENCE FROM MORPHOLOGY USING DATA FROM MODERN CROCODYLIA

SOOKIAS, Roland B., Museum für Naturkunde, Berlin, Germany

Phylogenies using DNA are increasingly reliable and stable for extant groups. For fossils we must, however, continue to rely on morphology. Current methods of inferring phylogeny from morphology often disagree with DNA data for extant groups, and thus appear to be inadequate. To begin to address this problem, data from modern crocodilians are investigated. Crocodilians make an excellent case study because of their close relationship to extinct pseudosuchians and dinosaurs, yet tractable number of taxa. All characters were investigated and documented, and those found to be robust to three tests—observability, compatibility with scoring, and plausible apomorphy—were significantly ($p = 0.01$) less homoplastic than non-robust characters when mapped onto a DNA-based composite phylogeny. Cranial characters were also significantly less homoplastic than postcranial ($p = 0.05$). When only characters robust to these tests were used to infer a phylogeny using maximum parsimony, *Gavialis* (gharial) and *Tomistoma* (false gharial) were placed as progressively closer sister taxa to other extant taxa, and *Melanosuchus* was still resolved within *Caiman*. This did not represent a major improvement to the original dataset, and further work using different outgroups and recoding non-robust characters is required. A neighbor-joining approach demonstrated the overall greater similarity of *Tomistoma* and *Gavialis* to crocodile-line than alligator-line taxa, and was thus in some ways more concordant with DNA data.

Grant Information
Alexander von Humboldt postdoctoral research grant, Deutsche Forschungsgemeinschaft

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

RESOLVING THE *MESADACTYLUS* COMPLEX OF DRY MESA QUARRY, MORRISON FORMATION, COLORADO

SPRAGUE, Michael, Loma Linda University, Riverside, CA, United States of America; MCLAIN, Matthew A., The Master's University, Santa Clarita, CA, United States of America

The Dry Mesa Quarry (DMQ) of southwestern Colorado is a prolific locality of the Morrison Formation known for a diverse assemblage of vertebrates, including the large theropods *Allosaurus*, *Ceratosaurus*, and Torvosaurus, and the sauropods *Supersaurus*, *Camarasaurus*, and *Apatosaurus*. The assemblage is also host to numerous non-dinosaurian vertebrate fauna, including fish, amphibians, crocodiles, lizards, turtles, and a mammal. Also present is the single pterosaur genus *Mesadactylus*, the only recognized pterosaur from DMQ with a holotype consisting of an isolated synsacrum. At the time of this writing, all DMQ pterosaur material has been ascribed to *Mesadactylus*, though other authors have been skeptical of the affinity of the entirety of the material to *Mesadactylus*. We examined material from the DMQ *Mesadactylus* complex, held in the Brigham Young University Museum of Paleontology. Of particular interest were four humeri, three femora, a scapulocoracoid, and the *Mesadactylus* synsacrum. The humeri and scapulocoracoid are non-pterodactyloid, while the femora seem to represent three different clades: Rhamphorhynchinae, Dsungaripteroidea, and possibly Ornithocheiroidea.

The only DMQ pterosaur material that can be confidently assigned to *Mesadactylus* is the holotype synsacrum, which is notable for its large supraneural plate. To complicate matters, while *Mesadactylus* is diagnostic, the taxonomic affinity of the genus is still uncertain. The presence of a supraneural plate has been considered diagnostic for the clade containing Ornithocheiroidea, Dsungaripteroidea, and Azhdarchoidea, but *Mesadactylus* does not appear to belong to any of these taxa, and previous work focusing on the phylogenetic signature of supraneural plates has not included *Mesadactylus*. The presence of a supraneural plate in *Mesadactylus* may indicate either supraneural plates are present in more clades than previously recognized, or our understanding of the phylogenetic importance of supraneural plates is wrong. Further, the poor preservation of pterosaur sacra has obscured important morphological details, currently making a more precise designation for *Mesadactylus* difficult.

Due to the lack of complete, well-preserved fossils, Morrison pterosaur diversity is poorly understood. Drawing out this previously unrecognized diversity of DMQ pterosaurs gives us the opportunity to reassess Morrison pterosaur diversity and compare it to other Upper Jurassic deposits around the world, such as the Solnhofen Limestone and Tendaguru Formation.

Grant Information
Funding received from Loma Linda University.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

DESERT WETLANDS RECORD A NEW PLEISTOCENE VERTEBRATE FAUNA FROM DEATH VALLEY NATIONAL PARK

SPRINGER, Kathleen B., U.S. Geological Survey, Denver, CO, United States of America; PIGATI, Jeffrey S., U.S. Geological Survey, Denver, CO, United States of America; SCOTT, Eric, Cogstone Resource Management, Inc., Orange, CA, United States of America; SANTUCCI, Vincent L., National Park Service, Gettysburg, PA, United States of America; FERLICCHI, Matthew, Great Basin Institute, Reno, NV, United States of America

The National Park Service, U.S. Geological Survey, and Cogstone Resource Management, Inc., have combined capabilities to systematically survey Pleistocene strata in a little studied wilderness area in Death Valley National Park (DEVA) for vertebrate, invertebrate, and plant paleontologic resources in concert with establishing a detailed stratigraphic and geochronologic framework for the deposits. Our study area, the Lake Rogers basin, is located in the northern portion of the park and is occupied by extensive, light colored, fine-grained sediments known for decades to produce Pleistocene vertebrate fossils, although

the area has never been systematically investigated. As the name implies, the sediments were initially interpreted as a lacustrine sequence; we instead recognize the deposits as representing widespread, spring-derived paleowetlands. Desert wetlands are keystone ecosystems in arid environments and are preserved in the geologic record as groundwater discharge deposits. These deposits contain long records of climatic and hydrologic conditions, and commonly preserve vertebrate fossils. Since 2017, 2% of the ~57 km^2basin has been surveyed and 78 fossil resource localities have been recorded. Field identifications indicate the nascent large mammal component of the fauna is dominated by *Mammuthus*, *Equus*, and *Camelops*, along with less common remains of *Bison*. Vertebrate fossils are observed in three discrete spring discharge intervals that range in age from at least ~50 to 25 ka. Each discharge cycle is terminated by stable surfaces and/or erosion, followed by renewed spring activity, as the wetlands waxed and waned in response to climate perturbations. Understanding the temporal and depositional context of the inset faunas has utility in determining how vertebrate animals responded to these climate stressors in DEVA, as well as other areas in the American southwest. This research augments the rich geologic and paleontologic history of DEVA and supports science-informed interpretation, management, and protection of these nonrenewable resources.

Grant Information
This project was funded by the USGS's Climate and Land Use Change Research and Development Program (Paleohydrology of Desert Wetlands project) and the National Park Service.

Technical Session XIV (Saturday, October 20, 2018, 8:00 AM)

TANYRHINICHTHYS, A LONG-ROSTRUMED CARBONIFEROUS RAY-FINNED FISH (ACTINOPTERYGII), AND THE EVOLUTION OF ELONGATE SNOUTS IN FISHES.

STACK, Jack, University of Pennsylvania, Philadelphia, PA, United States of America; HODNETT, John-Paul M., Maryland-National Capital Parks and Planning Commission, Poolesville, MD, United States of America; LUCAS, Spencer, New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America; SALLAN, Lauren, University of Pennsylvania, Philadelphia, PA, United States of America

Tanyrhinichthys mcallisteri, a member of the diverse and well-preserved fish fauna within the Upper Pennsylvanian (Missourian) Atrasado Formation of the Kinney Brick Quarry (KBQ), is a small (standard length ~15 cm), elongated actinopterygian with a lengthened rostrum. New material suggests that *Tanyrhinichthys* was a bottom feeder morphologically similar to the modern sturgeon (*Acipenser*). Like sturgeon, *Tanyrhinichthys* had a rostrum that extended past its lower jaw and a resultant small, subterminal mouth, as well as a number of other convergent features, including a long anal fin set forward of the dorsal, large lateral line scales, and an anteriorly-deepened body with ventral insertion of the paired fins. Two other long-rostrumed actinopterygians, an unnamed taxon from Indiana and *Phanerorhynchus* from the U.K., are known from similarly-aged, Pennsylvanian freshwater coal deposits. Various skeletal features indicate that these long-rostrumed fishes were not closely related. As supported by the existence of the paddlefish-like shark *Bandringa* in similarly aged deposits from Illinois, there was widespread convergence on a bottom-feeding freshwater morphotype amongst Pennsylvanian fishes. An examination of other fossil and modern ray-finned fishes with elongate snouts suggests that they tend to build outwardly similar rostra using different sets of cranial bones, implying that strong functional selection (rather than pre-existing variation) drives the evolution of this trait. The majority of these long-rostrumed forms can be divided into common ecomorphological categories resulting from convergence on shared niche space (e.g., bottom feeder, pursuit predator, etc). *Tanyrhinichthys* itself falls into a group of fishes with short electro-sensory rostra with less skeletal support anteriorly, likely facilitating a bottom-roving feeding strategy. This group of fishes includes living taxa (sturgeon, paddlefish, and armored catfishes), along with fossil taxa such as *Phanerorhynchus*. Although there are some exceptions, it appears that long-rostrumed fishes are driven to evolve grossly similar structures in pursuit of distinctive life modes.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

NEW CRANIODENTAL MATERIAL OF *MICROPTERNODUS* CF. *M. MORGANI* FROM THE TURTLE COVE MEMBER OF THE JOHN DAY FORMATION, OREGON

STEED, Brittany L., University of Calgary, Calgary, AB, Canada; SAMUELS, Joshua X., East Tennessee State University, Johnson City, TN, United States of America; SCOTT, Craig S., Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; THEODOR, Jessica M., University of Calgary, Calgary, AB, Canada

New material recovered from Turtle Cove Member (unit E1) at John Day Fossil Beds National Monument is referred to *Micropternodus* cf. *M. morgani*, a species previously known only from an incomplete skull that importantly lacks the basicranium, and an associated incomplete left dentary. New radiometric dates of tuff units indicate the specimen is between 29.586–31.356 Ma in age, referable to either the Whitneyan or early Arikareean (Ar1) NALMA. JODA 6211 includes a partial skull and articulated dentaries, with the teeth in occlusion. Micro CT analysis allowed 3D reconstruction and identification of the dentition.

There is damage to the upper incisors and canines, but the remaining upper dentition is intact, with P3–M3 present. Both M1s show slight erosion at the buccal side near the roots. P1 and P2 are not present, nor are their alveoli developed. The upper canines are less sectorial and the P3 metastylar cusp is less well developed than in UCMP 60801, the holotype of *M. morgani*. In the dentary, there are three incisors, p2–4 and m1–3. The lower molars lack cingulids, and the paraconids appear somewhat more labially positioned than UCMP 60801. The rostrum is well preserved, with portions of the cranial roof and basicranium present. Micro CT analysis shows the petrosals and bony labyrinths are preserved on both sides, with the malleus and incus preserved on the left side, and the incus on the right. The cochlea is relatively compact with two and a half turns. Further analysis of the auditory region will clarify the systematic position of *Micropternodus* relative to Eulipotyphla.

Micropternodus is known from earlier deposits in Montana, Wyoming, Nebraska, Utah, and Saskatchewan, but JODA 6211 possibly represents the earliest occurrence of a eulipotyphlan in the Pacific Northwest. Unit E1 is interpreted as representing a relatively open habitat based on paleosol evidence, and it also records the first clear open habitat specialist in the region, the burrowing beaver, *Palaeocastor peninsulatus*.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

THE PRESENCE OF INTERVERTEBRAL STRUCTURES TRACK BODYSIZE IN ARCHOSAURIA, NOT PHYLOGENY, AND THE LOSS OF THE STRUCTURES IN LIVING MEMBERS OF THE CLADE

STEFANIC, Candice M., Stony Brook University, Stony Brook, NY, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America

The body size of the largest terrestrial vertebrates alive today (5-ton elephants) is far smaller than the biggest members of the reptile clade Archosauria (e.g., 80-ton titanosaurs, 20-ton theropods). Whereas the major body size transitions in extinct archosaurs are well documented, less is known about the changes in skeletal morphology that correspond with major body size shifts, particularly the evolution of larger body sizes. We hypothesize that modification of articulations between vertebrae allowed for larger bodies in the clade. To test this hypothesis, we focused on an accessory articulation structure seen only in extinct members of Archosauria, the hyposphene–hypantrum. First, we provide a strict definition of the articulation and using these criteria, identified it in a variety of crocodylian- and avian-line archosaurs. Second, using ancestral state reconstruction (in Mesquite), we compared the gains and losses of the structures across Archosauria. We determined body size thresholds for presence and absence of the hyposphene–hypantrum using femoral length. We find that non-crocodylian pseudosuchians with femoral lengths above 212–300 mm and non-avian dinosaurs with femoral lengths above 130–170 had the articulation, and these body size thresholds arose independently in both lineages. In taxa that fall below the lower limits of these thresholds, the articulation is absent, regardless of phylogenetic history. It is permanently lost prior to the origin of each archosaurian crown clade (Crocodylia, Aves) when taxa reduce to body lengths of ~> 1 meter (e.g., the crocodylomorph *Sphenosuchus*, the avialian *Archaeopteryx*). After the shift to small body sizes in both lineages, vertebrae character states change (e.g., evolution of procoely, heterocoely) and later when members of the lineages reach larger sizes (*Deinosuchus*, *Struthio*), the hyposphene–hypantrum does not reappear. To further test the relationship between vertebral articulation and body size, we measured the articular surface area of zygapophyses (relative to centrum height) of taxa with and without the hyposphene–hypantrum. Living taxa are all without a hyposphene–hypantrum and they show a trend of increasing surface area with larger body size, whereas the extinct archosaurs we sampled that did possess a hyposphene–hypantrum did not follow that trend. The relative zygapophyseal surface area of those extinct taxa plotted closer to small birds than to large crocodylians, even though many of them are much larger than even the largest crocodylians.

Grant Information
NSF EAR 1349667

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

NEW AND EXTRALIMITAL TETRAPODS FROM MIDDLE–LATE HOLOCENE PACKRAT MIDDENS ON PUBLIC LANDS IN THE BEARS EARS REGION OF SOUTHEASTERN UTAH, U.S.A.

STEGNER, M. A., UW Madison, Madison, WI, United States of America; STIDHAM, Thomas, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China

The middle–late Holocene was a period of major environmental change on the Colorado Plateau, including climatic fluctuations, and anthropogenic effects (pre- and post-European contact). Detailed paleoecological records from Quaternary deposits are pivotal in characterizing changes among species and communities, as a result of such past environmental fluctuations. However, only a handful of Quaternary localities sampling the small vertebrate community of the Colorado Plateau have been studied to date, and thus the changes to and responses by those clades to shifting Holocene environments are poorly known. Here, we report on the faunal diversity of four middle–late Holocene localities from public lands in the Bears Ears region of southeastern Utah. Bone-rich sediments from four alcoves geographically proximate to one another were excavated 2013–2014 and dry screened for vertebrate, plant, and other fossil remains. The activity of woodrats, roosting owls/raptors, and mammalian carnivores at these various sites accumulated and concentrated the fossils, that were later buried by eolian sedimentation. These sites document the presence of tetrapods typical for the Colorado Plateau today alongside several extralimital taxa. Mammals found at these sites which are consistent with the modern fauna include: packrats (*Neotoma*), pocket gophers (*Thomomys*), kangaroo rats (*Dipodomys*), prairie dogs (*Cynomys*), deer mice (*Peromyscus*), grasshopper mice (*Onychomys*), microtine voles (likely *Microtus*), pocket mice (likely *Perognathus*), deer (*Odocoileus*), gray fox (*Urocyon cinereoargenteus*), weasels (*Mustela*), and desert shrew (*Notiosorex crawfordii*). The desert shrew is not known to occur in the region today, but the current geographic range boundary is within 100 km. Late Holocene avifauna of these sites includes strigid owls and oscine songbirds, which are found in the region today, as well as a parakeet-sized parrot. The small parrot specimen (a coracoid from a juvenile or sub-adult) indicates that there must have been a nest (with parents) near the Rone Bailey Alcove locality. Further, this specimen is too small to belong to any of the geographically closest species (in southern Arizona), and it is not a macaw, which were associated with Ancestral Puebloan avian trade. The specimen-rich herpetofauna of these sites is yet to be studied in detail but includes several different snakes and lizard species. This combination of expected and unexpected fossils demonstrate that Holocene faunas are not simply an extension of current conditions.

Technical Session XVII (Saturday, October 20, 2018, 1:45 PM)

EGGSHELL OF BASAL SAUROPODOMORPH DINOSAURS AND THE ORIGIN OF THE AMNIOTE EGGSHELL

STEIN, Koen, Vrije Universiteit Brussel, Brussels, Belgium; HUANG, Timothy, Jilin University, Jilin, China; PRONDVAI, Edina, Eötvös-Lorand University, Budapest, Hungary; BAELE, Jean-Marc, University of Mons, Mons, Belgium; SANDER, Martin,

University of Bonn, Bonn, Germany; REISZ, Robert R., University of Toronto at Mississauga, Mississauga, ON, Canada
A great mystery of the fossil record is the absence of preserved eggs or eggshell during the first third of the known 315 million year history of amniote evolution. Our current understanding of the origin and evolution of calcareous eggshell and amniotic eggs in general has been largely based on Middle Jurassic to Late Cretaceous fossils, whereas the primitive condition was hypothesized through parsimony arguments. The most parsimonious inference yields a thick shelled egg (300–500 µm) for most dinosaurs. Such eggshells are indeed richly represented in the Late Cretaceous fossil record. The oldest known eggs or eggshells have been reported from three Early Jurassic (195–192 Ma) sauropodomorph dinosaurs, *Massospondylus* (specimens housed in the Bernard Price Institute of Palaeontology collections of the University of Witwatersrand, catalogue no. BP/1/5254, BP/1/5347) from the Elliot Formation of South Africa, *Lufengosaurus* (Chuxiong Prefectural Museum, catalogue no. C2019 2A233) from the Lufeng Formation of Yunnan, China, and *Mussaurus* (Instituto 'Miguel Lillo", Tucuman, catalogue no. PVL 5965) from the Laguna Colorada Formation of Argentina. We performed polarised light microscopic and geochemical analyses (cathodoluminescence, micro X-ray fluorescence, and Raman spectroscopy) on samples of these eggshells. Different diagenetic settings of their respective localities affected the original microstructure to different degrees, with *Lufengosaurus* having the best, and *Mussaurus* the least preserved details. Despite these alterations, we were still able to make some important general observations. Our analyses show that the eggs of these basal sauropodomorph dinosaurs all have an extremely thin calcareous layer (≤ 100 µm) with interlocking units of radiating crystals (mammillae) and a thick shell membrane. These observations are in strong contrast with the considerably thicker calcareous shells of more derived dinosaurs. Phylogenetically informed analyses and their great age indicate that the thin eggshell of basal sauropodomorphs represents a major evolutionary innovation at the base of Dinosauria, and that the much thicker eggshell of sauropods, theropods, and ornithischian dinosaurs evolved independently. The appearance of these first mineralised eggshells also corresponds with a global trend of atmospheric oxygen increase. Egg physiology and low atmospheric oxygen levels may thus have inhibited eggshell thickening before the end of the Early Jurassic, when atmospheric oxygen levels started to rise again.
Grant Information
KS is funded by the Fonds Wetenschappelijk Onderzoek Vlaanderen

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

CAUDAL FIN OF THE LATE CRETACEOUS SHARK, *CRETOXYRHINA MANTELLI* (LAMNIFORMES, CRETOXYRHINIDAE) MORPHOMETRICALLY COMPARED TO THAT OF EXTANT LAMNIFORM SHARKS

STERNES, Phillip C., DePaul University, TINLEY PARK, IL, United States of America; SHIMADA, Kenshu, DePaul Univ, Chicago, IL, United States of America
CMN 40906 is a partial skeleton of a shark from the Upper Cretaceous Niobrara Chalk of western Kansas, U.S.A. housed in the Canadian Museum of Nature, Ottawa, Ontario. It consist of a string of vertebral centra that includes the posterior-most trunk vertebrae and most of the caudal vertebrae along with a complete set of hypochordal rays. Although the specimen does not preserve any teeth, it is identified as *Cretoxyrhina mantelli* (Lamniformes, Cretoxyrhinidae) based on the size and shape of the vertebrae. The specimen shows a sharp upward bend of the vertebral column at the trunk-caudal transition, and the hypocordal rays are robust and ventrally directed. Based on these characteristics, a previous study reconstructed the caudal fin of *C. mantelli* to have a lunate tail, whereas another study pointed out that the curvature of the vertebral column and the angle of hypochordal rays are similar to those of fast swimming extant lamniform sharks, such as lamnids (e.g., *Carcharodon*, *Isurus*, and *Lamna*). Using a principal component analysis, we newly analyzed the shape of the reconstructed caudal fin of *C. mantelli* with respect to the caudal fin shape of all 15 extant lamniform species based on non-embryonic preserved specimens housed in various museums. Our results suggest that the caudal fin of *C. mantelli* was most similar to that of the shortfin mako (*Isurus oxyrinchus*) that is known to be the fastest swimming shark. Fossil evidence has demonstrated an unsuccessful attack of *C. mantelli* on a small mosasaur that is consistent with the interpretation that *C. mantelli* was a fast swimming shark that actively pursued prey. However, because the fossil record also includes *C. mantelli* feeding on large marine turtle suggests that *C. mantelli* was an opportunist, rather than an obligatory predator. Because *C. mantelli* belongs to Cretoxyrhinidae, whereas *Isurus* belongs to Lamnidae and has no direct phylogenetic link with Cretoxyrhinidae, our morphometric result is another example of convergent evolution between *C. mantelli* and *Isurus*, besides their superficial (homoplasious) resemblance in tooth morphology.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE OLDEST, DIVERSE MODERN-TYPE FRESHWATER DIVING BIRD COMMUNITY FROM THE LATE MIOCENE OF YUNNAN, CHINA

STIDHAM, Thomas, Institute of Vertebrate Paleontology & Paleoanthropology, Chinese Academy of Sciences, Beijing, China; LI, Zhiheng, Institute of Vertebrate Paleontology & Paleoanthropology, Chinese Academy of Sciences, Beijing, China; JABLONSKI, Nina G., The Pennsylvania State University, University Park, PA, United States of America; JI, Xueping, Yunnan Institute of Cultural Relics and Archaeology, Kunming, China
The growing sample of avian fossils from the ~6 Ma Zhaotong anthropoid primate locality in Yunnan, China, represents the most diverse avifauna from the Miocene of southern Asia, with representatives of many aquatic, terrestrial, and arboreal clades. Among those fossils are new species of darter (*Anhinga*), cormorant (*Phalacrocorax*), and grebe (aff. *Podylimbus*), in addition to material attributable to the extinct diving duck *Aythya shihuibas*. The co-occurrence of all four diving bird clades (comprising a freshwater diving community today) in this single locality appears to be the oldest documentation of this community.
The new material of *Aythya shihuibas* includes humeri, coracoids, and other bones. The humeri confirm the presence of an open pneumatic ventral pneumotricipital fossa (the primitive state), and are suggestive of a basal position within the genus. The *Anhinga* material includes the oldest known darter skull and some limb and girdle elements, and are the first records of the clade in China. Anhingids are absent in China today, but have an extant tropical to subtropical range. Fossils of a new extinct crown group species of *Phalacrocorax* include a skull, and major limb and girdle bones, and the species exhibits (diagnostic) unusually large antitrochanters. Grebe fossils include carpometacarpi, humeri, and tarsometatarsi, and are the oldest grebe specimens in China and south Asia. The tarsometatarsus has a canal for the m. flexor perforatus digiti II, and the humerus has a distally extending flexor process. Therefore, the Zhaotong grebe does not appear to be *Miobaptus*, but possibly is a relative of *Podylimbus*.
The Zhaotong locality is within the current subtropics, but in the late Miocene it would have been much warmer than today. Zhaotong's diving bird diversity and their current habitat preferences and requirements suggest that water depth reached at least a few meters, and that open water (lacking emergent vegetation) was present. Body mass estimates for these underwater pursuit piscivores (grebe, 0.45 kg; duck, 0.7 kg; darter, 1.3–1.5 kg; and cormorant, 1.8–2.0 kg) are within the range present in modern communities. The occurrence of this (possibly winter) community in the late Miocene is suggestive of the great antiquity of some avian interspecies interactions (such as cooperative feeding behaviors) observed between members of these clades today.
Grant Information
National Natural Science Foundation of China NSFC41772013; Chinese Academy of Sciences CAS, XDPB05

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

COELUROSAURIAN MANUAL DIGITS ARE II, III, IV, AND SOMETIMES V: NEW EVIDENCE CONFLICTS WITH PREVIOUS HYPOTHESES FOR THEROPOD DIGIT REDUCTION

STIEGLER, Josef B., The George Washington University, Washington, DC, United States of America; MOORE, Andrew J., The George Washington University, Washington, DC, United States of America
The prevailing hypotheses for digit reduction in theropod dinosaurs (e.g., frameshift, lateral shift) include a homeotic shift in digit identities that resulted in a mismatch between digit position and homology. While some have adopted reference to the three functional digits of non-avian theropods as II–IV and paleornithologists often use avian-specific nomenclature, most paleontologists continue to refer to these digits as I–III. New evidence from extant birds informs this debate.
We identified an ossified metacarpal in position 5 in several phylogenetically disparate lineages of extant birds, and its proposed homology with metacarpal V is supported by developmental, myological, and paleontological evidence. The bone ossifies postnatally and is only present as an independent element for a short period before fusing with metacarpal IV. An element with similar morphology and topology has been previously reported in the Jurassic theropods *Guanlong* and cf. *Tanycolagreus* (AMNH 587) among coelurosaurs, and we document its presence in several additional non-avian coelurosaurs and Mesozoic birds.
The apparent phylogenetic and ontogenetic transience of a laterally positioned, diminutive metacarpal V near the origin of Neotheropoda and in extant birds suggests that the potential for its ossification was never lost, and hypotheses for digit reduction should focus on the loss of digit I. The three functional digits present in coelurosaurs are most parsimoniously interpreted as being derived from positions 2–4, and this hypothesis can be extended to earlier-diverging nodes within Tetanurae depending on the phylogenetic position of Megaraptora and the nature of the homeotic shift in digit identities (abrupt and complete vs. gradual and piecemeal).
If digit nomenclature reflects conserved digit morphologies or identities (i.e., I-III), it will always be inconsistent because the presumed identities are not ontogenetically or phylogenetically static and individual digits may be homologous in part to multiple ancestral digits. If digit nomenclature instead reflects the position of elements relative to their ancestors (II-V), roman numeral identifiers can remain consistent for all crown-group tetrapods.
Grant Information
Data collection contributing to this project was supported by NSF EAPSI (OISE 1311000 to JBS) and NSF GRFP (DGE 1246908 to AJM).

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

FOSSIL UNWRAPPING PARTIES: THE INTERSECTION OF PALEONTOLOGY, CITIZEN-SCIENCE, AND UNDERGRADUATE RESEARCH OPPORTUNITIES

STOCKER, Michelle R., Virginia Tech, Blacksburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; SHARP, Llyn, Virginia Tech, Blacksburg, VA, United States of America
Citizen science is key to both data collection and conveying the importance and excitement of scientific discovery to the public. At Virginia Tech the Paleobiology & Geobiology Research Group hosts the "Fossil Unwrapping Party", a citizen science event in rural Appalachia for the public to have hands-on involvement in the process of paleontology. We partner with the Museum of Geosciences to promote local informal STEM education and reach a broader audience. Each event begins with a lecture by the lead paleontologists for the fossils that will be processed that evening. These short presentations highlight the 'how' of fieldwork using photos, drone videos, and recorded interviews. They provide a sense of what the fossils are, how they were collected, and the distant places (e.g., American Southwest, Tanzania, Zimbabwe) where the fossils were found. Following the presentations, we give instructions for unpacking the field wrapped specimens and creating the labels. The audience is divided up into small groups at hands-on stations according to locality; this allows participants to work directly with the faculty, undergraduate, and graduate students who collected these fossils. Each specimen is carefully unwrapped, locality information is transferred by hand onto preprinted labels, and each specimen is placed into an appropriate box, then checked by station leaders. As station leaders, Paleobiology graduate and undergraduate students practice scientific communication, on-the-spot mentoring, and fossil identification, building their confidence as scientists. The public in turn receives personal interactions with student researchers and faculty members, opening discussions of deep time, evolutionary change, and the importance of science. Because this museum-based event welcomes participants as varied as public school

teachers, Virginia Master Naturalists, students and faculty from Virginia Tech, and interested community members (including children over age seven), the attendance reached nearly 100 participants the first year and 180 in the second. Social media (Twitter, local news) allows members of VT Paleobiology to reach additional people as well as create a digital record of the event. Our Fossil Unwrapping Parties are a key preliminary step for undergraduate involvement in the Fossil Preparation Lab through weekly open lab nights as well as student research projects and peer-reviewed publications.

Grant Information
NSF EAR 1337291; NSF EAR 1349667; National Geographic Research Grant # 9606-14

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

WITH OUR POWERS COMBINED: INCREASING AUDIENCE REACH FOR SMALL MUSEUMS THROUGH COLLABORATIVE EDUCATION AND OUTREACH INITIATIVES

STONEBURG, Brittney E., Western Science Center, Hemet, CA, United States of America; SANTOS, Gabriel-Philip, Raymond M. Alf Museum of Paleontology, Claremont, CA, United States of America

Outreach and education are common goals among all museums; however, budget is often a factor for many institutions as to how successful outreach efforts are in their surrounding communities. Large institutions with larger budgets can have a greater reach and impact on their communities, while smaller budgets at small institutions can be a limiting factor in their efforts. Collaboration between neighboring institutions can help to alleviate this issue. The Western Science Center and the Raymond M. Alf Museum of Paleontology are two smaller institutions in the Southern California area that partnered together to increase our outreach efforts throughout the region and share operational costs for outreach opportunities that would have otherwise been too expensive for the institutions on our own. Together we have collaborated through the following measures: 1) splitting costs of off-site exhibitions; 2) attending and promoting each institution's events, 3) providing information and specimens for exhibits at both institutions; 4) cross-promoting through outreach marketing initiatives such as the National Fossil Day "instaswap"; and 5) having staff from both institutions guest present to each other's students, volunteers, and guests, along with other projects still in development. Through a combination of collaborative education, outreach, and exhibit design, both institutions have raised regional awareness about our respective programs, alleviated costs, and increased attendance outreach numbers. For example, both institutions partnered to attend Los Angeles Comic Con, which would normally be too expensive to attend alone. By attending together, the cost was reduced to $375 for each institution and we added 1200 people to our outreach numbers. By working on initiatives together rather than apart, the Western Science Center and Raymond M. Alf Museum of Paleontology are achieving our wider goal of increasing geoscience literacy and comprehension in Southern California. Through these initiatives, it is the goal of both institutions to eventually foster a permanent partnership that can serve as a model for other natural history museums.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

WEST VIRGINIA SCIENCE ADVENTURES: FOSTERING STEM DIVERSITY THROUGH UNIVERSITY SPONSORED SCIENCE FESTIVALS

STRAIT, Suzanne G., Marshall Univ, Huntington, WV, United States of America; DILLMAN, Terry, Marshall University, Huntington, WV, United States of America

Science festivals are great community outreach activities, introducing families to STEM and can contribute to increasing STEM diversity. In rural areas with no access to traditional informal STEM enrichment venues it is universities that must take the leading role and offer STEM community opportunities. This outreach doubles as recruitment, especially when activities are done on campus. Studies show that the earlier you get children on to college campuses the more likely they will attend college. This type of structured in-house outreach program also benefits faculty, facilitating access to programs they can use for greater impacts to strengthen grant success. Students also benefit by service learning projects directed at designing and participating in science festivals and therefore introducing them to discipline-specific community service involvement. We have developed best practices for developing low budget annual festivals and for recruitment of volunteers.

For science festivals to work towards STEM diversity, it is necessary to identify the group(s) you most want to serve and target them in your design, cost structure, and advertising (ours was low income families). At our last festival (Spring 2018) 90 parents of 197 children were interviewed to test for our demographic goals. Most children were brought by woman (80%) and slightly more boys attended than girls (52%, 48% respectively). We targeted advertising at schools in low income areas and posted to homeschool social media groups. Additionally, in order to be attractive to a wide range of families from different backgrounds that might not be drawn to something science-themed, we offered something that was more generally family friendly (e.g., an Easter egg hunt at our spring event). 44% of our attending parents did not have college degrees (with 20% of the parents only having high school degrees and 6% with no high school degree/GED). Additionally, it was the first time that 65% of these parents and their children ever visited an academic building at a college (not a sports venue). Providing university sponsored science festivals children get exposure to both exciting hands-on science, while also helping to demystify college and STEM by exposing children at an early age to campuses and research labs.

Technical Session X (Friday, October 19, 2018, 8:00 AM)

VERTEBRATE DIVERSITY AND ENVIRONMENT OF A LATE CRETACEOUS BEARPAW SEA BONEBED FROM SASKATCHEWAN

STREET, Hallie P., Royal Saskatchewan Museum, Eastend, SK, Canada

The Late Cretaceous (late Campanian–Maastrichtian) Bearpaw Formation of Alberta and Saskatchewan is known to yield excellent marine reptile fossils, and the holotypes of three plesiosauroids have been discovered in these deposits. However, the complete vertebrate diversity of this seaway is comparatively poorly known. A bonebed discovered near the town of Herschel, Saskatchewan, provides a unique survey of the fauna that inhabited the Bearpaw Sea. The most abundant fossils from this site are isolated plesiosaur skeletal elements, representing both Polycotylidae and Elasmosauridae. Mosasaur fossils are far less common than the plesiosaur material, but there is evidence of both Plioplatecarpinae and Mosasaurini. Recognizable marine turtle material is very rare, but a single large costal element is referable to Toxochelyidae. An unexpected component of the marine reptile assemblage from this site is the relatively high frequency of juvenile material. Particularly, there are numerous small, incompletely ossified plesiosaur propodials and most of the plesiosaur vertebrae consist of disarticulated centra and neural arches. In addition to the marine reptile material, vertebrae of both bony and cartilaginous fishes are abundant and teeth from these vertebrates are common. The teeth are referable to large actinopterygian groups including Enchodontidae, Pachycormidae, and Ichthyodectidae. The majority of the cartilaginous fish teeth are diagnostic of various genera of Lamniformes, but Hybodontidae and Callorhinchidae are also represented. The fish vertebrae are less diagnostic, but both cartilaginous and osseous vertebrae are preserved, with the cartilaginous forms being more abundant. Other fossils from the site include marine invertebrate burrows and rare terrestrial material including wood, amber, and dinosaur bone. The presence of these fossils indicates a shallow marine setting with terrestrial influences. A shallow, highly productive system would have provided an ideal environment for juvenile marine reptiles and could account for the high frequency of immature plesiosaurs from this site.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

OXYGEN ISOTOPIC COMPOSITION OF TURTLE PHOSPHATE FROM THE LOWER CRETACEOUS HOLLY CREEK FORMATION, ARKANSAS U.S.A. A TOOL FOR UNDERSTANDING THE HYDROLOGIC CYCLE IN GREENHOUSE WORLDS

SUAREZ, Celina A., University of Arkansas, Fayetteville, AR, United States of America; FRUCCI, Mason, University of Arkansas, Fayetteville, AR, United States of America; PITTMAN, Jeff, Ouachita Mountains Biological Station, Mena, AR, United States of America

The Lower Cretaceous Holly Creek Formation in southwest Arkansas holds the first discovered Cretaceous-aged vertebrate assemblage in the state of Arkansas. Among these fossils include many specimens of turtle shell fragments attributed to *Naomichelys speciosa*. The oxygen isotopic composition ofphosphatic animal remains can be used as a proxy for the isotopic composition of meteoric water. The isotopic composition of meteoric water is controlled by the hydrologic cycle, and under higher global temperatures, is amplified. Thus, the goal of this work is to add $\delta^{18}O_w$ data to a latitudinal transect of $\delta^{18}O_w$ for North America. Between 0.3 and 0.5 mg apatite samples drilled from the carapace and plastron are converted to Ag_3PO_4 and analyzed on a high temperature conversion elemental analyzer attached to a Thermo Delta Advantage isotope ratio mass spectrometer. The isotopic composition of phosphate oxygen ($\delta^{18}O_P$) was determined relative to the Vienna Standard Mean Ocean Water (V-SMOW). The $\delta^{18}O_P$ data is then used to back-calculate the $\delta^{18}O$ of living water, approximately equal to the isotopic composition of meteoric water ($\delta^{18}O_w$). The mean $\delta^{18}O_w$ for these specimens was -3.4‰ with an average standard deviation of ± 0.6‰ VSMOW. The values are tested against an oxygen isotope latitudinal $\delta^{18}O_w$ gradient derived from pedogenic carbonates for this region at paleolatitude of 25°N. The turtle-generated $\delta^{18}O_w$ values are not significantly different from the carbonate-generated $\delta^{18}O_w$ values from the relatively correlative Glen Rose Formation of Texas. Inspection of this data concludes that apatite from fossilized turtle carapace is a reliable source for oxygen isotope data equivalent to pedogenic carbonates, suggesting turtles can be used for regions in which carbonate is not preserved.

Technical Session XIII (Friday, October 19, 2018, 1:45 PM)

A NEW ARCHOSAURIFORM REPTILE FROM THE MIDDLE TRIASSIC (LADINIAN) OF GERMANY DOCUMENTS GREATER TROPHIC DIVERSITY AMONG EARLY ARCHOSAURIFORMES

SUES, Hans-Dieter, National Museum of Natural History, Washington, DC, United States of America; SCHOCH, Rainer R., Staatliches Museum für Naturkunde Stuttgart, Stuttgart, Germany; IRMIS, Randall, University of Utah, Salt Lake City, UT, United States of America; DESOJO, Julia B., CONICET, La Plata, Argentina

Recent discoveries have demonstrated a much greater diversity of body plans and inferred ecological roles among Triassic non-archosaurian archosauriform reptiles than traditionally assumed. Some of these specializations later independently developed in various archosaurian lineages.

A new archosauriform reptile from the Middle Triassic (Ladinian) Erfurt Formation of Baden-Württemberg (Germany) differs from all other known non-archosaurian archosauriforms in the structure of its dentition. Known from two partial associated skeletons to date, it is a small-bodied form (femur length: 43 mm). The premaxilla holds five teeth with slightly recurved conical crowns. The maxilla has at least 11 markedly heterodont teeth. The mesial and distal carinae of the labiolingually flattened maxillary and dentary tooth crowns bear large serrations oriented at a steep angle to the apicobasal axis of the crown. All teeth have thecodont implantation. The teeth resemble the enigmatic tooth morphotype *Protecovasaurus* from the Upper Triassic of the American Southwest and those of early sauropodomorph dinosaurs. The new taxon apparently lacked dermal armor and has gracile limbs. Phylogenetic analysis recovers it among non-archosaurian arrchosauriforms as most closely related to the Late Triassic *Vancleavea* but support for this placement is weak.

The structure of the maxillary and dentary teeth of the new archosauriform indicates specialized dietary habits. All other known non-archosaurian archosauriforms have teeth consistent with faunivory, in contrast with the dental disparity observed in both early archosauromorphs and archosaurs. Thus, the new taxon documents greater range of feeding habits among non-archosaurian archosauriforms than previously inferred and, along with other recent discoveries, hints at complex ecological roles among the diverse reptilian communities in Triassic non-marine ecosystems.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE POSSIBLE PALEOBIOLOGICAL SIGNIFICANCE OF LONG UNCINATE PROCESSES IN THE EARLY CRETACEOUS BASAL BIRDS *JEHOLORNIS* AND *CONFUCIUSORNIS*

SULLIVAN, Corwin, University of Alberta, Edmonton, AB, Canada; O'CONNOR, Jingmai, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

Uncinate processes (UPs) are bony prongs that extend caudally from the ribs of nearly all extant birds and appear to increase the mechanical advantage of the appendicocostalis component of the respiratory musculature. The distribution of UPs among Mesozoic birds is complex. Although widespread in ornithuromorphs, they are very rarely found in enantiornithines. They occur in confuciusornithiforms, and have been reported but never extensively described in *Jeholornis*, but appear absent in *Archaeopteryx* and *Sapeornis*. Among non-avian dinosaurs closely related to birds, UPs occur in oviraptorosaurs and dromaeosaurids, but not in troodontids or scansoriopterygids.

Here we focus on the UPs of *Jeholornis* and *Confuciusornis*. As in other non-ornithuromorphs, UPs are infrequently preserved in these basal birds, evidently because they were not fused to the ribs. Nevertheless, we were able to locate several specimens of each genus with at least one intact UP. In both *Jeholornis* and *Confuciusornis* the UPs are tapering, slightly curved structures, lacking the additional spurs seen in some extant birds. Up to four pairs of UPs were preserved in the specimens we examined. UP length and shape varied considerably along the series of thoracic segments, with the longest UPs evidently in the middle of the series.

By using established equations to estimate body mass based on femur length and humerus length, we added *Jeholornis* and *Confuciusornis* to a data set comprising UP lengths and body masses in extant birds, which was previously used to demonstrate that diving birds have longer UPs in proportion to mass than walking and "non-specialist" birds. Regardless of the mass estimation method used, *Jeholornis* and *Confuciusornis* plot close to the regression line for diving birds on a log-log plot of UP length vs. mass, across a wide range of body sizes. The long UPs of diving birds have been hypothesized to correlate with their characteristically long sterna, which trunk muscles can only move effectively by employing long UPs as levers. Given, however, that the sternum is proportionally short in *Jeholornis* and *Confuciusornis* compared to the Ornithuromorpha, these taxa likely required long UPs for other reasons, perhaps because the appendicocostalis muscles were less developed than in extant birds. Limited data from dromaeosaurids and oviraptorosaurs indicate that their UPs were also longer relative to body mass than in most modern avian taxa, suggesting that large UPs are representative of the plesiomorphic condition and were secondarily re-acquired by diving birds.

Grant Information
This research was supported by an NSERC Discovery Grant (RGPIN-2017-06246), the Chinese Academy of Sciences, and start-up funds from the University of Alberta.

Technical Session IX (Friday, October 19, 2018, 11:45 AM)

INFERRING IMMIGRATION OF ISLAND INSECTIVORES: A NEW DESCRIPTION OF A NESOPHONTID MAMMAL FROM THE MIOCENE OF HISPANIOLA

SULSER, Richard B., American Museum of Natural History, New York, NY, United States of America; MACPHEE, Ross D., American Museum of Natural History, New York, NY, United States of America

How was the mammalian fauna of the West Indies formed, and what was its timing and mode? Did taxa diversify on the islands, or were they already diversified prior to arrival? Competing hypotheses suggest that either mammals arrived on the Caribbean islands in a series of over-water dispersal events from elsewhere in the Americas, or that vicariance led to the endemic assortment of Caribbean mammals. In order to test these hypotheses, we examined a partial thoracic vertebral column encased in amber from the famous La Toca mine in Hispaniola, dating to the mid-Miocene. We used computed tomography (μCT) and subsequent 3D reconstruction using the Mimics software suite for segmentation and identification of diagnostic characters. The specimen is definitively mammalian, as the ribs of the specimen are bicipital and the vertebrae lack zygosphenes and zygantra characteristic of Antillean lizards and snakes. Transarcual canals in tandem with strongly caudally projecting neural spines and rostral-caudal keels on thoracic centra are strongly reminiscent of homologous vertebrae of the extinct lipotyphlan family Nesophontidae. Furthermore, these features do not occur in this configuration in, and allow for the exclusion of, all known New World rodent, primate, xenarthran, chiropteran, and marsupial major taxa. The ancient presence of nesophontids in the West Indies is chronologically concordant with current molecular estimates for nesophontid divergence from its closest living relative, *Solenodon*, likewise unique to the Antilles. On this evidence we conclude that the amber specimen represents a species of Nesophontidae or closely related taxon within infraorder Solenodonta. This is the first Neogene fossil evidence of lipotyphylan insectivores within the West Indies and lends support for endemic mammalian diversification within the Greater Antilles.

Grant Information
This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. 1447167.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

PARTNERING VERTEBRATE PALEONTOLOGISTS WITH LOCAL NATIVE AMERICAN HIGH SCHOOL STUDENTS DEVELOPS A DEEPER UNDERSTANDING OF STUDENTS' LANDS WHILE SIMULTANEOUSLY INCREASING PALEONTOLOGICAL ACCESS ON RESERVATION LANDS BELONGING TO THE PUEBLO OF JEMEZ, NEW MEXICO

SUMIDA, Stuart S., California State University San Bernardino, San Bernardino, CA, United States of America; MADALENA, Kevin M., Utah Dine Bikeyah, Jemez Pueblo, NM, United States of America

Reservation lands in Jemez Pueblo, northwest New Mexico, host a remarkable span of fossiliferous sediments ranging from the early Permian Cutler Group to Late Cretaceous age Fruitland Formation. Due to historic restrictions of lands by tribal officials to residents of the Pueblo, geological and paleontological assessment and reporting have been limited. Now, with the support of the David B. Jones Foundation, a collaborative effort between California State University San Bernardino (CSUSB) and Jemez personnel is in place to provide summer internships in vertebrate paleontology to resident high school students from Walatowa Charter and Jemez Valley High Schools. The reciprocal agreement of student training and paleontological access is facilitated by utilizing Jemez's greatest resources: local geology expertise and local students with an understanding of Jemez geography. CSUSB personnel bring paleontological mentorship and training to those students. Students are provided a stipend to compensate for loss of summer job income. After orientation to the known fossil record and geology of Jemez Pueblo, each native student partners with project co-PI Kevin Madalena, project co-PI Sumida, or other personnel from CSUSB, generating prospecting teams that could cover more territory than CSUSB or Jemez Geology staff could otherwise cover on their own. Inclusion of local native youth participating in immersive summer field work simultaneously affords the first access to fossil-bearing sediments and sections to the paleontological community, while providing local native students education and financial support. A taxonomic list generated by preliminary surface prospecting of lower Permian sediments have demonstrated the presence of the sail-backed pelycosaurian synapsid *Dimetrodon* (cf. *D. occidentalis* Berman), the sail-backed dissorophoid amphibian *Platyhistrix*, the temnospondyl amphibian *Eryops*, as well as footprints and plants. Late Triassic taxa identified to date include large temnospondyl metoposaurs, aetosaur scutes, and phytosaur teeth. Although initial prospecting has yielded fossil documentation restricted to late Paleozoic and early Mesozoic sediments, it provides proof of concept for recruiting a larger number of field teams to survey the extensive Mesozoic sediments in the Pueblo's lands in subsequent years.

Grant Information
Funding Sources: David B. Jones Foundation, California State University San Bernardino Department of Biology

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

TAPHONOMIC ANALYSIS OF AN UPPER JURASSIC SAUROPOD SITE FROM THE VILLAR DEL ARZOBISPO FORMATION (ALPUENTE, VALENCIA, EASTERN SPAIN)

SUÑER, Maite, Museo Paleontológico de Alpuente, Alpuente (Valencia), Spain; MARIN-MONFORT, María Dolores, Museo Nacional de Ciencias Naturales, Madrid, Spain; SANTOS-CUBEDO, Andrés, Universitat Jaume I de Castelló, Castellón, Spain; ROYO-TORRES, Rafael, Fundación Conjunto Paleontológico de Teruel-Museo Aragonés de Paleontología, Teruel, Spain; HOLGADO, Borja, Museu Nacional / Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil; GAMONAL, Arturo, Museo Paleontológico de Alpuente, Alpuente (Valencia), Spain; GALOBART, Àngel, Institut Català de Paleontologia Miquel Crusafont, Barcelona, Spain; SANTISTEBAN, Carlos, Universitat de València, Valencia, Spain

The Villar del Arzobispo Formation is a mixed siliciclastic-carbonate unit located in the eastern part of the Mesozoic Iberian Trough and is one of the richest Kimmeridgian–early Berriasian units in the Iberian Peninsula in terms of the number and preservation of dinosaur remains. In contrast with the numerous systematic studies published, taphonomic analyses are relatively scarce.

In this work, the Baldovar site is examined. Sedimentological analysis shows us that it is the infill of an estuarine incised channel. The fossil bones in this site can be attributed to a subadult individual of a probable new taxon of large basal macronarian sauropod. The studied individual comprises a partial sacrum, caudal vertebrae, chevrons, pelvic bones, and hind limbs.

The low level of dispersion of some of the elements, even the presence of articulated bones and lack of abrasion, indicates that the accumulated bones did not experience significant transport processes. An extended sub-aerial exposure of the bone assemblage is discarded due to the absence of surface weathering. Skeletal elements do not exhibit predatory and scavenging activity or trampling, so we can infer that the breakage was not produced by these agents.

The remains were found in a medium- to coarse-grained micaceous channel sandstone that is 190 cm thick. The presence of cross-laminae in the sandstones and the coexistence of associated and articulated elements seem to indicate that they could have gone through different burial stages.

We bring to attention the results obtained through the petrographic analysis. Based on the processes identified in the samples from Baldovar fossil site, an idealized diagenetic sequence can be established: (1) a first event of permineralization with pyrite that covered the inner wall of the cavity and turned into iron oxides; (2) later cementation by drusy calcite, interpreted as cement formed in a continental vadose diagenetic environment; (3) a late-stage permineralization event with calcite with mosaic texture, characteristic of the phreatic zone; (4) dolomitization; (5) fracturing, with infill by gypsum precipitates and other particles. Baldovar fossils show that depositional environments were middle to light REE-enriched. A remarkable result is a very high zinc concentrations, moderate uranium concentrations, and low thorium concentrations.

The interpretation of the results of the microstructural and mineralogical analysis is consistent with the estuarine context of the Baldovar site.

Grant Information
Project CGL2008-06533-C03-01/03/BTE funded by the Spanish Ministry of Research.

Technical Session II (Wednesday, October 17, 2018, 9:00 AM)

TUBERCULOSIS-LIKE RESPIRATORY INFECTION IN 245-MILLION-YEAR-OLD MARINE REPTILE SUGGESTED BY BONE PATHOLOGIES

SURMIK, Dawid, University of Silesia, Sosnowiec, Poland; SZCZYGIELSKI, Tomasz, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland; JANISZEWSKA, Katarzyna, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland; ROTHSCHILD, Bruce M., Carnegie Museum, Pittsburgh, PA, United States of America

Pathological conditions observed in fossil skeletal remains provide an exceptional opportunity for epidemiologic studies in prehistoric animals. The fossil record, although very selective and incomplete, fills the gaps in our understanding of the evolution and transmission of pathogenic taxa. Herein, we demonstrate the oldest pathological condition inferred to be a tuberculosis-like respiratory infection, preserved in a Middle Triassic marine sauropsid from Poland. The diagnosis is established based on macroscopic,

radiological, and histological studies of several rib and vertebral lesions. This pneumonia-related bone involvement, manifested as bleb-like surficial elevations of bone tissue, was recognized on the visceral surfaces of at least four consecutive dorsal ribs on the left side of the ribcage of an eosauropterygian, "*Proneusticosaurus*" *silesiacus* Volz. The lesions are elliptical in shape, ranging in diameter from 0.5 to 3 mm. X-ray microcomputed tomography revealed thickening of the periosteal lining of the bone, interrupted internally by multiple branching channels.

Histological documentation of the penetrating branching channels and the recurring bleb-like pattern of LAGs in deeper layers of bone tissue reveals an infectious nature of the pathologic process and suggests a chronic disease, with symptoms spanning several seasons.

While the localization of this periosteal reaction represents the earliest evidence for pneumonia, the noted blebs may have an additional implication, as they have apparently only been recognized as a correlate of tuberculosis in humans. Such an interpretation is also supported by the presence of focal erosions in dorsal vertebrae comparable with human vertebral turberculosis.

This case pushes the earliest record of mycobacteriosis back to the early Mesozoic, the dawn of the age of reptiles. The presence of probable tuberculosis-related changes on a skeleton of an extinct reptile living before the ascent of mammals supports the view of an ancient origin of mycobacterioses and their long-lasting influence on various vertebrate taxa.

Grant Information
This research project was supported by the NSC grant (2011/01/N/ST10/06989) and by NanoFun POIG.02.02.00-00-025/09.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

TAPHONOMY OF A VERTEBRATE MICROFOSSIL BONEBED IN THE UPPER CRETACEOUS (CAMPANIAN) TWO MEDICINE FORMATION OF MONTANA—A COMPARATIVE APPROACH

SURPRENANT, Rachel L., Macalester College, St Paul, MN, United States of America; ROGERS, Raymond R., Macalester College, St Paul, MN, United States of America; CURRY ROGERS, Kristina, Macalester College, Saint Paul, MN, United States of America

Vertebrate microfossil bonebeds (VMBs, a.k.a. microvertebrate assemblages or microsites) are abundant and well-studied in the Upper Cretaceous (Campanian) Judith River Formation (JRF) of north-central Montana. In contrast, VMBs are rarely encountered in the correlative Two Medicine Formation (TMF) of northwestern Montana, and to date, none have been described in detail from this alluvial unit. Our study aims to remedy this fact by describing the depositional environment and taphonomy of a Two Medicine VMB (site TM-020). Taphonomic attributes of TM-020 are then compared with two VMBs from a similar depositional setting in the JRF.

Site TM-020 is situated near the top of the TMF (Landslide Butte field area) in a mudstone that preserves freshwater mollusks and ostracods, along with charophytes. The sedimentology and paleontology of the site are consistent with deposition in a shallow floodplain lake. Bulk samples of fossiliferous matrix from TM-020 were sieved and recovered fossils were studied to advance comparison with previously described Judith River sites, with emphasis on bioclast size and shape. The mean long axis of 1858 vertebrate bioclasts recovered via sieving is 1.5 mm; this result is generally comparable to the average size of bioclasts documented in the sieved samples from the two Judith River comparison sites. However, TM-020 does preserve considerably more material in the 0.5–1 mm size fraction, which potentially reflects a more favorable chemistry in the TMF burial environment that was more conducive to the preservation of very small bioclasts. With regard to shape characteristics, the distributions of common shape categories (plate, equidimensional, elongate, conical) are indistinguishable among the compared sites. All three sites are dominated by equidimensional and plate-shaped fossils. The only truly notable distinction among VMB sites relates to their taxonomic composition. Both Judith River VMBs are dominated by amphibious and aquatic animals, with diverse assemblages of teleost fishes and abundant amphibians. In contrast, site TM-020 from the TMF is characterized by a more depauperate fish assemblage notably enriched in gar, yields relatively few amphibians, and preserves relatively more terrestrial animals, including dinosaurs and lizards. These faunal distinctions are now contextualized in a taphonomic framework that suggests that significant bias should not be a factor, and they are consistent with the distinct paleoenvironments of the two formations (TMF alluvial uplands vs. JRF coastal plain lowlands).

Grant Information
This research was funded by NSF (EAR-1052673) and the David B. Jones Foundation.

Poster Session III (Friday, October 19, 2018, 4:15 – 6:15 PM)

NEW DATA ON THE SHELL STRUCTURE OF THE BASALMOST TRUE TURTLES, *PROTEROCHERSIS* SPP.

SZCZYGIELSKI, Tomasz, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland; SŁOWIAK, Justyna, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland; SULEJ, Tomasz, Institute of Paleobiology, Polish Academy of Sciences, Warsaw, Poland

The Norian Proterochersidae of Poland and Germany are the basalmost branch of true (fully shelled) turtles (Testudinata). The rich collection of *Proterochersis porebensis* materials gathered in recent years in Poreba, Poland (lower Patoka Member or the Grabowa Formation) includes at the moment 270 catalogued specimens. This, complemented by the historically obtained *P. robusta* shells from the vicinity of Stuttgart, Germany (lower Löwenstein Formation), greatly expands our knowledge about the shell structure and variability in these earliest turtles and allows an in-depth analysis of the earliest stages of carapace evolution. This is especially important due to virtually nonexistent data about the number and layout of dermal bones in the carapaces of other Late Triassic testudinates—even in the best understood *Proganochelys quenstedti* nothing is known about the fully dermal carapacial components (nuchal, peripherals, suprapygals, pygal) due to complete shell ankylosis.

The most significant is the presence of a mosaic of irregular dermal ossifications in the nuchal and pygal region of *Proterochersis* spp. carapace. These numerous bones apparently were external to the costals and partially covered them externally. Such a morphology is supported by several specimens of *P. robusta* and *P. porebensis*, and is congruent with the morphologies reported previously for another Norian turtle, *Chinlechelys tenertesta* from the U.S.A. The phylogenetic analysis including these taxa recovers *Proterochersis* spp. and *C. tenertesta* as distinct branches along the turtle stem separated by *P. quenstedti* and thus suggests that the carapacial mosaic may be plesiomorphic for Testudinata. *Proterochersis* spp. is also unique in its paired nuchal bone, likely intermediate between the cleithra of turtle ancestors and the single nuchal of more derived turtles. The collected material also suggests that the caudal processes of the plastron are supported by separate ossifications and may be homologous to the hypoischium of other early pantestudinates. The Principal Component Analysis of this region results in a statistically significant division into two clusters, likely revealing the sexual dimorphism in *Proterochersis* spp. Finally, several cases of scute abnormalities were observed, indicating that the developmental background of scute formation at the dawn of shell evolution was already similar to that present in modern turtles.

Grant Information
This research was supported by the National Science Centre, Poland grant 2016/23/N/NZ8/01823.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE FIRST LAMBEOSAURINE MATERIAL FROM THE LISCOMBBONEBED OF THE UPPER CRETACEOUS PRINCE CREEK FORMATION, ALASKA

TAKASAKI, Ryuji, Hokkaido University, Sapporo, Japan; FIORILLO, Anthony R., Perot Museum of Nature and Science, Dallas, TX, United States of America; KOBAYASHI, Yoshitsugu, Hokkaido University Museum, Sapporo, Japan; TYKOSKI, Ronald S., Perot Museum of Nature and Science, Dallas, TX, United States of America

The Upper Cretaceous Prince Creek Formation of Alaska, deposited in the lower most delta plain, is important to understand vertebrate ecology in the Arctic during the Cretaceous because of its prolific fossil record. Here we report on a lambeosaurine hadrosaurid supraoccipital from the Liscomb Bonebed of the formation. This is the first definitive report of this group in the Arctic region. It has lambeosaurine features, including well- developed squamosal bosses and the short sutural surface with the exoccipital-opisthotic complex and also shows a strong similarity to lambeosaurine supraoccipitals from the Dinosaur Park Formation in Canada in having anteriorly positioned squamosal bosses. This confirms that the new specimen is referrable to Lambeosaurinae and shows an affinity with Canadian forms. The discovery of lambeosaurine material from the Liscomb Bonebed expands the paleogeographic distribution of lambeosaurines much further north, indicating lambeosaurines were inhabiting an ancient Arctic environment. Affinities with Canadian lambeosaurines elucidate more extensive faunal exchange between the Arctic and lower paleolatitudes than previously suggested, which is also supported by the presence of *Edmontosaurus*, *Pachyrhinosaurus,* and *Troodon* in both regions.

The presence of one lambeosaurine and eight hadrosaurine supraoccipitals in the Liscomb Bonebed, a deposit formed by a mass death event, suggests co-existence of both groups but dominance of hadrosaurines over lambeosaurines in the area. The co-existence of both groups has been documented in lower-latitude multitaxic monodominant bonebeds in U.S.A., Russia, and China. The hadrosaurine abundant faunal structure resembles that found in U.S.A. (Careless Creek Quarry in Montana), deposited in a lower coastal plain environment similar to the Liscomb Bonebed, but differs from the lambeosaurine dominant structures of the other localities in Russia and China interpreted as more inland environments. This may suggest that the co-existence was common and that lambeosaurines had less preference for near-shore environments than hadrosaurines in both Arctic and lower paleolatitudes.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

REPORT ON A THEROPOD NESTING SITE FROM HYOGO, JAPAN

TANAKA, Kohei, Nagoya University, Nagoya, Japan; ZELENITSKY, Darla K., University of Calgary, Calgary, AB, Canada; THERRIEN, Francois, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; FERNANDEZ, Mariela S., Instituto de Investigaciones en Biodiversidad y Medioambiente, Río Negro, Argentina; SAEGUSA, Haruo, University of Hyogo; Museum of Nature and Human Activities, Hyogo, Sanda, Japan; IKEDA, Tadahiro, University of Hyogo; Museum of Nature and Human Activities, Hyogo, Sanda, Japan; KUBOTA, Katsuhiro, Museum of Nature and Human Activities, Hyogo, Sanda, Japan

Fossil sites that preserve the remains of dinosaur eggs are extremely rare in Japan. The richest egg site known is from the Kamitaki locality in the eastern Hyogo Prefecture of southwestern Japan, where exposes the Lower Cretaceous (Albian) Ohyamashimo Formation. The Kamitaki locality has produced over 90 eggshell fragments from a bonebed layer containing skeletal elements of various dinosaurs (e.g., basal hadrosaurid, ankylosaur, titanosauriform sauropod, tyrannosauroid, therizinosauroid, and indeterminate theropod). Although previous discoveries of egg remains at the site were limited to tiny eggshell fragments (i.e., one ornithopod and four theropod ootaxa), we report here on new complete and partial eggs discovered in mudstone layers about five meters above the bonebed layer. So far, up to eight nearly complete and partial eggs, as well as dozens of scattered eggshell fragments, have been recovered from this new level. The eggs are small and elongate (estimated size of 5 cm by 2 cm). The eggshell from the eggs and scattered fragments has a smooth external surface, is thin (<0.2 mm in thickness), and is composed of two microstructural layers (i.e., mammillary and continuous layers). The presence of these characteristics in all eggs and eggshell fragments indicates that they are referable to a single, previously unknown ootaxon, and likely belonged to a small maniraptoran. Analysis of scattered eggshell fragments reveals that over 60% of eggshell fragments are oriented concave-up (40% concave-down), suggesting that the eggs/eggshells were buried in-situ and have not been transported. Some eggs were found in clusters of partial clutches, indicating that the site may have been used by multiple individuals.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

CATEGORIZING THE DIET OF TWO HYPOCARNIVOROUS BOROPHAGINE CANIDS, *CYNARCTOIDES LEMUR* AND *PHLAOCYON LATIDENS*

TANIS, Brian P., Oregon State University, Corvallis, OR, United States of America; DESANTIS, Larisa G., Vanderbilt University, Nashville, TN, United States of America; TERRY, Rebecca C., Oregon State University, Corvallis, OR, United States of America

The genera *Cynarctoides* and *Phlaocyon*, which together form the tribe Phlaocyonini, are a noteworthy basal group of borophagine canids evolving morphological features pointing to increasingly hypocarnivorous diets. However, morphology alone can't capture the potential for plasticity in dietary behavior. As theory shows dietary plasticity can promote species coexistence and trophic stability, quantifying dietary breadth of these hypocarnivorous species could help shape our understanding of the evolution of hypocarnivory within Borophaginae and inform how relatively high canid diversity was supported during the Arikareean in North America. Here, we reconstructed diets of two primitive Phlaocyonini, *Cynarctoides lemur* and *Phlaocyon latidens,* using dental microwear texture analysis (DMTA). We then compared these taxa to two modern canids, the red fox (*Vulpes vulpes*) and grey fox (*Urocyon cinereoargenteus*). These modern foxes are sympatric opportunistic omnivores, with scat and stomach contents reflecting a diet of small vertebrates, invertebrates, and occasional fruit and vegetative matter, and share several, independent traits with the Phlaocyonini. We sampled the hypoconid facet of either the lower first or second molars from fossil and modern species housed in museum collections, focusing on three microwear parameters indicative of diet within carnivorans: complexity (indicative of durophagy), anisotropy (reflecting flesh consumption), and textural fill volume. Overall, mean diet between the two fossil taxa were similar for all microwear parameters ($p > 0.57$ for all); however, *P. latidens* displayed less variability in microwear parameters, particularly complexity ($p = 0.07$). Similarly, modern fox species were indistinguishable from each other in complexity, anisotropy, and textural fill volume ($p > 0.05$). Fossil taxa had higher values of complexity than *U. cinereoargenteus* ($p < 0.05$) yet were similar to *V. vulpes* ($p > 0.88$). Fossil taxa did not differ from modern foxes in either anisotropy or textural fill volume ($p > 0.28$ for both). Our results confirm that *C. lemur* and *P. latidens* were generalist omnivores, with diets similar to modern day *V. vulpes*, and were not yet reflecting a highly specialized hypocarnivorous diet. Instead, we hypothesize that overlapping diets in these basal species led to the development of increased hypocarnivory in crown Phlaocyonini later in the early Miocene. Furthermore, being able to exploit a wider range of resources likely permitted *C. lemur* to persist into the Miocene longer than *P. latidens*.

Grant Information
American Society of Mammalogists Grants-In-Aid, Oregon State University Zoology Research Funds, Oregon State University Paul and Mary Roberts Evolution Fellowship

Romer Prize Session (Thursday, October 18, 2018, 9:45 AM)

CHANGES IN DISPERSAL CAPACITY THROUGH TIME WITHIN CROCODYLIA

TARAILO, David A., University of Iowa, Iowa City, IA, United States of America

Most fossil and extant crocodylian diversity lies within the clades Alligatoroidea (caimans and alligators) and Crocodyloidea (crocodiles and possibly tomistomines). Alligatoroids have a more limited geographic distribution than crocodyloids despite having a very similar level of extinct diversity. Analysis of the biogeographical history of these clades using parsimony and maximum likelihood analyses using both morphological and molecular phylogenetic trees reveals that non-alligatoroids (crocodyloids and gavialoids) have dispersed across major ocean barriers twice as frequently as alligatoroids. This disparity in dispersal capacity likely stems from a suite of osmoregulatory characters observed in crocodyloids that are less developed or absent in alligatoroids, thereby improving the ability of crocodyloids to survive prolonged immersion in saline water. In order to generate estimates of when dispersals occurred, I used the biogeographical stochastic mapping function of the R package BioGeoBEARS. Crocodylian-inhabited regions that had been isolated by major ocean barriers for most of the Cenozoic were delineated and used for geographic binning. Two different equal-duration time binning schemes were used and results for each were standardized to control for the effects of diversity. These estimates consistently show the highest rates of dispersal (dispersals per node) during the Cretaceous for most major crocodylian clades. Because these higher rates of dispersal are shared across Crocodylia, a universal explanation, like the more clustered continental configuration of the Cretaceous and early Paleogene, is preferred. This explains why the dispersals of Caimaninae to South America and Diplocynodoninae to Europe occurred early in the history of Alligatoroidea, followed by few later ocean-crossing dispersal events. Neogene dispersals are virtually unknown for Alligatoroidea and Gavialoidea. Caimaninae and Crocodylinae both experience an expansion in diversity of cranial shape during the Neogene in South America and Africa, respectively, but a patchy Paleogene fossil record for these continents obscures any possible correlation between cranial diversity and changes in dispersal frequency and endemism.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ISOTOPIC FINGERPRINTING OF FOSSIL SMALL MAMMALS IN BLACK HILLS CAVES

TARNG, Cheng, Penn State Univ, University Park, PA, United States of America; GRAHAM, Russell W., Penn State Univ, University Park, PA, United States of America; FANTLE, Matthew, Penn State Univ, University Park, PA, United States of America

Climate-driven ecological change preserved in fossil assemblages is valuable in unraveling the formation of modern ecosystems and improving the current ecological models. Due to their restricted habitat range and short lifespan, small mammals, such as rodents, are useful in reconstructing past climate and environments. In a previous study, ecological replacement of rodent species was documented at Don's Gooseberry Pit (DGP) in the Black Hills, SD during the rapid warming at the end of the Pleistocene ~20 ka to 8 ka. The presence of a paleotemperature proxy like *Dicrostonyx* within the assemblage can establish a link between climate and ecological change. However, it is critical to know whether the source of the proxy is local or regional. The Black Hills, a 'domal' uplift in the Western Plains, offers a unique and relatively short distance between major lithologies (granite, phyllite, and sedimentary rocks). In an effort to resolve source location for various species at DGP, geological tracer $^{87}Sr/^{86}Sr$ signatures were utilized to pinpoint the fossil provenance. The accordance between strontium signatures from the fossil with that of the limestone around the cave rather than with the crystalline rocks from higher elevations suggests the fossil taxa were derived locally. Thus, the direct correlation between the inferred climatic and ecological settings are characteristic of the site of discovery.

Grant Information
PSU EMS Museum and Art Gallery

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A *LUANGWA*-LIKE CYNODONT FROM NORTHERN ZIMBABWE AND ENDEMISM ACROSS THE CARNIAN OF SOUTHERN AFRICA

TARUVINGA, Hazel R., , Bulawayo, Zimbabwe; TOLAN, Stephen, , Mfuwe, Zambia; GRIFFIN, Christopher T., Virginia Tech, Blacksburg, VA, United States of America

The full recovery of terrestrial ecological systems following the devastating end-Permian mass extinction (250 Ma) took tens of millions of years. The world appears to have recovered by the Carnian stage of the Late Triassic, with Carnian taxa becoming more endemic than immediately after the extinction. Cynodonts are a diverse group of therapsids that survived the end-Permian mass extinction and thrived in the aftermath, with diversification peaks occurring during the late Anisian (particularly in Africa) and the Carnian of South America and India. Therefore, cynodo nts are an excellent study system to understand the intersection of biogeography and extinction recovery in southern Pangea. We recovered cynodont material from a new locality in the Pebbly Arkose Formation of northern Zimbabwe, the first cynodont material reported from this country. We preliminarily date this locality as Carnian by the presence of hyperodapedontid rhynchosaurs, a common Carnian taxon across Pangea. The most well-preserved dentary that we recovered possess quadrangular gomphodont (i.e., molar-like) postcanine teeth with anteriorly positioned transverse crests, diagnostic of a traversodontid cynodont. These rhomboid postcanines (in occlusal view) are dissimilar from the ovoid postcanines of early-diverging traversodonts (e.g., *Scalenodon*), but are not imbricated as in later-diverging groups (e.g., Massetognathinae), suggesting an 'intermediate' morphology, which is present in *Luangwa*. The sigmoid curvature of the ventral border of the dentary in lateral view is also suggestive of *Luangwa.* Therefore, we identify this Zimbabwean form as a *Luangwa*-like traversodontid cynodont, potentially assignable to *Luangwa*. This occurrence of *Luangwa* among a probable Carnian fauna corresponds with recent biochronological schemes for southern Africa, which place this taxon in the Carnian of Zambia and Tanzania instead of the Middle Triassic. Therefore, our tentative diagnosis of *Luangwa* in Zimbabwe may correlate the Pebbly Arkose fauna (rhynchosaurs, sauropodomorphs, pseudosuchian archosaurs) with distinct faunas of Tanzania and Zambia (dicynodonts, archosauromorphs, avemetatarsalians). This is consistent with the hypothesized increase in endemism during the Carnian Stage, with even neighboring faunas possessing distinct ecological players.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A *LUANGWA*-LIKE CYNODONT FROM NORTHERN ZIMBABWE AND ENDEMISM ACROSS THE CARNIAN OF SOUTHERN AFRICA

TARUVINGA, Hazel R., Bulawayo, Zimbabwe; TOLAN, Stephen, Mfuwe, Zambia; GRIFFIN, Christopher T., Virginia Tech, Blacksburg, VA, United States of America

The full recovery of terrestrial ecological systems following the devastating end-Permian mass extinction (250 Ma) took tens of millions of years. The world appears to have recovered by the Carnian stage of the Late Triassic, with Carnian taxa becoming more endemic than immediately after the extinction. Cynodonts are a diverse group of therapsids that survived the end-Permian mass extinction and thrived in the aftermath, with diversification peaks occurring during the late Anisian (particularly in Africa) and the Carnian of South America and India. Therefore, cynodonts are an excellent study system to understand the intersection of biogeography and extinction recovery in southern Pangea. We recovered cynodont material from a new locality in the Pebbly Arkose Formation of northern Zimbabwe, the first cynodont material reported from this country. We preliminarily date this locality as Carnian by the presence of hyperodapedontid rhynchosaurs, a common Carnian taxon across Pangea. The most well-preserved dentary that we recovered possess quadrangular gomphodont (i.e., molar-like) postcanine teeth with anteriorly positioned transverse crests, diagnostic of a traversodontid cynodont. These rhomboid postcanines (in occlusal view) are dissimilar from the ovoid postcanines of early-diverging traversodonts (e.g., *Scalenodon*), but are not imbricated as in later-diverging groups (e.g., Massetognathinae), suggesting an 'intermediate' morphology, which is present in *Luangwa*. The sigmoid curvature of the ventral border of the dentary in lateral view is also suggestive of *Luangwa.* Therefore, we identify this Zimbabwean form as a *Luangwa*-like traversodontid cynodont, potentially assignable to *Luangwa*. This occurrence of *Luangwa* among a probable Carnian fauna corresponds with recent biochronological schemes for southern Africa, which place this taxon in the Carnian of Zambia and Tanzania instead of the Middle Triassic. Therefore, our tentative diagnosis of *Luangwa* in Zimbabwe may correlate the Pebbly Arkose fauna (rhynchosaurs, sauropodomorphs, pseudosuchian archosaurs) with distinct faunas of Tanzania and Zambia (dicynodonts, archosauromorphs, avemetatarsalians). This is consistent with the hypothesized increase in endemism during the Carnian Stage, with even neighboring faunas possessing distinct ecological players.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A *LUANGWA*-LIKE CYNODONT FROM NORTHERN ZIMBABWE AND ENDEMISM ACROSS THE CARNIAN OF SOUTHERN AFRICA

TARUVINGA, Hazel R., Bulawayo, Zimbabwe; TOLAN, Stephen, , Mfuwe, Zambia; GRIFFIN, Christopher T., Virginia Tech, Blacksburg, VA, United States of America

The full recovery of terrestrial ecological systems following the devastating end-Permian mass extinction (250 Ma) took tens of millions of years. The world appears to have recovered by the Carnian stage of the Late Triassic, with Carnian taxa becoming more endemic than immediately after the extinction. Cynodonts are a diverse group of therapsids that survived the end-Permian mass extinction and thrived in the aftermath, with diversification peaks occurring during the late Anisian (particularly in Africa) and the

Carnian of South America and India. Therefore, cynodonts are an excellent study system to understand the intersection of biogeography and extinction recovery in southern Pangea. We recovered cynodont material from a new locality in the Pebbly Arkose Formation of northern Zimbabwe, the first cynodont material reported from this country. We preliminarily date this locality as Carnian by the presence of hyperodapedontid rhynchosaurs, a common Carnian taxon across Pangea. The most well-preserved dentary that we recovered possess quadrangular gomphodont (i.e., molar-like) postcanine teeth with anteriorly positioned transverse crests, diagnostic of a traversodontid cynodont. These rhomboid postcanines (in occlusal view) are dissimilar from the ovoid postcanines of early-diverging traversodonts (e.g., *Scalenodon*), but are not imbricated as in later-diverging groups (e.g., Massetognathinae), suggesting an 'intermediate' morphology, which is present in *Luangwa*. The sigmoid curvature of the ventral border of the dentary in lateral view is also suggestive of *Luangwa.* Therefore, we identify this Zimbabwean form as a *Luangwa*-like traversodontid cynodont, potentially assignable to *Luangwa*. This occurrence of *Luangwa* among a probable Carnian fauna corresponds with recent biochronological schemes for southern Africa, which place this taxon in the Carnian of Zambia and Tanzania instead of the Middle Triassic. Therefore, our tentative diagnosis of *Luangwa* in Zimbabwe may correlate the Pebbly Arkose fauna (rhynchosaurs, sauropodomorphs, pseudosuchian archosaurs) with distinct faunas of Tanzania and Zambia (dicynodonts, archosauromorphs, avemetatarsalians). This is consistent with the hypothesized increase in endemism during the Carnian Stage, with even neighboring faunas possessing distinct ecological players.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

A *LUANGWA*-LIKE CYNODONT FROM NORTHERN ZIMBABWE AND ENDEMISM ACROSS THE CARNIAN OF SOUTHERN AFRICA

TARUVINGA, Hazel R., , Bulawayo, Zimbabwe; TOLAN, Stephen, , Mfuwe, Zambia; GRIFFIN, Christopher T., Virginia Tech, Blacksburg, VA, United States of America

The full recovery of terrestrial ecological systems following the devastating end-Permian mass extinction (250 Ma) took tens of millions of years. The world appears to have recovered by the Carnian stage of the Late Triassic, with Carnian taxa becoming more endemic than immediately after the extinction. Cynodonts are a diverse group of therapsids that survived the end-Permian mass extinction and thrived in the aftermath, with diversification peaks occurring during the late Anisian (particularly in Africa) and the Carnian of South America and India. Therefore, cynodonts are an excellent study system to understand the intersection of biogeography and extinction recovery in southern Pangea. We recovered cynodont material from a new locality in the Pebbly Arkose Formation of northern Zimbabwe, the first cynodont material reported from this country. We preliminarily date this locality as Carnian by the presence of hyperodapedontid rhynchosaurs, a common Carnian taxon across Pangea. The most well-preserved dentary that we recovered possess quadrangular gomphodont (i.e., molar-like) postcanine teeth with anteriorly positioned transverse crests, diagnostic of a traversodontid cynodont. These rhomboid postcanines (in occlusal view) are dissimilar from the ovoid postcanines of early-diverging traversodonts (e.g., *Scalenodon*), but are not imbricated as in later-diverging groups (e.g., Massetognathinae), suggesting an 'intermediate' morphology, which is present in *Luangwa*. The sigmoid curvature of the ventral border of the dentary in lateral view is also suggestive of *Luangwa.* Therefore, we identify this Zimbabwean form as a *Luangwa*-like traversodontid cynodont, potentially assignable to *Luangwa*. This occurrence of *Luangwa* among a probable Carnian fauna corresponds with recent biochronological schemes for southern Africa, which place this taxon in the Carnian of Zambia and Tanzania instead of the Middle Triassic. Therefore, our tentative diagnosis of *Luangwa* in Zimbabwe may correlate the Pebbly Arkose fauna (rhynchosaurs, sauropodomorphs, pseudosuchian archosaurs) with distinct faunas of Tanzania and Zambia (dicynodonts, archosauromorphs, avemetatarsalians). This is consistent with the hypothesized increase in endemism during the Carnian Stage, with even neighboring faunas possessing distinct ecological players.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A NEW MIDDLE MIOCENE DESMATOPHOCID PINNIPED (MAMMALIA, CARNIVORA) FROM THE OREGON COAST AND ITS POTENTIAL FOR GREATER RESOLUTION OF PINNIPED PHYLOGENY AND PALEOECOLOGY

TATE-JONES, Kellum, University of Oregon, Eugene, OR, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America; DAVIS, Edward B., University of Oregon, Eugene, OR, United States of America

Despite several decades of morphological and molecular study, a consensus on the phylogeny of the carnivoran suborder Pinnipedia has remained elusive. The majority of studies within the last 10 years have supported a monophyletic origin for pinnipeds. Questions remain about whether pinnipeds are more closely related to ursids or musteloids and about the positioning of early-branching clades, such as Desmatophocidae. Researchers have alternately placed Desmatophocidae as a sister taxon to phocids (true seals), otariids (sea lions and fur seals), and odobenids (walruses), and no clear consensus yet exists about its positioning. Species of desmatophocid, including those of genus *Desmatophoca* and the more derived *Allodesmus*, are reported from throughout the Miocene of Japan, the Pacific coast of Mexico, and the Washington, Oregon, and California coasts.

Here we report a newly prepared specimen of *Desmatophoca* sp., represented by a skull with partial dentition from the Astoria Formation of Oregon. The shallow marine Astoria Formation, dated from 19.2 to 15.1 Ma, produces a host of marine invertebrate fossils as well as fossil cetaceans, desmostylians, and five separate pinniped taxa, including the type specimen for *Desmatophoca*. The distinct morphology of the jugal-squamosal contact in this specimen allows for placement of this specimen into genus *Desmatophoca*. However, several factors preclude diagnosis within one of the previously identified species, *D. brachycephala* and *D. oregonensis*. A more laterally compressed orbital fenestra and presence of a medial septum in the incisive foramen exclude it from *D. brachycephala*. Diagnosis within *D. oregonensis* is barred by two factors. This specimen has unusually wide anterior nares with a width of 43.3 mm, compared to the *D. oregonensis* mean of 26.4 mm (n = 3, σ = 2.5 mm). Additionally, the foramen magnum of *D. oregonensis* has a mean width of 31.0 mm (n = 4, σ = 1.3 mm), but the foramen magnum of this specimen is 21.3 mm wide and more circular than dorsoventrally elongated. The presence of a prenarial shelf distinguishes *Desmatophoca* sp. from inclusion within either of the other species. At least six pinniped fossil species have now been recovered from the Astoria Formation, representing a similar level of pinniped diversity to that present on the Oregon Coast today, even before accounting for preservation bias.

Grant Information

Funding for this project was provided by the University of Oregon Department of Earth Science and the University of Oregon Vertebrate Paleontology Lab.

Technical Session XV (Saturday, October 20, 2018, 8:15 AM)

BODY MASS PREDICTS DIET-BIOAPATITE $\Delta^{13}C$ ISOTOPE ENRICHMENT IN HERBIVOROUS MAMMALS

TEJADA, Julia V., Columbia University & American Museum of Natural History, New York, NY, United States of America; MACF.ADDEN, Bruce J., University of Florida, Gainesville, FL, United States of America; BERMUDEZ, Lizette, Huachipa Zoo, Lima, Peru; ROJAS, Gianmarco, Huachipa Zoo, Lima, Peru; SALAS-GISMONDI, Rodolfo, Museo de Historia Natural-UNMSM, Lima, Peru; FLYNN, John J., American Museum of Natural History, New York, NY, United States of America

The carbon isotopic signatures recorded in vertebrate tissues reflect ecologies and ecosystems because carbon in animal body tissues derives from ingested food. For almost two decades most carbon isotope-based ecological interpretations of extant and extinct herbivorous mammals have used a single diet-bioapatite enrichment value (14‰). This 14‰ value has been systematically applied in virtually all dietary and environmental interpretations of fossil and extant mammalian herbivores, regardless of body size, phylogenetic affinities, or other life history traits. However, the assumption that this single value pertains across all herbivorous mammals, from tiny monkeys to giant elephants, overlooks potential effects of distinct physiological and metabolic processes on carbon fractionation. By analyzing a never before assessed herbivore group spanning a broad range of body masses—sloths—we discovered considerable variation in diet-bioapatite $\delta^{13}C$ enrichment among mammals. Statistical tests (OLS, quantile, robust regressions, and AICc model tests) document independence from phylogeny, and a previously unrecognized strong and significant correlation with body mass. These analyses, spanning body sizes ranging over > 5 orders of magnitude, permit development of a size-dependent prediction of diet-bioapatite enrichment for herbivores across Mammalia and for distinct types of gastric fermentation. Consequently, our proposed regression models may also predict type of digestive physiology for fossil mammals (foregut vs. hindgut fermentation). Thus, our results show that ground sloths, the largest mammals that ever existed in South America would be, together with modern hippos, the largest known non-ruminant foregut fermenters, challenging previously proposed ideas of constraints imposed by large body sizes on foregut fermentation.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

STRANGERS IN A STRANGE LAND: THE TAPHONOMY OF 80+ SPHENOSUCHIANS (BASAL CROCODYLOMORPHA) IN THE SAINTS & SINNERS QUARRY, A LATE TRIASSIC (NORIAN OR RHAETIAN) OASIS IN THE EOLIAN NUGGET SANDSTONE OF NORTHEASTERN UTAH

THEURER, Brandon, Brigham Young University, Provo, UT, United States of America; ESPLIN, Rebecca, Brigham Young University, Provo, UT, United States of America; CHURE, Daniel J., retired, Jensen, UT, United States of America; ENGELMANN, George F., University of Nebraska, Omaha, Omaha, NE, United States of America; SCHEETZ, Rodney D., Brigham Young University, Provo, UT, United States of America; CLARK, James M., George Washington University, Washington, DC, United States of America; BRITT, Brooks B., Brigham Young University, Provo, UT, United States ofAmerica

A remarkable occurrence of at least 88 individuals of a new sphenosuchian in the Saints & Sinners Quarry is the basis for this taphonomic study. They occur in two of three ~25 cm thick superimposed lacustrine beds of silty fine-grained sandstones separated by thin clay partings that are part of an interdunal package in the Nugget Sandstone. The articulated and associated skeletons occur at the interface of the basal and middle quarry beds up through the lower two-thirds of the middle bed. The top of the middle bed has only dispersed, disarticulated bones. The beds formed as storms blew sands into the lake from lake-margin dunes.

The quarry fauna includes nine terrestrial vertebrate taxa. This study utilizes only the remains of a new sphenosuchian diagnosed by a fenestrated quadrate, basisphenoid pneumaticity, and the lack of a basipterygoid joint. The MNI is 88 (26 articulated and 62 associated/disarticulated individuals). Skeletons are 140 to 350 mm long, femora 13 to 59 mm long, and skulls 18 to 42 mm long. It is not clear that the largest specimens are mature. The 26 articulated skeletons exhibit no preferred snout-tail orientation. Vertebral long axes are preferentially oriented north-south. Twenty are preserved belly down, four on right side, one on left side, one contorted, and zero belly up. Of the 62 associated but disarticulated skeletons, six are belly down, three belly up, and the rest indeterminate.

There are several clusters of mixed articulated and disarticulated skeletons. However, one cluster ($1.5m^2$), close to the shoreline, consists solely of eight articulated skeletons with vertebral axes roughly parallel. Three of these skeletons are closely appressed side-by-side, with same snout orientation, and intertwined limbs. The fifth other individuals occur individually with the opposite snout-tail-orientation. We attribute the parallel orientation to wave action along the lake's strand line.

At the quarry site, articulated sphenosuchian carcasses were buried prior to maceration and disturbance. Decomposing individuals disarticulated, and possibly floated and transported, prior to burial. The sphenosuchian accumulation could represent a single drought assemblage in a drying, possibly saline, lakebed. During an episode of strong winds, sand from adjacent dunes buried some articulated individuals oriented by near-shore wave action. At the same time, other articulated individuals, along with more macerated and disturbed remains, were buried a few meters offshore. Continued wave action dispersed the disarticulated sphenosuchian bones found in the upper part of the middlebonebed.

Technical Session X (Friday, October 19, 2018, 8:15 AM)

PALEOENVIRONMENTS OF THE MID-CAMPANIAN FOREMOST FORMATION AND THE EVOLUTION OF THE LATE CAMPANIAN BIOTA OF THE BELLY RIVER GROUP OF SOUTHERN ALBERTA, CANADA

THOMPSON, Michael G., Carleton University, Ottawa, ON, Canada; RYAN, Michael J., Cleveland Museum of Natural History, Cleveland, OH, United States of America; SCHRÖDER-ADAMS, Claudia, Carleton University, Ottawa, ON, Canada

During the middle Campanian (~80–77 Ma), North America was bisected by the Claggett Seaway, which was undergoing a major sea level regression, reducing marine influence and increasing the available terrestrial habitat. This marine-to-terrestrial transition is represented within the central and southern Alberta plains by the deposits of the middle Campanian Foremost Formation (FF), the oldest member of the Belly River Group (BRG). Characterizing the nature of the marine-to-terrestrial transition has important implications for the evolution of the late Campanian vertebrate assemblages of the much better documented, fully terrestrial, younger members of the BRG, the Oldman and Dinosaur Park formations. Localities adjacent to the Milk River in southern Alberta were measured and sampled to reconstruct the facies of the FF transitional zone using additional data obtained from whole rock geochemistry, and Foraminifera and vertebrate (microsite and whole body) paleontology.

Sedimentological and stratigraphic data suggests that the lower portions of the FF display a prograding sequence of coastal estuarine or barrier island/lagoonal environments overlain by coastal plain marsh and fluvial deposits of the Taber Coal Zone (marking the top of the FF). This depositional trend coincides with a shallowing Claggett Sea and the replacement of fully marine microvertebrate biota by an increasing dominance of terrestrial (e.g., lissamphibian, fish, and dinosaur) taxa near the top of the FF. Benthic foraminiferal assemblages further indicate previously unrecorded stressed salinity, nutrient and bottom water oxygen conditions within the brackish water estuarine, lagoonal, and coastal marsh environments. Vertebrate microsite community makeup and diversity analysis indicate a twofold increase in family level diversity in the time represented within the FF. The presence of gryposaur-level hadrosaurs and centrosaurine ceratopsids in the terrestrial portions of the uppermost FF suggest that the derived members of these dinosaur groups were either already established in, or rapidly immigrated into, southern Alberta by the time of deposition of the first fully terrestrial sediments of the BRG in the mid to late Campanian.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PREY SIZE PREFERENCE DETERMINATION OF MODERN AND FOSSIL CATS USING GEOMETRIC MORPHOMETRICS

THOMPSON, Sophia C., SUNY Geneseo, Geneseo, NY, United States of America; BURCH, Sara H., SUNY Geneseo, Geneseo, NY, United States of America

The forelimbs of cats play an important role in prey capture and subjugation. Previous studies have shown that the prey size preference of cats can be distinguished using linear morphometrics to capture the shape of the bones in the forelimb. We investigated this relationship using two-dimensional geometric morphometrics to landmark the same points on the scapula, humerus, radius, and ulna of 31 felid species. A principal component analysis was performed after Procrustes alignment and each species was classified by prey size preference. Results showed large and small prey specialists were well separated along the first principal components axis, with mixed prey specialists overlapping both of the other regions. This suggests that mixed prey specialists retain a general forelimb structure suitable for exploiting a variety of prey sizes. Cats that hunt large prey had more robust forelimbs with thicker distal ends of the humerus. This is important for resisting the force of large, struggling prey. Cats that hunt small prey had long and slender forelimbs to aid in quick capture of the animal. An important exception to this was the cheetah, *Acinonyx jubatus*, which is a large prey specialist but plotted within the small prey specialists because of its unique hunting strategy that does not involve grappling to bring down their prey. These results show that small and large prey specialists can be distinguished by the shape of their forelimb bones. We then investigated the classification of prey-size preference for 11 species of extinct cats. Saber-toothed cat species belonging to the subfamily Machairodontinae were largely separated from the other felids along the first principal component axis and clustered near the large prey specialists. They had the most robust forelimbs when compared to the other cats in the analysis. Extinct cheetahs were borderline large prey specialists, falling also within the mixed prey specialist group. This suggests that they lack the specialized hunting strategy of modern cheetahs. *Pseudaelurus*, which is the most basal cat of the 42 species, plotted in the middle of the first principal component axis. This suggests that this primitive cat was not a specific prey size specialist and most likely hunted a variety of prey.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

FOSSIL TRACKS AND TRACKWAYS FROM THE LATE PLIOCENE BEAR SPRINGS WASH BEDS OF GRAHAM COUNTY, SOUTHEASTERN ARIZONA

THRASHER, Larry, US Bureau of Land Management, Safford, AZ, United States of America

The Bear Springs Wash beds in Graham County, Arizona are a sequence of fresh water sediments about 3 million years old that contain tracks and trackways of mammals and birds, as well as other fossils. The beds are of late Pliocene, or middle Blancan age, and have been known for their fossil footprints since at least the 1970s, though little has been published on them. Tracks of camels, three-toed horses, and mastodonts are the most common, with others including antelope, goose, and possible bear also present. The tracks occur on a few thin, laterally extensive beds of fresh water limestone that form hard, resistant layers in the otherwise soft sedimentary deposits of the formation. Two of the layers are well shown in cross-section in the local geologic landmark known as the Red Knolls Amphitheater. The Bureau of Land Management (BLM) designated much of the area as the Bear Springs Badlands Area of Critical Environmental Concern, based on the significance of the fossils and the unusual badlands terrain they are found in. Over the past 20 years, the BLM has been working closely with the Arizona Museum of Natural History in Mesa on the further discovery and documentation of these fossils, leading to numerous new tracks and sites, many of which are shown here.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

UNIQUE TAPHONOMY OF A TYRANNOSAURID-DOMINATED BONEBED FROM THE UPPER CAMPANIAN KAIPAROWITS FORMATION, GRAND STAIRCASE-ESCALANTE NATIONAL MONUMENT, UTAH

TITUS, Alan L., Grand Staircase-Escalante National Monument, Kanab, UT, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America; KNOLL, Katja, Grand Staircase Partners, Kanab, UT, United States of America; GLASSPOOL, Ian, Colby College, Waterville, ME, United States of America; SUAREZ, Celina A., University of Arkansas, Fayetteville, AR, United States of America; RICHARDSON, Scott, Grand Staircase-Escalante National Monument, Kanab, UT, United States of America

The upper Campanian (74–76.5 mya) Kaiparowits Formation of southern Utah contains abundant fossils, sometimes in exceptional states of preservation (e.g., soft tissue impressions). In contrast with contemporaneous northern strata, nearly all Kaiparowits Formation macrovertebrate sites yield isolated elements, single individuals, or small accumulations of individuals preserved in limited areas (<100 m^2). In 2014, an extensive bonebed (~2,500 m^2) hosted in a charcoal laden, conglomeratic sandstone bed of fluvial origin was discovered in the Monument. It is by far the largest macrovertebrate bonebed excavated in the Kaiparowits Formation, approaching the scale of Dinosaur Park Formation examples. Vertebrate remains are mostly disarticulated and of mixed aquatic/terrestrial origin, with the aquatic portion dominated by *Atractosteus*-type gars and a diverse assortment of turtles, including a ~2 meter diameter ?toxochelid taxon that may be the largest freshwater turtle ever collected from the terrestrial Cretaceous of North America. Teleost fish and crocodyliform remains are less common, but do include an associated specimen of the giant alligatoroid *Deinosuchus*. The most abundant terrestrial vertebrate in the bonebed is the tyrannosaurid *Teratophoneus*, represented by individuals from at least four distinct ontogenetic stages. Invertebrates are represented by uncommon, poorly preserved steinkerns ofbivalves and gastropods. Fossil foliage, a ubiquitous feature in many other Kaiparowits bonebeds, is absent, with preserved vegetation consisting mostly of coalified roots and charred wood. Together with faunal evidence, sediment preserved in the interstices of macro- and mesovertebrate remains indicates initial burial in a mudstone deposited in a large-scale lacustrine system. Subsequent drying of the lake by extended drought produced pedogenic carbonate. Paradoxically, the site's aquatic component is hypothesized to be a mostly time-attritional lacustrine accumulation, while the tyrannosaurs, assumed to be a social or familial group, were killed catastrophically. Both terrestrial and aquatic components may have been significantly augmented by drought kill as the lake dried. Drought may also have led to the fire, which possibly triggered hydraulic chaos and forced the avulsion that exhumed and redeposited the fossils in the channel. The taphonomic signature of the site appears unique among major paracontemporaneous bonebeds, possibly as a result of more extreme southern Laramidian Late Campanian climatic fluctuations.

Grant Information

Crowd sourced funding through www.experiment.com, Bureau of Land Management, Grand Staircase-Escalante National Monument, and Grand Staircase Escalante Partners.

Podium Symposium (Wednesday, October 17, 2018, 11:45 AM)

THE END-PLEISTOCENE MEGAFAUNAL EXTINCTION CAUSED A SHIFT IN MAMMAL COMMUNITY STRUCTURE

TÓTH, Anikó B., Macquarie University, Sydney, Australia; LYONS, S. Kathleen, Lincoln, NE, United States of America; WORKING GROUP, ETE, Smithsonian Institution, Washington DC, DC, United States of America; ALROY, John B., Macquarie University, Sydney, Australia

Large mammals are at high risk of extinction globally. To understand the potential consequences of their demise on community structure, we tracked species occupancy and co-occurrence patterns through the end-Pleistocene large mammal extinction in North America. We used 8847 end-Pleistocene and Holocene species occurrence records from 1139 sites in the FAUNMAP database, coupled with downscaled CCSM3 paleoclimate simulations and body mass estimates from the MOM database. We evaluated co-occurrence between all pairwise combinations of mammals greater than 1 kg across the extinction interval. Pairs were sorted into categories in which (1) both survived (SS), (2) both went extinct (EE), and (3) one species survived and one species went extinct (SE). We also investigated the influence of abiotic factors such as mean annual temperature, precipitation, and latitude on each pair. The end-Pleistocene was characterized by many species with low (< 5%) to medium (5–25%) occupancy. Although the victims spanned the full range of occupancies, the occupancy distribution of surviving species shifted in the Holocene, leaving medium occupancies largely unrepresented. In the end-Pleistocene, a larger percentage of the species pool share the strongest associations, with the 2.5% most strongly aggregated and segregated pairs involving 64% and 52% of species, respectively. In the Holocene, 37% and 31% of the species pool is involved in the strongest aggregations and segregations, respectively. Strong end-Pleistocene aggregations were disproportionately represented by SS pairs. The strength of segregations across all pairs increased over the Pleistocene–Holocene transition, and the number of aggregations decreased in SS pairs. The increase in segregation strength was not due to loss of pairs involving the megafauna, but rather a shift in the co-occurrence patterns of survivors concurrent with the extinction. Cluster analyses on the sites and on species pairs confirm that the Pleistocene was characterized by three faunas representing southeastern, western, and northern biogeographic provinces, but these were compressed into overlapping area by the ice sheets. The Holocene contains three analog faunas that are much reduced in diversity and more geographically segregated. Species may have responded more similarly to changes in climate than was once believed. These results suggest that the megafaunal extinction had profound effects on the interactions and continental-scale community structure of surviving species.

Grant Information

Funding was provided by an NMNH grant to the ETE program and NSF-DEB 1257625. ABT was supported by an IPRS scholarship from Macquarie University.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

THE SKELETON OF *DIPLOBUNOPS* AND IMPLICATIONS FOR UNDERSTANDING VARIATION IN EARLY ARTIODACTYLS

TOWNSEND, K.E. Beth, Midwestern University, Glendale, AZ, United States of America; DELGADO, Adam, Midwestern University, Glendale, AZ, United States of America

The middle Eocene is a time of incredible diversification among the artiodactyls (the even-toed ungulates, such as sheep, cows, deer). During this period, artiodactyls began to 'modernize' and many basal taxa arose that formed many of the taxonomic groups of artiodactyls that we recognize today (i.e., ruminants, camels, pigs). The genus *Diplobunops* is an intriguing taxon that is restricted to the late Uintan interval of the middle Eocene (~43–39 Ma) and has had a checkered taxonomic history: some scholars do not consider it a valid genus, while others think the opposite. Based on our study of closely-related taxa and thorough investigation of this new specimen, we hypothesize that *Diplobunops* is a valid genus. Our study is the first to describe in detail the skeleton of *Diplobunops*. The area of the first lower molar is often taken as a proxy for body size and, in this character, the upper end of the *Protoreodon* species range overlaps with that of *Diplobunops*; however, the postcranial comparisons indicate that *Diplobunops* was a more robust animal with stouter limbs than its close relative, *Protoreodon*. The strict consensus tree resembles that of Theodor and Foss (2005) but unlike the published tree of these authors, the addition of *Diplobunops* resolves the polytomy among early ruminant artiodactyls.

In 2013, a rather complete skeleton of *Diplobunops* (13-262) was found at a middle Eocene locality in the Uinta Formation, Uinta Basin, Utah. The skeleton was reconstructed, and measurements were taken using Mitutoyo digital calipers and an osteometric board. To evaluate the position of *Diplobunops* among other early ruminant artiodactyls, we performed a phylogenetic analysis based on the data matrix of Theodor and Foss (2005). We updated this matrix with characters for *Diplobunops*. Trees were generated using a heuristic search option in PAUP 4.0a152 and character evaluation was performed in Mesquite. We evaluated shape indices for major joint surfaces in order to evaluate any major differences in locomotor preferences. Skeletons of *Diplobunops* are available in museums, but none have been described in great detail or used in phylogenetic analyses. Our study is the first step in evaluating this genus and our preliminary data suggest that *Diplobunops* is a valid genus.

Grant Information
This project was funded by Midwestern University Kenneth Suarez Summer Research Fellowship and Midwestern University ORSP Intramural Funding.

Romer Prize Session (Thursday, October 18, 2018, 9:30 AM)

PATAGONIAN ARIDIFICATION AND ECOLOGICAL SHIFTS AT THEONSET OF THE MID-MIOCENE CLIMATIC OPTIMUM

TRAYLER, Robin B., Boise, ID, United States of America

High atmospheric CO_2concentrations (pCO_2> 400 ppm), low ice volumes, and high ocean temperatures during the mid-Miocene Climatic Optimum (MMCO; ~17.0–14.5 Ma) are thought to have driven the expansion of warm, wet ecosystems to high latitudes. Faunas of fossil bearing strata of the Santa Cruz Formation (SCF.), southern Argentina (47-52° S latitude) record this expansion. The SCF. has produced a diverse assemblage of vertebrate fossils, with species richness similar to modern lowland tropical forests. Previous faunal analysis of the SCF. has suggested high mean annual precipitation (MAP > 1000 mm/yr) and warm mean annual temperatures (MAT > 14° C) but did not investigate ecological changes through time. Here I present stable carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotope compositions of fossil enamel and bone recovered from strata spanning the initiation of the MMCO. I also present new U-Pb ages for several interbedded tuffs (range ~17.5–16.5 Ma). Combined, I use these data to quantify changes in precipitation and temperature through time.

I collected isotope compositions from ~ 100 individuals dispersed over 150 m of stratigraphic section. Large herbivores—*Nesodon*, *Adinotherium*, and *Astrapotherium*—are best represented. Each sample was assigned an age and uncertainty based on its stratigraphic position using a Bayesian sedimentation model. I estimated intra-tooth variations in isotope composition by serially sampling several teeth. I used a Monte Carlo approach to propagate the uncertainties in age and intra-tooth variability to produce a continuous model of $\delta^{13}C$ and $\delta^{18}O$ values over a ~1.0 Ma interval. Modeled enamel $\delta^{13}C$ values indicate C_3 feeding with an increase from ~-12.3‰ to -11.0‰ over the interval. Modeled $\delta^{18}O$ values increased ~2‰ over the interval. Based on $\delta^{13}C$ of tooth enamel (plants consumed) and the atmosphere, MAP decreased ~50% over the interval from ~1200 to 600 mm/yr. $\delta^{18}O$ values of enamel (H_2O proxy) and bone (carbonate proxy) show an increase in MAT from ~20 to 26°C, over the same period. Isotopic zoning in serial sampled molars is low, ~±0.3‰ and ±0.8‰, for $\delta^{13}C$ and $\delta^{18}O$, respectively, suggesting little seasonal variability in diet and drinking watercompositions.

Combined, these data suggest an aridification of the SCF. and an ecological shift towards more open habitats at the onset of the MMCO. Modern atmospheric pCO_2 reached MMCO levels in mid 2016, making studies of this interval newly relevant to both paleo and modern studies of climate and ecology.

Grant Information
NSF EAR-1349749 (M.J. Kohn)

Podium Symposium (Wednesday, October 17, 2018, 3:30 PM)

CONTRAST-ENHANCED XROMM REVEALS IN VIVO SOFT TISSUE INTERACTION IN THE HIP OF *ALLIGATOR MISSISSIPPIENSIS*: IMPLICATIONS FOR PSEUDOSUCHIA

TSAI, Henry P., Brown University, Providence, RI, United States of America; TURNER, Morgan L., Brown University, Providence, RI, United States of America; MANAFZADEH, Armita R., Brown University, Providence, RI, United States of America; GATESY, Stephen M., Brown University, Providence, RI, United States of America

Archosaurs (birds, crocodylians, and their extinct relatives) evolved a wide diversity of hind limb skeletal morphologies, suggesting highly divergent articular soft tissue anatomies. Recent studies have shed light on the articular soft tissue anatomy of the archosaur hip joint, but the dynamic interactions among these tissues remain unknown, hampering further functional inferences. Here we use contrast- enhanced computed tomography to generate 3-D surface models of the pelvis, femora, and joint soft tissues of the American alligator, an extant archosaur. The hip joints were then animated using marker-based X-ray Reconstruction of Moving Morphology (XROMM) to visualize soft tissue articulation during forward terrestrial locomotion.

The anatomical femoral head of the alligator travels beyond the cranial extent of the bony acetabulum and does not act as a central pivot as has been suggested for some extinct archosaurs. Additionally, the fibrocartilaginous surfaces of the alligator's antitrochanter and femoral neck maintain engagement during hip flexion and extension, similar to the articulation between homologous structures in birds. Lastly, the fovea capitis of the femur remains in close proximity to the membrane-bound inner acetabular foramen, suggesting that the ligamentum capitis remains within this unossified portion of the acetabulum.

Our results illustrate the utility of contrast-enhanced XROMM for studying articular soft tissue interactions. These results also allow us to generate functional hypotheses about crocodylian hip joint soft tissues, expanding our knowledge of vertebrate connective tissue biology and the role of joint soft tissues in locomotor behavior. When considered in light of the osteological correlates of femoral and pelvic soft tissues in fossil pseudosuchians, these new data improve our ability to reconstruct hip articulation in pseudosuchians. In doing so, they form the basis for further studies of the evolutionary relationship between joint anatomy, locomotor posture, and body size transitions.

Grant Information
This research was supported by the Bushnell Postdoctoral Fellowship (HPT) and the Bushnell Faculty Research Grant (SMG) at Brown University.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

INDICATIONS FOR A HORNY BEAK AND EXTENSIVE SUPRAORBITAL CONNECTIVE TISSUE IN DIPLODOCID SAUROPODS

TSCHOPP, Emanuel, American Museum of Natural History, New York, NY, United States of America; MATEUS, Octávio, FCT - Universidade NOVA de Lisboa, Caparica, Portugal; MARZOLA, Marco, FCT - Universidade NOVA de Lisboa, Caparica, Portugal; NORELL, Mark, American Museum of Natural History, New York, NY, United States of America

Soft tissue structures can considerably alter body shape but are rarely preserved in fossils. Based on novel evidence from a new skull of a diplodocid sauropod from the Upper Jurassic Morrison Formation of the Bighorn Basin (Wyoming, U.S.A.), we propose that they had a horny beak and extensive connective tissue covering the orbits. Osteological features indicative of beaks identified in turtles, birds, and ornithischian dinosaurs, were also recognized in diplodocids. These are transversely expanded edges with striated rugosities posterior to the rear maxillary and dentary teeth. These rugosities are associated with neurovascular foramina and grooves, especially towards the tip of the rostrum and its expanded edges. Extensive connective tissue covering the eyes is deduced from striated rugosities on the dorsal orbital rim and the occurrence of bony spurs or tubercles on the lacrimal. The horny beak may have helped dissipate stresses at the tip during feeding and forms a continuous cutting edge along the snout. The supraorbital connective tissue may have provided shade, and both soft tissue structures might have been used for sexual display or species recognition.

Grant Information
Theodore Roosevelt Memorial Fund Postdoctoral Fellowship (ET)
FCT PhD fellowship SFRH/BD/99580/2014 (MM)
BLM permit PA16-WY-256 (OM, MN, ET)

Podium Symposium (Friday, October 19, 2018, 11:15 AM)

3D MORPHOMETRIC AND BIOMECHANICAL ANALYSES SUGGEST STRUCTURE-FUNCTION COVARIATION WITH NON-FEEDING ECOLOGICAL VARIABLES INFLUENCES EVOLUTION OF FEEDING SPECIALIZATION IN CARNIVORA

TSENG, Z. Jack, University at Buffalo, Buffalo, NY, United States of America; FLYNN, John J., American Museum of Natural History, New York, NY, United States of America

Skull shape convergence is pervasive among vertebrates. Although this is frequently inferred to indicate similar functional underpinnings, neither the specific structure-function linkages nor the selective environments in which the supposed functional adaptations arose are commonly identified and tested. Here we demonstrate that non-feeding factors relating to sexual maturity and precipitation-related arboreality also can generate structure-function relationships in the skulls of carnivorans (dogs, cats, seals, and relatives) through covariation with masticatory performance. Using a recently built Computed Tomography database of carnivoran skulls at the American Museum of Natural History, we estimated measures of masticatory performance related to ecological variables that covary with cranial shape in the mammalian order Carnivora, integrating geometric morphometrics and finite element analyses. Even after accounting for phylogenetic autocorrelation, cranial shapes are significantly correlated to both feeding and non-feeding ecological variables, and covariation with both variable types generated significant masticatory performance gradients. This suggests that mechanisms of obligate shape covariation with non-feeding variables can produce performance changes resembling those arising from feeding adaptations in Carnivora. These findings are of direct relevance to efforts underway to study the effect of complex structure-function linkages in paleoecological reconstructions of fossil carnivorans in our database. The results also highlight the power of digital 3D model databases in allowing use of structural morphing to test hypotheses about complex structure-function linkages.

Grant Information
NSF DEB-1257572

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ESTIMATION OF BODY MASS FROM THE CALCANEUM OF LAND MAMMALS

TSUBAMOTO, Takehisa, Ehime University, Matsuyama, Japan

In mammalian skeletons, calcaneum and astragali are compact and easily handled bones, and their fossil remains have relatively higher chances of being discovered as undamaged specimens. Fossil calcaneum and astragali have been well studied as indicators of the

functional morphology and phyletic relationships of mammals, and have been used to estimate body mass, which is important in paleoecological studies because of its strong correlation with animal ecology and physiology. While the relationship between the size of the astragalus and the body mass of fossil taxa has been studied intensively, only a few studies have investigated the relationship between calcaneal size and body mass. Furthermore, previous studies on the relationship between calcaneal size and body mass have been limited to a few selected taxonomic groups.
To expand the application of the calcaneum to more extensive groups of land mammals in estimating body mass, I examined the allometric relationships (using natural logarithm) between body mass and calcaneal size in an extensive sample of extant land mammals (10 orders, 44 species, 69 individuals; body mass ranging from 18 g to 1.4 metric tons) using regression analysis. The results indicate that the best body mass estimator for extensive land mammals is calcaneal width. Using calcaneal width, body mass with 95% prediction error is estimated by the following formula (adjusted R^2= 0.977; %SEE = 49.1; %MPE = 33.6): Body mass [g] = (EXP (2.917 x ln (calcaneal width [mm]) + 1.022 ± 0.798)) x 1.081. The %MPE and %SEE of this case are higher than those of the astragalus, indicating that for body mass estimation of large mammals, the astragalus is preferable to the calcaneum.
Grant Information
JSPS KAKENHI Grant Numbers 25840172 and 16K07534

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

TWO ICHNOGENERA OF IGUANODONTID FOOTPRINTS FROM THE LOWER CRETACEOUS KITADANI FORMATION, FUKUI, JAPAN: ICHNOTAXONOMIC IMPLICATIONS

TSUKIJI, Yuta, Hiroshima University, Higashihiroshima, Japan; AZUMA, Yoichi, Fukui Prefectural University, Eiheiji-Town, Japan; SHIRAISHI, Fumito, Hiroshima University, Higashihiroshima, Japan; SHIBATA, Masateru, Fukui Prefectural University, Eiheiji-Town, Japan; NODA, Yoshikazu, Fukui Prefectural Dinosaur Museum, Katsuyama, Japan
Iguanodontid footprints occur in multiple localities in Japan. Among them, the Lower Cretaceous Kitadani Formation (Akaiwa Subgroup, Tetori Group) in Katsuyama City, Fukui, central Japan, produced the largest number of reported specimens. In the present study, we revisit these previously-reported iguanodontid footprints and describe them as *Caririchnium* isp. and *Anblydactylus* isp. *Caririchnium* isp. is characterized by a track that is longer than wide, with a strong mesaxony. *Amblydactylus* isp. is characterized by a track that is wider than long, with a weak mesaxony. The bivariate analyses of ATL/ATW and FL/FW differentiate *Caririchnium* isp. and *Amblydactylus* isp. In addition, other ichnospecies, including *Caririchnium* (except *C. liucixini*) and *Amblydactylus* also appear distinct in these analyses. Two species of iguanodontians, a non-hadrosauroid *Fukuisaurus* and a basal hadrosauroid *Koshisaurus*, are reported from the Kitadani Formation. Coexistence of primitive and derived iguanodontians in the same formation implies that morphological variations of iguanodontid footprints may represent taxonomic differences of trackmakers. *Caririchnium*-type footprints are observed in the pre-middle Cretaceous strata, whereas *Amblydactylus*-type footprints are known from the post-middle Cretaceous strata in northern hemisphere. This occurrence is accord with the temporal and geographical distributions of iguanodontians, where non-hadrosauroid iguanodontians thrived in the Early Cretaceous, and hadrosauroid iguanodontians in the late Early to Late Cretaceous. Therefore, we propose that the trackmakers of *Caririchnium*-type are potentially non-hadrosauroid iguanodontians and those of *Amblydactylus*-type footprints are hadrosauroids.

Technical Session X (Friday, October 19, 2018, 8:45 AM)

RECENT ADVANCES IN TEMPORAL CALIBRATION FOR NEWLY DISCOVERED DINOSAURIAN ASSEMBLAGES IN THE MUSSENTUCHIT MEMBER OF THE CEDAR MOUNTAIN FORMATION, CENTRAL UTAH, U.S.A.

TUCKER, Ryan T., Stellenbosch Univ, RSA, Stellenbosch, South Africa; MAKOVICKY, Peter J., Chicago Field Museum, Chicago, IL, United States of America; ZANNO, Lindsay E., North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America
It is hypothesized that during the mid-Cretaceous, western North American (NA) faunal communities underwent a shift from endemism to a period of trans-continental exchange, as evidenced by paleoassemblage data recovered from terrestrial sediments spanning the Aptian/Albian–Turonian interval. Among these strata, the highly fossiliferous Cenomanian-aged Mussentuchit Member of the Cedar Mountain Formation, central Utah, arguably provides the most comprehensive record for discerning the tempo and nature of this transformation, with new taxa continuously being identified after more than two decades of study. Despite its key role for contextualizing faunal turnover events that would shape NA ecosystems for the following ~30 million years, the Mussentuchit Member has not been subject to extensive age-dating, and it has therefore been assumed that all taxa recovered to date represent a single paleoassemblage. To refine and calibrate the impact of faunal exchange and identify abiotic influences on fossil communities, we coupled U-Pb zircon geochronology with facies and architectural analyses of fossil localities.
The majority of fossil specimens are entombed within volcanilithic-rich, intercalated drab grey to light grey silty-mudstones and muddy siltstones, interpreted as representing an aggregational tidal flat; yet, clear differences in the types of depo-center(s) occur throughout the member. We find the lower, mud-rich Mussentuchit Member lacks developed channelized architecture, and likely incurred greater tidal to wave influenced sedimentation, being deposited no later than ±96 Ma. These dates conform to those previously generated for lower Mussentuchit Member ash horizons (i.e., 96.7 & 98.4 Ma). The upper Mussentuchit Member is predominantly comprised of silt-sand rich muds, crevasse splays, and channelized sandstones indicating upper to medial delta plane depo-center(s) with hyperpycnal channels draining from adjacent high relief and is no older than±93 Ma. Fossil materials isolated to the lower Mussentuchit Member include a new, early diverging iguanodontian, whereas upper Mussentuchit Member taxa include *Siats* and a new species of caenagnathoid. Undescribed orodromine and "*Eolambia*" materials span the entire member and have not yet been investigated for possible taxonomic refinements. Our refined temporal context suggests species data may best be interpreted as representing at least two temporally disjunct paleoassemblages highlighted by distinct paleoenvironmental signals.

Podium Symposium (Wednesday, October 17, 2018, 4:00 PM)

ECOLOGICAL TRANSITIONS AND SPECIATION RATES IN CROCODYLOMORPHA: ADAPTING STATE DEPENDENT DIVERSIFICATION MODELS TO FOSSIL TREES

TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America; LAING, Adam, Stony Brook University, Stony Brook, NY, United States of America; WILBERG, Eric W., Stony Brook University, Stony Brook, NY, United States of America; HÖHNA, Sebastian, Ludwig-Maximilians-Universität München, Munich, Germany
Major ecological transitions may affect not only the rates of morphological evolution, but also speciation and extinction rates. State-dependent speciation and extinction (SSE) modeling allows for rates of diversification and extinction to be propagated across a phylogenetic tree, generating net speciation rates that are dependent on characters of interest, such as ecological state. Until now SSE modeling required an ultrametric tree and was thus limited to studies of extant species. Building off existing SSE models and the fossilized birth-death model we have developed a new class of SSE models that incorporate fossil taxa and other non-ultrametric trees, the state-dependent speciation, extinction, and fossilization (SSEF) model. This model is expandable into the full SSE framework and thus can accommodate single binary characters (BiSSE), multiple states/traits (MuSSE), and hidden states (HiSSE). We have implemented the SSEF model in the probabilistic graphical model software RevBayes.
Whereas living crocodylomorphs (crocodylians) are semiaquatic ambush predators largely restricted to freshwater or estuarine environments, extinct crocodylomorphs include large fully marine taxa analogous to modern toothed whales, small terrestrial herbivores, and large terrestrial predators. Recent work has demonstrated a large number of independent habitat transitions through time and across the clade. This makes Crocodylomorpha an ideal test case for the SSEF model and a compelling clade to address the broader questions of how and to what extent do ecological transitions drive speciation and extinction. Using a 144 tip, time-calibrated phylogeny of Crocodylomorpha with taxa characterized into three ecological states (terrestrial, marine, semi-aquatic), we estimated ancestral states and rates of eco-type evolution. We found significant signal that rates of eco-type evolution differed within Crocodylomorpha. Next we applied a multistate SSEF analysis to estimate state dependent diversification rates. Initial results indicate that transitions into marine ecologies resulted in elevated speciation rates compared to terrestrial and semi-aquatic transition. With the appreciation that SSE models can have high Type I error rates, we next subjected the data to a hidden state model which can account for rate differences independent of the trait of interest. The hidden state SSEF model corroborates the standard multistate SSEF results and likewise recovers support of elevated speciation rates in lineages of marine crocodylomorphs.
Grant Information
National Science Foundation DEB 1754596

Podium Symposium (Friday, October 19, 2018, 10:45 AM)

WHERE DOES FOOTPRINT MORPHOLOGY COME FROM? INTEGRATING 3D METHODS FOR EXPLORING DINOSAUR TRACK FORMATION

TURNER, Morgan L., Brown University, Providence, RI, United States of America; FALKINGHAM, Peter L., Liverpool John Moores University, Liverpool, United Kingdom; GATESY, Stephen M., Brown Univ, Providence, RI, United States of America
Fossil tracks are purely sedimentary structures that preserve a compliant substrate's flow around a moving foot. During the period of foot interaction, both the original surface and deeper layers are deformed. Fossil slabs can be exposed at bedding planes throughout this track volume. Variation in pedal anatomy, kinematics, and substrate properties are all known to influence track formation, but how do the features that make up footprint morphology arise? For extinct theropod dinosaurs, experiments with living birds offer valuable reference, yet substrate and foot opacity hinders direct observation of subsurface foot movement and sediment flow. Here we present the 3D digital methods we use to simulate, visualize, and quantify key elements of the track formation process.
Using X-ray Reconstruction of Moving Morphology (XROMM), we imaged and animated 3D foot motion of guineafowl (*Numida meleagris*) walking through multiple deformable substrates. Combining skeletal kinematics with photogrammetric trackway geometry provides some context, but these footprint models are static and superficial. To visualize the dynamics of 3D subsurface flow, foot motion data serve as inputs for Discrete Element Method (DEM) substrate simulations made up of millions of particles. Splitting the substrate volume along "virtual bedding planes" exposes tracks as they emerge at any depth, elucidating how localized deformations associated with foot entry and exit generate specific features.
Fossil tracks are often exposed on only one deformed plane. Computed Tomography (CT) can reveal internal bedding surfaces, allowing features to be traced throughout the volume of rock by segmentation. Guided by trajectories reconstructed from an Early Jurassic track from the Connecticut Valley and by guineafowl kinematic patterns, we animated an articulated theropod foot model undergoing a hypothetical step. DEM simulations of track formation are compared to the original fossil tracks, providing feedback for modifying the substrate parameters and foot motion. To explore the dense volume of 3D data generated from these methods, we turned to an immersive virtual reality (VR) room, Brown's Yurt Ultimate Reality Theater (YURT). Our custom application creates interactive visualizations that allow us to synthesize substrate flow at the particle, particle cluster, surface, and volumetric scale. Integration of XROMM, photogrammetry, DEM, CT, and VR has provided a dynamic perspective on the 3D formation of dinosaur track morphology.
Grant Information
National Science Foundation grants EAR-1452119 (SMG and PLF) and IOS-0925077 (SMG); ARCHER Leadership award (PLF); Salomon Faculty Research Award, Brown University (SMG)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

NEW SPECIMENS AND RE-DIAGNOSIS OF THE ARCTIC CENTROSAURINE DINOSAUR *PACHYRHINOSAURUS PEROTORUM*

TYKOSKI, Ronald S., Perot Museum of Nature and Science, Dallas, TX, United States of America; FIORILLO, Anthony R., Perot Museum of Nature and Science, Dallas, TX,

United States of America; CIBA, Kentaro, Okayama University of Science, Okayama, Japan
Fossils of the pachyrostran centrosaurine *Pachyrhinosaurus perotorum* come from a small number of exposures of the Prince Creek Formation along the Colville River of the North Slope of Alaska at approximately 70 degrees north latitude, making *P. perotorum* the only Arctic ceratopsid dinosaur currently known. Age estimates of these sections of the Prince Creek Formation are mid-Maastrichtian (70 Ma–68.5 Ma), establishing the taxon as the geologically youngest centrosaurine ceratopsid known to date. Two other species of *Pachyrhinosaurus*, *P. canadensis* and *P. lakustai*, come from older, more southerly strata of Alberta, Canada. Ongoing preparation of material from the type locality (the Kikak-Tegoseak Quarry) has uncovered more cranial material from multiple individuals, including partial skulls and parietal pieces. We provide a new diagnosis of *P. perotorum* based on information revealed by these specimens and re-evaluation of the holotype. *Pachyrhinosaurus perotorum* remains distinguishable from the other *Pachyrhinosaurus* species based on craniofacial features. A cladistic phylogenetic analysis incorporating new data from this and other recent studies of centrosaurine relationships recovers a monophyletic *Pachyrhinosaurus* clade (*P. lakustai*, *P. canadensis*, and *P. perotorum*) as have most other recent analyses. Unlike most previous studies, the new analysis finds *Pachyrhinosaurus perotorum* in a weakly-supported sister-taxon relationship with *P. canadensis*. Characters uniting the two species to the exclusion of *P. lakustai* include the presence of an extra ossification on the lateral surface of the rostrum between the narial fossa and nasal boss, and enlarged supraorbital bosses that contact or nearly contact the posterior end of the nasal boss. Parietal and squamosal frill processes and ornamentations are useful in recognizing and diagnosing ceratopsid taxa, but alone do not adequately address the variables in craniofacial morphology needed to distinguish between species of *Pachyrhinosaurus*.
Grant Information
National Science Foundation Office of Polar Programs (OPP 0424594)

Podium Symposium (Wednesday, October 17, 2018, 8:00 AM)

THE ECOSYSTEM OF FOSSIL VERTEBRATE DATABASES: MUTUALISM OR COMPETITION?
UHEN, Mark D., George Mason University, Fairfax, VA, United States of America
Paleontologists make use of two classes of database: collections management databases and research databases. Collections management databases track specimens in museums while research databases have been crafted to answer particular sorts of questions about the fossil record. Both are extremely useful to our field, and can work together for mutual benefit. For instance, the Paleobiology Database (PBDB) has a rich system for managing taxonomic names and opinions. PBDB now works with the iDigBio database, which integrates data about biological entities from many collections management databases (both fossil and recent). The new ePANDDA API can query both systems and can provide data back to individual users and to the museums that are contributors to iDigBio. In this way, these collections management databases can update their taxonomies to those in the PBDB as well as update data on time, stratigraphy, and geographic location of fossil specimens.
There is no one research database to cover all of time, taxa, and space, nor should there be. Different fossils from different ages lend themselves to different, but related and overlapping data structures. Research databases can work together when they have related data. A good example of this is the Earth Life Consortium, an API that queries both PBDB and the Neotoma Paleoecology Database (Neotoma). These databases each have vast quantities of data on fossil organisms, but PBDB spans all of geologic time, while Neotoma focuses on much more recent time, and has that time represented at a finer scale. Thus, while there is some overlap in the data holdings of these two, they are much more complementary than they are overlapping. If one's research questions deal with the time covered by both, a single query can return data from both, matching a single set of query parameters.
Neotoma is already a federation of many databases, including: North American Pollen Database, FAUNMAP, and others. PBDB has subsumed other databases as well including the Evolution of Terrestrial Ecosystems (ETE), and the North American Mammalian Paleofaunal Database. But, additional databases need not become part of an existing database to share resources. The ELC API has been specifically designed to have additional databases added to the system, so that they can be queried along with PBDB and Neotoma simultaneously.
So, the answer to the question of mutualism or competition is clearly mutualism. This allows databases to leverage their particular strengths, and to share resources with each other to maximize data availability and data discovery.
Grant Information
Funding for these projects have come from NSF grants ICER 1540929 and ICER 1540997.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

UTILIZING THE PALEOBIOLOGY DATABASE TO PROVIDE HANDS-ON RESEARCH OPPORTUNITIES FOR UNDERGRADUATES
UHEN, Mark D., George Mason University, Fairfax, VA, United States of America; GEORGE, Christian O., High Point University, High Point, NC, United States of America; BENTLEY, Callan, Northern Virginia Community College, Annandale, VA, United States of America; BERQUIST, Peter, Thomas Nelson Community College, Hampton, VA, United States of America; LOCKWOOD, Rowan, The College of William and Mary, Williamsburg, VA, United States of America; LUKES, Laura A., George Mason University, Fairfax, VA, United States of America; RYKER, Katherine, University of South Carolina, Columbia, SC, United States of America
Numerous studies indicate that student participation in undergraduate research experiences can result in increased recruitment and retention of science majors. Many undergraduate students' only exposure to science comes through an introductory science class where research experience is limited or absent. One barrier to research in those classes is access to materials; another is having effective lessons that convey the scientific method. Most two and four-year colleges do not have extensive fossil collections of their own, yet all have access to the Internet and to "big data" science initiatives, such as the Paleobiology Database (PBDB). Here we report on the results of a multi-year NSF grant to: create several student activities using the PBDB; to investigate how students' attitudes towards scientific research change after engaging in inquiry experiences using the PBDB; and to create a system for others to develop student activities using the PBDB and to share them with the community.
The activities that we have developed are modular so that they can be utilized as in class assignments, laboratory exercise, field investigations, or as homework, and feature essential skills for scientifically literate citizens, including critical thinking and data analysis. All of these activities are hosted on the SERC website, and are also accessible via the PBDB website. Additional activities have been and are currently being developed that can be hosted at SERC, or on other sites that link to the PBDB website as well. They cover a range of topics from local fossils, to paleobiogeography, to paleoenvironments and more.
The new PBDB resource submission system now allows resources of any kind for undergraduate education, research tools, tutorial videos, etc. to be uploaded to the PBDB site for easy distribution to the paleobiology community. All of these resources are available to the entire community without becoming a member of thePBDB.
Finally, the results of our study indicate that students feel that they can learn about fossils, and the history of life on earth using the PBDB. They also feel that they can perform this research on their own or with minimal instructor guidance. These activities and the PBDB itself can be an additional resource for instructors teaching the history of life on earth at all manner of post-secondary educational institution.
Grant Information
NSF DUE 1504718

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW INSIGHTS INTO THE OSTEOLOGY AND PHYLOGENETIC AFFINITIES OF THE CRETACEOUS–PALEOGENE CHELONIID SEA TURTLE *CATAPLEURA REPANDA*
ULLMANN, Paul V., Rowan University, Glassboro, NJ, United States of America; LACOVARA, Kenneth J., Rowan University, Glassboro, NJ, United States of America
The most frequently encountered large vertebrate remains in Cretaceous–Paleogene greensands along the New Jersey coastal plain are those of sea turtles, especially those of chelonioids. Though turtles in these deposits have been studied for over a century, the anatomy and phylogenetic relationships of multiple taxa remain unclear due to the incomplete nature of many specimens. We describe a new partial skeleton of the cheloniid *Catapleura repanda* recently discovered at Jean and Ric Edelman Fossil Park in Mantua Township, NJ, which is the most complete individual of the taxon recovered to date, and provide the first cladistic evaluation of the phylogenetic affinities of this historically enigmatic taxon. Among the associated and partially articulated remains are a nearly complete carapace, numerous appendicular elements, and a partial skull, lower jaw, and plastron. Previously undescribed elements preserved in the new specimen include the premaxilla, maxilla, vomer, pterygoid, quadrate, surangular, prearticular, articular, ilium, and coracoid, as well as the first complete scapula and humerus. Comparisons to other chelonioid taxa reveal intriguing insights, such as that *Catapleura* shares with *Euclastes gosseleti* absence of a ventral knob on the nuchal for articulation with the eighth cervical vertebra and having the coracoid shorter than the humerus. *Catapleura* also shares absence of a posterior pygal notch with *Mexichelys*, *Eochelone*, and *Puppigerus*. Our phylogenetic analyses found weak support for *Catapleura* as a sister taxon of *Euclastes gosseleti* and agreed with assumptions by previous authors in identifying *Catapleura* as a stem pancheloniid more advanced than lophochelyines.
Grant Information
This research was funded by Drexel University and Rowan University.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

U-PB DATING OF VERTEBRATE-FOSSIL BEARING SEDIMENT FROM THE UPPER CRETACEOUS TAMAGAWA FORMATION IN KUJI, IWATE PREFECTURE, JAPAN
UNO, Hikaru, Waseda University, Tokyo, Japan; MITSUZUKA, Shunsuke, Nippon Koei Co, Ltd., Tokyo, Japan; HORIE, Kenji, National Institute of Polar Research (NIPR), Japan, Tokyo, Japan; TSUTSUMI, Yukiyasu, National Museum of Nature and Science, Ibaraki, Japan; HIRAYAMA, Ren, Waseda Univ, Tokyo, Japan
The Upper Cretaceous Kuji Group is distributed at the Kuji City of Iwate Prefecture, Japan, which comprises of three formations, Tamagawa, Kunitan, and Sawayama formations in ascending order. The outcrop of the upper portion of Tamagawa Formation occurs around the Kuji Amber Museum, where plenty of vertebrate fossils, such as turtles, crocodiles, dinosaurs, and sharks, were found as bone beds of floodplain and tidal deposits. Most of bones are disarticulated but little deformed. It is necessary to determine the depositional age for paleontological discussion.
Uranium-lead (U-Pb) dating is one of most common dating methods applicable to geological materials. The method is utilizing abundance of Pb isotopes produced by U decay. ^{238}U and ^{235}U undergo radioactive decay to ^{206}Pb and ^{207}Pb, respectively. Zircon ($ZrSiO_4$) is most frequently used for U-Pb dating due to its advantages: (1) Zircon is resistant to physical and chemical alteration; and (2) During formation of the zircon crystal, it relatively aggregates U but does not include Pb as primary components.
An ash-fall tuff is interbedded in the bone bed as lenticular sediment, which does not include exogenous matters, such as eroded sand and carbonaceous fragments. The tuff is mainly made of an autochthonous ash-fall without contamination by long-distance transport. The dating of zircon in the lenticular tuff is expected to approximately express the age of bone bed.
We analyzed the ratios of 206Pb/238U and Pb isotopes in the zircon grains in the tuff sample using SHRIMP IIe installed at NIPR. The dating based on the ratio, 45 of 107 data fell within a single youngest cluster which represented eruption (≈deposition) age, indicated 90.51 ± 0.54 Ma (95 % conf.; MSWD = 0.91). Thus, bone bed was deposited at approximately this age.
Palynological studies have concluded that the depositional age of the bone bed was the interval between the Coniacian and the lower Campanian (ca. 86.3–ca. 80 Ma) since low-diversity triprojectate pollen was found from the upper Tamagawa Formation corresponding to the bone bed. Low-diversity triprojectate pollen is an index expressing the interval between Santonian and Coniacian. This palynological dating disagrees with our result.

However, some studies pointed to the possibility that triprojectate pollen first appeared in Asia during older period than previously thought, and subsequently spread across the North Hemisphere. The U-Pb radioactive dating in this study is based on the tuff interbedded into the bone bed and would provide more closely real age of bone bed than previously discussed.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

AN INTEGRATED MODEL FOR REPRODUCTION AND GROWTH IN PTEROSAURS

UNWIN, David M., University of Leicester, Leicester, United Kingdom; DEEMING, Charles, University of Lincoln, Lincoln, United Kingdom

Recent finds of eggs, embryos, and neonates, together with a growing body of data on bone histology, have fostered numerous contradictory ideas regarding the reproductive biology and growth rates of pterosaurs. We combined current knowledge of reproduction and growth in extant sauropsids with a detailed re-assessment of all relevant fossil evidence to generate an integrated model that spans the pre- and postnatal development of pterosaurs. This approach included reanalysis of important finds such as multiple embryos of the Early Cretaceous ornithocheirid *Hamipterus*, which we interpret as representing both mid-term and near-term stages of development.

Female pterosaurs had paired oviducts and laid relatively small, oval eggs. Pterosaur eggshells were pliable and occasionally bounded externally by a thin calcitic layer. Contact incubation seems impractical and eggs were likely buried and developed at ambient temperatures. Ossification of principal load-bearing elements of the locomotor apparatus had begun by mid-term. Near term embryos were well ossified and hatchlings had postcranial proportions and well developed flight membranes that indicate a superprecocial flight ability. The possibility of pterosaur parental care cannot be excluded, but there is no evidence to show that it occurred.

The presence of 'lags' in histological sections from several species, including near complete growth series for *Rhamphorhynchus* and *Pterodaustro*, provide the first quantitative evidence for pterosaur growth rates. These findings reinforce the idea that growth was relatively slow, e.g., ~1g per day for individuals of 2–2.5 kg, and cyclical, with individuals taking several years to reach osteological maturity, likely due, in part, to the allocation of resources to maintenance, locomotion and feeding as well as growth. The growth rates recovered for pterosaurs are comparable to those reported for extant reptiles and a magnitude lower than in extant birds, where sustained rapid growth allows individuals to reach adult size in months, or even weeks, rather than years.

That the proposed growth rates and reproductive mode for pterosaurs are consistent with one another is supported by theoretical models and confirmed by studies of extant sauropsids. The same general mode and rates, typical for extant reptiles and likely plesiomorphic for sauropsids, was probably universal for pterosaurs in that at least some evidence consistent with the model is present in all principal clades.

Technical Session III (Wednesday, October 17, 2018, 3:45 PM)

HOW GOOD IS THE FOSSIL RECORD OF PINNIPEDS? A HISTORIOGRAPHIC EVALUATION OF ITS BIASES AND MODES

VALENZUELA-TORO, Ana M., University of California Santa Cruz, Santa Cruz, CA, United States of America; PYENSON, Nicholas D., National Museum of Natural History Smithsonian Institution, Washington DC, DC, United States of America; KOCH, Paul L., University of California Santa Cruz, Santa Cruz, CA, United States of America

Pinnipeds (seals, fur seals, sea lions, and walruses) have a rich fossil record that extends at least from the late Oligocene to the present. This record shows that pinnipeds had times of higher species richness than today. However, it is unclear if our reading of pinniped evolution is biased by factors associated with taphonomy, geology, research effort, and even the taxonomic practices of researchers. In this study, we examined the historiography of the published fossil record of pinnipeds (primarily using the Paleobiology Database) with the principal aim to identify the major trends, modes, and potential biases affecting our interpretations of the evolutionary history of this group. Our compilation resulted in 1444 documented occurrences of fossil pinnipeds, of which almost 90% are from the Northern Hemisphere, with occurrences along the Eastern North Pacific and the Western North Atlantic Ocean basins as the most productive regions. Surprisingly, ~63% of the fossil occurrences recognized at the species level are referred to taxa also present nowadays (of which 99% comes from the Pleistocene and Holocene). We counted 101 extinct species, of which 50% only have a single occurrence. Phocidae (seals) constitute the most taxonomically diverse family with 46 extinct species, followed by Odobenidae (walruses) and Otariidae (fur seals and sea lions) with 20 and 10 extinct species, respectively. Other extinct groups (e.g., Desmatophocidae) represent minor proportions. Furthermore, we detected that ~23% of the extinct species of pinnipeds have type specimens represented solely by isolated postcranial elements, with humeri and femora as the most frequent elements. Overall, our work provides the first assessment of the principal geographic and taxonomic trends in the study of the pinniped fossil record, and also highlights the necessity of addressing intra- and interspecific osteological variation in fossil and living species to verify the diagnostic value of postcranial elements. Lastly, our results concur, in part, with analogous studies of the fossil record of cetaceans and other taxa, stressing the relevance of historiographic evaluations when investigating evolutionary patterns.

Grant Information
AVT was funded by CONICYT-PCHA/Doctorado en el Extranjero/2016-72170286 and a Smithsonian Institution Graduate Fellowship.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

AFRICAN LAND MAMMAL AGES

VAN COUVERING, John A., American Museum of Natural History, New York, NY, United States of America; HARRIS, Judith A., University of Colorado Museum, Boulder, CO, United States of America; DELSON, Eric, American Museum of Natural History, Bronx, NY, United States of America

We present the first land mammal age (LMA) biochronology for the Cenozoic of the Afro-Arabian continent, the second largest land mass of the planet, with a mammal record that is more complete than that of other major Gondwanan elements, including South America, Indopakistan, and Australia. Even though Cenozoic deposits are largely absent on the stable surface of the great plateau that makes up most of the continent, more than 760 genera have been identified so far from more than 400 localities that formed in coastal margins, karst caves, and the Neogene rift valleys, supporting the definition of 16 LMAs from Paleocene to Recent. The chronostratigraphic model for African LMAs differs from others, however, in that the boundaries are defined by key localities, rather than the range limits of key taxa, in recognition of the uncertainty of taxonomic ranges while active exploration continues, and the availability of an unusually well-developed chronology of dated localities—both resulting in large part from the worldwide interest and investment in the story of human evolution contained in the African fossil record.

Disparities are notable: although Africa is the highest of all continents, nearly every Paleogene locality was formed at sea level, and its vast rainforest ecosystem remains virtually unsampled. The Paleogene fauna is relatively isolated and endemic, whereas the Neogene begins with a suddenly open Laurasian exchange due to the Tauride collision, with a simultaneous (and probably related) opening of the East African rift valleys wherein well-dated samples of the newly revolutionized fauna are abundantly preserved. The focus of LMAs on genera rather than species clarifies the continent-wide response to increased seasonality during the Neogene, and in particular, the outstandingly rapid turnover of the hominin lineage in the open-country ecosystems.

Grant Information
National Geographic Society, Leakey Foundation, Wenner-Gren Foundation, National Science Foundation, Smithsonian Institution, U. of Colorado, Goldfields Namibia

Technical Session II (Wednesday, October 17, 2018, 11:15 AM)

UNDERSTANDING MIDDLE PERMIAN PAREIASAUR DIVERSITY: THE CRANIAL MORPHOLOGY OF *NOCHELESAURUS ALEXANDERI* AND *EMBRITHOSAURUS SCHWARZI*

VAN DEN BRANDT, Marc J., Evolutionary Studies Institute, Johannesburg, South Africa; RUBIDGE, Bruce S., Evolutionary Studies Institute, Johannesburg, South Africa; BENOIT, Julien, Evolutionary Studies Institute, Johannesburg, South Africa; ABDALA, Fernando, Unidad Ejecutora Lillo, Tucumán, Argentina

Pareiasaurs were abundant, large, herbivorous parareptiles of the middle and late Permian with a global distribution. During the middle Permian of South Africa they comprised 25% of the terrestrial tetrapod fauna, making them important stratigraphic markers for biodiversity turnover. The most basal pareiasaurs known are from the middle Permian of South Africa, suggesting a Gondwanan origin for the group. Despite their abundance, the large middle Permian South African taxa are poorly known. Unabated naming of new species, created taxonomic confusion which persisted for more than 100 years until Lee conducted an alpha-taxonomic reorganisation of all pareiasaurs, reducing the middle Permian South African taxa from 11 to four species (*Bradysaurus baini, B. seeleyi, Embrithosaurus schwarzi* and *Nochelesaurus alexanderi*). However, Lee's revision did not include detailed anatomical descriptions of the 262 million year old middle Permian *Tapinocephalus* Assemblage Zone forms from South Africa.

In the first part of a study designed to address the lack of anatomical knowledge of the group, we present the first detailed cranial descriptions of *Embrithosaurus schwarzi* and *Nochelesaurus alexanderi* and updated diagnoses for all South African middle Permian pareiasaurs. We find dentition and cranial ornamentation of the cheek the most useful for identification of the basal species. *Nochelesaurus alexanderi* has mandibular teeth with a unique, very small cusp at base of the mesial margin, and *Embrithosaurus schwarzi* has nine marginal cusps on all maxillary and mandibular teeth, with very wide maxillary teeth. The new diagnostic features were used to re-identify 39 out of 108 cranial specimens to produce updated biostratigraphic occurrence ranges for all taxa, where we find *B. seeleyi* as the first pareiasaur to appear in the middle Permian of the Karoo Basin. Our updated cladistic analysis reaffirms the middle Permian pareiasaurs from the *Tapinocephalus* Assemblage Zone as phylogenetically the basal-most taxa.

Grant Information
(DST-NRF) Centre of Excellence in Palaeosciences (COE-Pal), the Paleontological Scientific Trust (PAST), the National Research Foundation (NRF).

Technical Session V (Thursday, October 18, 2018, 9:15 AM)

TOUGHER TIMES FOR YELLOWSTONE GRAY WOLVES: RATES OF TOOTH WEAR AND FRACTURE INCREASE AS PREY NUMBERS DECLINE

VAN VALKENBURGH, Blaire, University of California Los Angeles, Los Angeles, CA, United States of America

Rates of macroscopic tooth wear and fracture have been used to infer greater bone consumption and heavier carcass utilization in extinct large carnivorans of the Pleistocene relative to their extant counterparts. Furthermore, the pattern of greater tooth wear has been argued to reflect top-down forcing and more intense food competition in Pleistocene than modern predator guilds. However, studies of dental microwear in Pleistocene carnivorans have not supported greater bone consumption. The conflicting results likely reflect differences in temporal scale of the two proxies with microwear reflecting diet of the last few weeks and macrowear/fracture reflecting years of diet. To better understand the relationship between food limitation and tooth wear, I took advantage of a natural experiment, the reintroduction of gray wolves (*Canis lupus*) to Yellowstone National Park (YNP). Approximately 20 gray wolves were brought to YNP in 1995, a time of extreme elk abundance. Over the past 23 years, elk numbers declined, and the ratio of elk to wolves fell from nearly 400:1 to around 115:1. As the availability of their primary prey declined, wolves were expected to consume carcasses more fully and thereby wear their teeth more rapidly. Using a sample of 156 YNP wolf skulls collected between 1996 and 2016 with known age at death, I collected data on dental wear and tooth fracture. The sample was split into those that died before (n = 74) and after (n = 82) January 2007 when the elk to wolf ratio had stabilized around 115:1. Results are striking; within each age category (young, mature, old), the proportion of individuals with moderate to heavy wear was greater in the wolf population after 2007. Moreover, wolves 4 years and older were much more likely to have suffered at least one broken tooth in the 2007–16 sample than the earlier sample. Between 2007 and 2016, 90% of all individuals exhibited at least one broken tooth whereas that same percentage was 41% prior to 2007. Notably, the teeth that showed the greatest increase in fracture rate were the incisors and carnassials. Incisors are often used

to gnaw bones and carnassials are involved in slicing, chewing, and bone crushing. The combination of more rapid rates of tooth wear and a higher incidence of tooth fracture, especially of incisors and cheek teeth, strongly suggests that YNP wolves were consuming more bone on average after 2006, and supports the use of dental wear and fracture as proxies of bone consumption in fossil and extant carnivores.
Grant Information
NSF EAR 1237928

Technical Session XVII (Saturday, October 20, 2018, 2:00 PM)

QUANTITATIVE AND QUALITATIVE ASSESSMENT OF MODERN NESTING SITE TAPHONOMY

VARRICCHIO, David J., Montana State Univ, Bozeman, MT, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America

To better understand fossil nesting assemblages, we taphonomically surveyed nesting sites for a variety of extant amniotes and then quantitatively assessed the relationships between reproductive attributes and the observed skeletal assemblages. Surveyed taxa included two turtles, two crocodylians, and 13 birds, capturing a range of reproductive behaviours. Nesting localities occur on beaches and small islands, adjacent to inland waterways, near wetlands, in grasslands, and in arboreal colonies. Hatchlings range from precocial (turtles, crocodylians, ducks, crane) to semi-precocial (gulls, tern), semi-altricial (great blue heron), and altricial (pelican, cormorant). Parental care of young varies from none (turtles) to assistance at hatching (crocodylians), to more extensive care (most birds) and is largely proportional to post-hatching residence time. Data collection involved mapping, counts, taxonomic identification, and taphonomic assessment of biotic materials (bone, eggs, eggshell, pellets). Shallow excavations were conducted at some localities.

Multivariate multiple regressions were used to assess the relationship of a subset of the observed taphonomic variables (proportion of convex-up eggshell; eggshell density per m^2; bone density per m^2; and proportion of bone assemblage composed of nestling material) to a suite of ecological variables. Preliminary analyses find nesters with precocial young associated with reduced eggshell abundances and low bone density. Eggshell orientation, although variable from nest to nest and across taxa, largely falls between 60:40 to 50:50 concave up versus concave down. Proportions of convex-up eggshell, however, were not predictive of any of the ecological variables. No other ecological variables showed consistent, statistically significant associations with particular taphonomic patterns.

Qualitative observations include: The associated ground assemblage for the arboreal nester (heron) compared closely to those of other birds with similar young. Subsurface assemblages mimicked those at the surface but with lower eggshell content. Embryos within a clutch may die asynchronously, challenging the assessment of asynchronous hatching in fossil assemblages.

Grant Information
This research was supported in part by National Science Foundation grant 0847777 (EAR) to D. Varricchio.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW DATA ON THE EARLY OTARIID *PITHANOTARIA STARRI*

VELEZ-JUARBE, Jorge, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America

The early otariid *Pithanotaria starri* had been regarded, until recently, as the earliest diverging member of that group. Phylogenetic analyses and recent discoveries of earlier otariids in older deposits place *Pithanotaria* as a more derived taxon, sometimes within crown Otariidae. Nevertheless, the morphology and relationships of this taxon are still poorly understood. Here *Pithanotaria starri* is reanalyzed based on new material from the late Miocene Monterey Formation of Orange County, California. The new material consists of two skulls, eight mandibles, and two, partial postcranial skeletons, including forelimb and hind limb elements. Some aspects of the limb bones are more reminiscent of early pinnipeds, such as the morphology of the humerus, while other aspects, such as the simplification of the postcanine dentition is similar to later diverging otariids. *Pithanotaria starri* also displays intraspecific variation in the presence/absence of M2/m2 and sexual dimorphism in the size of the canines. Preliminary results of phylogenetic analyses place *Pithanotaria* within the crown, which combined with the late Tortonian–earliest Messinian (8.5–7.1 Ma) age of the type and referred specimens could be considered as a callibration point for the origins of crown Otariidae.

Technical Session II (Wednesday, October 17, 2018, 9:45 AM)

ONTOGENY AND OSSIFICATION PATTERNS IN THE EARLY PERMIAN CLADE MESOSAURIDAE (SAUROPSIDA, PARAREPTILIA)

VERRIÈRE, Antoine, Museum fur Naturkunde, Berlin, Germany; FRÖBISCH, Jörg, Museum für Naturkunde, Berlin, Germany

Mesosaurs represent a small and extinct clade of Early Permian reptiles, which are notable in that they represent the first fully aquatic amniotes, and are generally considered the basalmost parareptile clade. Although they are very commonly housed in collections worldwide due to the high productivity of their fossil sites in southern Gondwana, many aspects of their anatomy and ontogeny remain poorly understood. Here we analyse a set of measurements taken on a large sample of mesosaur specimens and describe the ossification sequence in *Mesosaurus tenuidens* and *Stereosternum tumidum*, two of the three mesosaurid species currently considered valid.

In the smallest specimen, the skull seems fully ossified, whereas the ossification of the vertebral column is incomplete and shows a zipper-like pattern of fusion of the paired neural arches proceeding from anterior to posterior. This is a general pattern in tetrapods, but it is the first time this feature is being described in a Palaeozoic taxon. Based on several specimens, the limb ossification sequence in mesosaurs follows the pattern common to all amniotes, with stylopodial and zeugopodial elements ossifying first, followed by digit ossification with a postaxial polarity in the order of digit IV-(V or III)-II-I. This supports the idea that this pattern was the ancestral condition for Amniota. Only the youngest juveniles have incompletely ossified diaphyses, whereas in older juveniles or sub-adult individuals they are fully ossified and only the epiphyses, carpals, and tarsals remain partially ossified. In contrast, one of the specimens studied displays an aberrant ossification pattern, with some of the autopodial epiphyses being more ossified than the distal ends of the diaphyses. This suggests the presence of separate ossification centres in the epiphyses, which is rare in non-mammalian tetrapods and might represent a pathology in this individual. Our morphometric analysis highlights no allometric differences between the three species in terms of skull and long bones dimensions. Most parts of the skeleton show isometric growth, although the mid-shaft diameters of the long bones display a slightly negative allometry. This lag in growth rates highlights a slimming of long bones throughout ontogeny. Only the first digit of the pes, as well as the distal width of the fibula, which is quite enlarged in mesosaurs, exhibit positive allometry and therefore an accelerated growth.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

HISTOLOGICAL ANALYSIS OF OVIRAPTORID EGGSHELL FRAGMENTS FROM THE UPPER CRETACEOUS NEMEGT FORMATION OF MONGOLIA WITH ASSOCIATED SKELETAL MATERIAL

VICE, Rebekah M., University of Alberta, Edmonton, AB, Canada; RYAN, Michael P., Cleveland Museum of Natural History, Cleveland, OH, United States of America; CURRIE, Philip J., University of Alberta, Edmonton, AB, Canada; KOPPELHUS, Eva B., University of Alberta, Edmonton, AB, Canada; LEE, Yuong-Nam, Seoul National University, Seoul, Korea, Republic of (South); KHISHIGJAV, Tsogtbaatar, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia

Eggshell fragments from the Upper Cretaceous Nemegt Formation of Mongolia (Ultan Ulla II) were collected and analyzed to determine if they could be referred to a known ootaxon. Oviraptorid skeletal material was collected simultaneously from the same locality, and may represent immature individuals of the species responsible for producing the eggs. Standard histological analysis of one eggshell fragment identified elongate mammillary cones closely packed together and round to sub-round pores characteristic of the oofamily Elongatoolithidae. These structures are similar to those found in previous studies of shell material from eggs that contained oviraptorid embryos; these eggs were also identified as Elongatoolithidae. This type of egg is typical for theropods and has been described in association to oviraptorid skeletal material and embryos. The eggshell fragments are tentatively assigned to the oofamily Elongatoolithidae, which leads to the belief that the eggs were laid by oviraptorids, but further descriptions of the associated skeletal material are necessary to confirm the taxon. If the skeletal material is determined to be from hatchlings and not embryos, it could have important implications for the parental care and development of oviraptorids. Such implications include the length of parental investment to the young after they hatch.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

WHO'S THE BEST? A CROSS-STATE COMPARISON OF FOSSIL VERTEBRATE RICHNESS, TEMPORAL COMPLETENESS, AND BIODIVERSITY IN THE U.S.A.

VIETTI, Laura, University of Wyoming, Laramie, WY, United States of America

As the University of Wyoming Geological Museum and Collections Manager, museum visitors often ask me 'Which state has the best fossil record in the U.S.A.?' To address this vague question, I used data drawn from the Paleobiology Database to calculate a variety of biodiversity and temporal metrics for each state to ascertain which states' fossil vertebrate record may be considered 'the best'. Biodiversity metrics considered in this study include taxon abundance and richness at the class, order, family, and genus level for the entire Phanerozoic and by period. To account for differences in evenness and sampling, I also calculated the Shannon-Wiener index, Simpson index, and rarefaction curves at the genus level for each state by geologic period.

A total of 72,033 fossil vertebrate occurrence records from the U.S.A. were returned. Utah and Nevada have the most temporally complete fossil record (~36% of the geologic Ages represented), and Wyoming is ranked third (26% of the geologic Ages represented). Wyoming has the most abundant fossil vertebrate record in the U.S.A. (24% of total returned records, n = 17,330, trailed by California and Nebraska) and Wyoming also has the richest vertebrate fossil record at the order, family, and genus levels; California and Texas ranked second or third. When taking taxonomic evenness into account, on average, the Shannon-Wiener index and the Simpson index rank Wyoming third behind Texas and Utah. Rarefaction curves regularly rank New Mexico, Utah, and Nevada as having higher biodiversity sampling rates; however, Wyoming's record is better sampled based on curve length. In summary, under the consideration of the inferred collecting and publishing biases inherent with the Paleobiology Database data set, no single state consistently ranked first; however, Wyoming was found to have the most abundant and richest vertebrate fossil record in the U.S.A., and Texas, Utah, New Mexico have either the most temporally complete vertebrate fossil record or the most diverse fossil vertebrate record in the U.S.A., depending on the taxonomic level or time bin.

Technical Session XV (Saturday, October 20, 2018, 9:15 AM)

WHO'S EATING WHOM? THE CONSEQUENCES OF TERMINAL PLEISTOCENE MEGAFAUNAL EXTINCTION ON THE ISOTOPIC NICHE SPACE OF LARGE MAMMALS IN THE EDWARDS PLATEAU, TX

VILLASEÑOR, Amelia, University of New Mexico, Albuquerque, NM, United States of America; ELLIOTT SMITH, Emma A., University of New Mexico, Albuquerque, NM, United States of America; TOMÉ, Catalina P., University of New Mexico, Albuquerque, NM, United States of America; LYONS, S. Kathleen, University of Nebraska, Lincoln, NE, United States of America; NEWSOME, Seth D., University of New Mexico, Albuquerque, NM, United States of America; SMITH, Felisa A., University of New Mexico, Albuquerque, NM, United States of America

Size-selective extinction is a hallmark of human-dominated ecosystems. For example, approximately 14.5–13 thousand years ago—concurrent with the arrival and spread of humans—North America lost the majority of its large-bodied predators and herbivores. More recently, large herbivore and carnivore populations have been extirpated from ecosystems in which they were abundant historically. The loss of these large-bodied

species that perform important ecosystem services by reducing herbivore populations (e.g., lions) or modifying vegetation structure (e.g., elephants), threaten to affect the function of their local ecosystems. Analyses of fossil ecosystems have the power to elucidate the long-term ecological effects of the loss of both large predators and megaherbivores on the rest of the mammal community. We measured bone collagen carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope values from carnivores and herbivores (n = 10 genera) from the Edwards Plateau, Texas before and after the megafaunal extinction. Pre-extinction, there are clear divisions in the $\delta^{13}C$ values between large-bodied C_4 grazers (*Bison* and *Equus*) and smaller-bodied C_3 browsers (*Antilocapra* and *Odocoileus*). Carnivores also demonstrate niche differentiation pre-extinction, where felid hyper-carnivores (*Panthera*) show specialization for C_4 grazers, similar to their counterparts in modern African systems. The ursids (*Arctodus* and *Ursus*) fall into mixed C_3-C_4 to pure C_3 isotopic ranges. The $\delta^{15}N$ ranges of pre-extinction carnivores suggest that *Arctodus* was more omnivorous (average $\delta^{15}N$ = 7.6‰) than *Panthera* (average $\delta^{15}N$ = 12.5‰). The genus *Ursus* remains low in $\delta^{15}N$ space through time (average $\delta^{15}N$ = 4.2‰), despite the extinction of carnivores higher in nitrogen space. Post-extinction, the $\delta^{13}C$ niche space of several surviving browsers and carnivores (*Odocoileus* and *Ursus*) also does not change. However, Pleistocene herbivores show a significant increase in $\delta^{15}N$ values near the Pleistocene–Holocene transition that decreases again in the Holocene (post-extinction). This shift suggests a change in the biogeochemical cycling of the primary producers (e.g., vegetation) during this period of ecological change.

Grant Information
This research is supported by the National Science Foundation Division of Environmental Biology (DEB 1555525).

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

MESOZOIC PARAVIAN AND PTEROSAURIAN PALEOENVIRONMENTAL DISTRIBUTION OF THE (PALEO) NORTHERN HEMISPHERE

VILLEGAS-GARIN, Franco A., George Mason University, Fairfax, VA, United States of America; UHEN, Mark D., George Mason University, Fairfax, VA, United States of America

The Mesozoic Era gave rise to Paraves, a clade included within Theropoda and containing Anchiornithidae, Dromaeosauridae, Troodontidae, Scansoriopterygidae, and Avialae. For this study, Paraves was separated into two functional groups to compare and contrast Avialae with their close relatives. Herein, MPBs (Mesozoic Prehistoric Birds) only refers to Avialae alone, while SBDs (Small Bird-like Dinosaurs) refers to Paraves excluding Avialae (thus, Anchiornithidae, Dromaeosauridae, Troodontidae, Scansoriopterygidae). The evolutionary development of feathered wings and anatomical features capable of powered flight, seen in these groups, provided the foundation for our modern birds. The order Pterosauria acquired similar flight capabilities while evolving through a parallel anatomical approach. Because of their overlapping size and ecology, it is important to consider probable competitive behaviors among these three groups. This study presents a fundamental comparative paleoenvironmental assessment, based on the paleogeographical distribution, temporal range, geologic formation, and lithologic depositional environment for each fossil occurrence, which were completed or entirely added to the Paleobiology Database (PBDB) as part of the process. Statistical results took into consideration a mass threshold for comparative precision, where fossil femur lengths for MPBs and SBDs and wingspans for Pterosauria, were gathered from peer-reviewed publications and converted into estimated masses at the genera rank level. This threshold was established by rounding up the largest mass figure found within Avialae, being *Patagopteryx* at 1.42 kg to 2 kg. The results yielded data showing that the diversification of paleoenvironments increased for MPBs, whereas it decreased for SBDs as they approached the end of the Mesozoic Era. In contrast, Pterosauria diverged towards marine environments. It is increasingly apparent that potential territorial competition could have led to changes in paleoenvironmental diversity and type. This brings up the question of background extinction of certain paravian phylogenetic groups and the evolution of Pterosauria, due to the arrival of Avialae before the mass extinction event marked by the K/Pg boundary.

Grant Information
This study was partially funded by the Undergraduate Research Scholars Program (URSP), George Mason University.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

FOSSIL RECORD OF THE ROCK IGUANA *CYCLURA* (IGUANIDAE) IN CUBA: IMPLICATIONS FOR ITS SYSTEMATICS, PALEOECOLOGY, AND PALEODISTRIBUTION.

VINOLA, Lazaro W., Montana State University, Bozeman, MT, United States of America

The West Indies is one of the areas with the highest biodiversity and high number of endangered species. Endemic to this region is the genus of Rock Iguanas, *Cyclura*. This genus has been studied as a model to understand the dispersion and speciation processes that took place in this group of islands. The discovery of new fossils remains from five Pleistocene–Holocene deposits in western Cuba suggest the presence of a form of *Cyclura* larger than *C. nubila* that coexisted with this species. Morphological comparison with all *Cyclura* species and histologic comparison with *C. nubila* were used to assign the remains to *C. lewisi*. This taxon is the most endangered species *Cyclura* and is only known from Grand Caiman. Interspecific competition, extirpation, and response to human modification of both taxa have further implications for the conservation. Remains of *C. lewisi* in Cuba indicate a wider distribution in the past and places Cuban as a most suitable center origin, instead of Grand Caiman as was supposed. The extirpation of the biggest taxa agree with previous studies on lizards, where the risk of extinction and extirpation is strongly positively correlated with increasing body size and insularity. At the same time recent studies have pointed out the occurrence of *C. lewisi* haplotype in specimens of *C. nubila* from Cuba. This result, along the co-occurrence of fossils of *C. lewisi* and *C. nubila* in three localities, plus the existence of some intermediate specimens on those localities, is interpreted here as possible evidence of ancient hybridization between species.

Podium Symposium (Friday, October 19, 2018, 9:15 AM)

AUTOMATED GEOMETRIC MORPHOMETRIC METHODS AS A COMPONENT OF THE PHENOMIC TOOLKIT: A CASE STUDY USING PALEOGENE PERADECTIDS (MAMMALIA, MARSUPIALIA)

VITEK, Natasha S., University of Florida, Gainesville, FL, United States of America; BOYER, Doug M., Duke University, Durham, NC, United States of America; STRAIT, Suzanne G., Marshall University, Huntington, WV, United States of America; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America

Automated three dimensional geometric morphometric analysis (auto3dgm) is a promising high-throughput tool for studying shape variation across space and time. Here, we use the fossil record of peradectid marsupial molars from before, during, and after the Paleocene–Eocene Thermal Maximum (PETM) in the Bighorn Basin (BHB), Wyoming, to exemplify uses and challenges of auto3dgm. The PETM is marked by a rapid onset negative carbon isotope excursion that lasted ~175 thousand years with an associated shift towards warmer global mean annual temperatures (MAT) by ~5–10°C followed by a post-excursion recovery to cooler MAT. At least 40% of measured mammalian genera recovered from the BHB were smaller during the PETM compared to adjacent time intervals. The question of whether PETM peradectids belong to the same taxon as non-PETM peradectids has been complicated by long-standing difficulties discriminating isolated second and third lower molars (m2, m3) in order to compare homologous tooth positions.

Using 3D digital models, we assembled a dataset of lower molars (N = 65) following previously published protocols for surface creation and alignment. Most (N = 52) were peradectid m2s or m3s. A minority (N = 13) were either of another family or tooth position included to demonstrate the outcome of analyzing misidentified specimens. In a principal component analysis (PCA) those 'mistakes' were not clearly differentiated from correctly identified specimens in PCs 1–2 but occupied the edges of specimen clusters. These results illustrate that while auto3dgm is not immune to the 'garbage in, garbage out' problem, a careful check of which surfaces occupy the margins of distributions can help avoid spurious results in downstream analyses.

After misidentified specimens were removed, the PCA decomposed the dataset into two non-overlapping clusters of PETM vs. non-PETM specimens along PC1. These results support a two-taxon interpretation across this interval. Within each cluster, PC2 partially separated known m2s from known m3s. Heat maps of mean differences between known m2s and m3s highlighted trigonid proportions as important for discrimination. A resulting trigonid length-to-width ratio became a simple tool for identifying isolated molars, including broken and worn specimens, to tooth position. Crown area of the m2 of the PETM peradectid is larger than that of the pre- and post-PETM peradectid that it replaces, in contrast to size patterns documented in other mammals. Overall, auto3dgm forms one part of a broader morphometric toolkit necessary to document faunal change in the PETM.

Grant Information
NSF DGE-1315138 (NSV), EAR-0640076 (JIB, JK, R Secord), EAR-0719941 (JIB), BCS-1440558 (JIB), BCS-1440742 (DMB, GFG), BCS-1552848 (DMB), Lucy Dickinson Fellowship (NSV)

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

BRINGING MICROVERTEBRATES INTO THE MATH CLASSROOM: STEM INTEGRATION USING 3D PRINTED FOSSILS AND OTHER BIOLOGICAL OBJECTS

VITEK, Natasha S., University of Florida, Gainesville, FL, United States of America; BAKER, Christopher A., Marjorie Kinnan Rawlings Elementary School, Gainesville, FL, United States of America; BLOCH, Jonathan I., Florida Museum of Natural History, University of Florida, Gainesville, FL, United States of America

The difficulty of seeing microvertebrate fossils without microscopy presents an outsized challenge in connecting the public to a majority of vertebrate diversity. One approach to bridging this gap is to create 3D digital models of fossils and then 3D print scaled-up versions of the models for people to see and touch. A primary risk in this approach is one of misinformation: people may not realize that the 3D prints are not true to size and may not appreciate the degree to which models were scaled.

This risk presents an opportunity for STEM integration, or the connection between Science, Technology, Engineering, and Math. Scaled 3D prints not only serve as an introduction to an otherwise inaccessible segment of biological diversity, but also an opportunity to reinforce concepts of exponents, logarithms, and comparisons across orders of magnitude. The 3D prints of fossils may be particularly useful in classrooms where the relative paucity of everyday uses for these topics can make it difficult for students to engage.

To take advantage of this opportunity, we designed a two-lesson mathematics curriculum that aims to: (1) engage students' interest in and awareness of the diversity of life that occupies very small body sizes; and (2) improve students' grasp of number systems and comparisons across orders of magnitude through quantitative problem-solving. The curriculum gives students access to fossil and biological specimens, such as micromammalian molars and tardigrades, and a tactile sense of what it means to differ in scale.

To evaluate the effectiveness of the program, we recruited 4^{th}–5^{th} grade members of an after-school math team in a Gainesville elementary school to participate in the curriculum. Both aims were at least partially met in the evaluation. Students expressed interest in the species behind the 3D models, and wanted to know even more about them than what was presented in the lesson. As they calculated the actual size of specimens based on measuring the 3D prints, several expressed surprise at their results. Improvement in mathematical proficiency was measured through pre- and post-tests consisting of word problems comparing objects at different scales. Although students did not attempt to solve significantly more word problems before vs. after the curriculum, the proportion of attempts employing the correct problem-solving approach was significantly higher in the post-test ($p = 0.009$). Overall, the curriculum provides an example of how STEM integration can further open segments of museum collections and biodiversity to the public.

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

PALEONEUROANATOMICAL DIVERSITY WITHIN PSEUDOSUCHIA (ARCHOSAURIA): LOOKING FOR EVOLUTIONARY PATTERNS

VON BACZKO, Maria Belen, CONICET - Museo de La Plata, La Plata, Argentina; DESOJO, Julia Brenda, CONICET-Museo de la Plata, La Plata, Argentina; BONA, Paula, CONICET - Museo de La Plata, La Plata, Argentina

The Triassic records the broad radiation of archosaurs, which gave rise to modern crocodiles and birds. The diversity of the crocodilian lineage, Pseudosuchia, was remarkably higher during the Middle-Late Triassic than nowadays, represented by continental and marine forms, either quadrupedal or bipedal, as well as carnivores and herbivores. The endocranial morphology of pseudosuchians is under study to unveil more information about their sensorial capacities and ecological roles, which exhibit an outstanding variety of forms.

The paracrocodylomorphs *Prestosuchus*, *Shuvosaurus* and possibly *Saurosuchus*, and the aetosaur *Desmatosuchus* have strong cephalic flexures (115-120º), differing from much wider flexures seen in the crocodylomorphs *Gryposuchus*, *Sebecus*, *Simosuchus*, and *Gavialis*, and the phytosaurs *Wannia*, *Ebrachosuchus,* and *Parasuchus* (145-150º). When evaluating the width of the olfactory bulbs against that of the cerebral hemispheres, this ratio is highest in *Prestosuchus* with bulbs being double the width of the hemispheres and contrasting with phytosaurs (*Ebrachosuchus*, *Parasuchus*) and some crocodylomorphs (*Sebecus*, *Alligator*) in which the bulbs were half the width of the hemispheres. An intermediate condition was identified in the suchians *Desmatosuchus*, *Parringtonia* and the shuvosaurid *Shuvosaurus* in which the olfactory bulbs were almost as wide as the hemispheres. This information did not support a direct correlation between the olfactory development and feedings habits as expected. The floccular recess, related to the flocculus which is associated to visual stabilization, is present and well developed in terrestrial suchians (*Gracilisuchus*, *Neoaetosauroides*, *Desmatosuchus*), non-crocodylian paracrocodylomorphs (*Saurosuchus*, *Batrachotomus*, *Postosuchus*, *Arizonasaurus* and possibly *Prestosuchus*), and aquatic phytosaurs (*Wannia*, *Parasuchus*, *Ebrachosuchus*), whereas it is incipient in either terrestrial or aquatic crocodylomorphs (*Simosuchus*, *Alligator*, *Caiman*). The vestibular region of the inner ear is highly variable within pseudosuchians, being almost high as wide in *Neoaetosauroides*, *Saurosuchus* and *Postosuchus*, whereas it is more than two times wider than high in *Parasuchus*, *Parringtonia*, and *Gavialis*.

Several pseudosuchain groups still need to be analysed to better understand the paleobiological implications of the endocranial structures, to recognize morphological patterns, and its evolution from the early radiation of pseudosuchians to their modern representatives, crocodiles.

Grant Information
Funded by PICT 2014-609, PICT 2016-481 and PICT 2016-159

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A DESCRIPTION OF TWO NEW JUVENILE SPECIMENS OF *GORGOSAURUS LIBRATUS* (TYRANNOSAURIDAE, ALBERTOSAURINAE): MORPHOLOGICAL VARIATION ASSOCIATED WITH ONTOGENY

VORIS, Jared T., University of Calgary, Calgary, AB, Canada; ZELENITSKY, Darla K., University of Calgary, Calgary, AB, Canada; THERRIEN, Francois, Royal Tyrrell Museum of Palaeontology, Drumheller, AB, Canada; WITMER, Lawrence M., Ohio University, Athens, OH, United States of America; RIDGELY, Ryan, Ohio University, Athens, OH, United States of America

Albertosaurinae is a clade of tyrannosaurid theropod represented by two species, *Albertosaurus sarcophagus* and *Gorgosaurus libratus*, mostly known from the late Campanian-early Maastrichtian of southern Alberta. Previous studies on the ontogeny of albertosaurines have reported major differences in cranial morphology between juvenile and adult individuals, but have been limited by the incomplete or disarticulated nature of available juvenile material. Recently, two articulated juvenile skeletons of *Gorgosaurus libratus*, both referable to the "small Stage 1" tyrannosaurid ontogenetic stage, were discovered in the upper Campanian Dinosaur Park Formation of Alberta, Canada. With skull lengths of ~500 mm, these are approximately 50% the size of the largest known *Gorgosaurus* and are the smallest articulated albertosaurine specimens recovered from North America. As such, the juvenile specimens provide insight into previously unknown aspects of early ontogeny in North American tyrannosaurids. The new specimens exhibit several cranial features typically observed in juvenile tyrannosaurids, such as a low and elongate skull, weakly developed or absent cranial ornamentation, relatively large orbits, and laterally compressed teeth. In the context of a previously documented *Gorgosaurus* ontogenetic series, cranial elements contributing to the orbital margin (i.e., lacrimal, postorbital, and jugal) are observed to increase significantly in robusticity from stage 1 onwards but do so at different rates, resulting in high morphological variability among similar-sized individuals. Other significant differences are observed in the neurocranium, where juvenile specimens have a dorsoventrally shallow parabasisphenoid, short preotic pendants, and short and uninflated paroccipital processes compared to adults. The inflation of the paroccipital processes through growth is due to an increase in volume of the paratympanic air sinus, which may reflect differences in auditory capabilities between juvenile and adult individuals. Despite significant anatomical differences observed between juvenile and adult *Gorgosaurus*, several synapomorphies of Albertosaurinae are present at all ontogenetic stages (e.g., rostrally emarginated dorsal squamosal suture of postorbital as a concave notch). The ontogenetically invariant nature of these synapomorphies therefore provides a means to differentiate juvenile albertosaurines from morphologically similar sympatric juvenile tyrannosaurines (e.g., *Daspletosaurus*).

Grant Information
Dinosaur Research Institute Student Project Grant to JTV; Soderstrom Scholarship to JTV; Royal Tyrrell Student Research Funding to JTV; NSERC Discovery Grant to DKZ

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

FIRST RECORD OF AN EARLY-DIVERGING CROCODYLOID (REPTILIA, CROCODYLIA) FROM THE PALEOGENE OF NORTHERN VIETNAM AND ITS PHYLOGENETIC RELATIONSHIP WITH *ASIATOSUCHUS*-LIKE CROCODYLOIDS

WAKUI, Meg, University of Tokyo, Tokyo, Japan; PHA, Phan Dong, Institute of Marine Geology and Geophysics, Vietnam Academy of Science and Technology, Hanoi, Vietnam; DOAN DINH, Hung, Vietnam National Museum of Nature, Vietnam Academy of Science and Technology, Hanoi, Vietnam; KOMATSU, Toshifumi, Kumamoto University, Kumamoto, Japan; HIRAYAMA, Ren, Waseda University, Tokyo, Japan; NGUYEN, Minh Trung, Vietnam National Museum of Nature, Vietnam Academy of Science and Technology, Hanoi, Vietnam; TSUIHIJI, Takanobu, University of Tokyo, Tokyo, Japan

The evolution of ecosystems in southeast Asia, especially those during the Paleogene, is still poorly understood despite the area being a biodiversity hotspot today. In the Na Duong Basin in northern Vietnam, one of the Cenozoic pull-apart basins associated with the Red River Fault Zone, the Na Duong Formation consisting of putatively Paleogene lacustrine sediments crops out, producing a rich record of vertebrate, invertebrate, and plant fossils. Although this formation has been known to produce crocodylian remains with multiple cranial morphotypes, no detailed description or systematic assessment of such specimens has been published. We herein report an early-diverging crocodyloid specimen collected from a coal layer of this formation. The specimen consists of a skull including the lower jaw and associated postcranial elements, including numerous vertebrae, ribs and scutes, as well as a partial pelvic girdle, right humerus, and partial left femur, tibia and fibula. The skull is approximately 60 cm in length, whereas the right humerus is approximately 23 cm. The skull is highly compressed dorsoventrally although most parts except for the posterior skull roof are preserved. It shows an overbiting occlusion although an incipient notch between the premaxilla and maxilla appears to be developed. The most prominent, potentially phylogenetically-informative character preserved in the skull is an elongated mandibular symphysis, a feature that has traditionally been considered diagnostic of the genus *Asiatosuchus*, which was erected on the basis of mandibular materials from the Middle Eocene of Mongolia but has become a wastebasket taxon lumping Paleogene crocodylians from Europe, Asia and North America. A phylogenetic analysis based on a previously-published data matrix placed the present specimen in a polytomy consisting of so-called *Asiatosuchus*-like crocodyloids outside of the crown Crocodylidae. Because of such phylogenetic positions of *Asiatosuchus*-like forms, the morphology and systematics of these taxa are crucial for a better understanding of the origin of Crocodylidae, both morphologically and paleobiogeographically. The present specimen represents a rare occurrence of such forms in the Indochina Region, thus filling a gap, both stratigraphically and geographically, in the crocodyloid fossil record.

Colbert Prize (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

JAW DISPARITY IN RELATION TO DIET IN THE BOVIDAE, WITH IMPLICATIONS FOR PALEOECOLOGY

WANG, Bian, University of Michigan, Ann Arbor, MI, United States of America; ZELDITCH, Miriam, University of Michigan, Ann Arbor, MI, United States of America; BADGLEY, Catherine, University of Michigan, Ann Arbor, MI, United States of America

The family Bovidae is the most taxonomically and ecologically diverse group of ungulates in the world today and has been widely studied in ecomorphological research, with important applications to paleoecological reconstructions of Plio-Pleistocene hominid sites in East Africa. Most ecomorphological analyses of bovids to date have focused on the postcranial skeleton, especially limb elements. Studies using the craniodental features of bovids are not only limited in number and application, but also bear a number of limitations that arise from traditional morphological measurements of length, width, and depth. Here, we investigate the relationship between mandibular morphology and dietary category in bovids by quantifying mandibular shape with landmark-based geometric morphometrics. We took photographs of mandibles in labial view from 109 of the 142 extant bovid species, covering all tribes within the family, with an average of four specimens per species. Only mandible specimens of adult individuals from their natural home ranges were included. Ten landmarks were chosen to capture the overall morphology of the mandible, and semi-landmarks were used to document the curvature between landmarks. Species were divided into three ruminant feeding categories widely used in literature—the concentrate selectors (the 'browsers' and fruit-eaters), the grass and roughage eaters (the 'grazers'), and the intermediate (mixed) feeders. Each category was further divided into subcategories based on detailed forage selectivity and preference. Consistent with previous studies, our analyses show significant differences between the jaw morphology of different feeding categories, especially in the depth of mandibular body and the shape of the angular process. We established a dietary model using the quantitative relationship between mandibular shape and diet of the bovids. Dietary extremes (i.e., obligate grazers vs. browsers) are distinct in the range of their morphospace, whereas intermediate feeding categories have overlapping morphospace with other categories. Our morphospace model provides a new tool for paleoecological inference for fossil ungulates, which constitute a widely distributed and diverse component of the Cenozoic fossil record of North America.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

AN INTEGRATIVE LOOK AT VERTEBRATE ORIGINS

WANG, Qinchuan, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; HERNANDEZ-OCHOA, Erick, University of Maryland School of Medicine, Baltimore, MD, United States of America; VISWANATHAN, Meera, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; LUCZAK, Elizabeth, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; WU, Yuejin, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; GRANGER, Jonathan, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; YANG, Jinying, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; LOVERING, Richard, University of Maryland School of Medicine, Baltimore, MD, United States of America; CAMMARATO, Anthony, Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; SCHNEIDER, Martin, University of Maryland School of Medicine, Baltimore, MD, United States of America;

BEVER, Gabriel S., Johns Hopkins University School of Medicine, Baltimore, MD, United States of America; ANDERSON, Mark E., Johns Hopkins University School of Medicine, Baltimore, MD, United States of America

Origins are particularly difficult problems for evolutionary biologists. Comparative analyses of extant organisms are powerful at identifying the stem lineage along which a particular feature of the modern biota finds its origin. But because that origin will always lie outside the most inclusive crown clade exhibiting the feature, such comparisons are inherently weak at providing the details and context of the origin itself. Fossils can mitigate this weakness by narrowing the inferential bracket around the origin event, and experimental biology is becoming increasingly adept at engineering meaningful outgroups and ancestral conditions in the laboratory. We explore the integration of these approaches for our understanding of vertebrate origins; in particular the emergence along the vertebrate stem lineage of a metabolically active, predatory existence from the sessile, filter-feeding ecology of our deuterostome ancestors. We identify oxidative-mediated activity of the Calcium/Calmodulin-Dependent Protein Kinase II (CaMKII) as a key innovation of vertebrates that helped facilitate the functional potential of such iconic vertebrate apomorphies as an internal skeleton, sympathetic nervous system, increasingly efficient respiratory and circulatory systems, prechordal head, and placode-derived organs of special sensation. Using mutant taxonomic strains that lie phylogenetically inside and outside crown-clade Vertebrata, we provide support that the acquisition of this oxidative-mediated kinase activity ushered in a number of novel modalities for stem vertebrates that included heightened performance of skeletal muscle. The cruel irony of these results is that the same oxidative regulatory pathway that likely played a key role in our early success as vertebrates is also identified in a number of human disease processes, including heart disease, pulmonary disease, and cancer. We discuss these findings in the context of global oxidative conditions during the late Ediacaran and Cambrian and the fossil record of stem vertebrates.

Grant Information
NIH R35 HL140034

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

REINTERPRETATION OF JAW BONE STRUCTURES OF CAENAGNATHID OVIRAPTOROSAURS

WANG, Shuo, University of Southern California, Los Angeles, CA, United States of America; ZHANG, Qiyue, Capital Normal University, Beijing, China; YANG, Rui, Capital Normal University, Beijing, China

Among the characters of caenagnathid oviraptorosaurians, the lateral occlusal grooves and ridges on the occlusal surface of the jaw bones often receive special attention, and these structures were mis-interpreted as bony sturctures that supported the rhamphotheca. Recent studies demonstrated that the tooth reduction present in caenagnathid oviraptorosaurs were achieved through the same sort of ontogenetic truncation of odontogenesis as has been previously reported in *Limusaurus inextricabilis* and many other extinct and extant vertebrates, and therefore the lateral occlusal grooves and ridges are vestigial alveoli and interdental septa, respectively. Here, the dentary structures of caenagnathids were reevaluated based on CT images of *Caenagnathiasia* sp. IVPP V20377. Several previously unknown features including crateriform vestigial alveoli, the morphology of the dentary's interior hollow space, and the paired blind tubes beneath the dentary symphyseal shelf are recognized. Current lines of evidence suggest different jaw bone morphologies are likely produced by various tooth reduction patterns, which indicates ontogenetic dietary shift, if once present in caenagnathids and *Sapeornis*, may have been different from the condition seen in *Limusaurus*. The 3D images of dentary interior spaces suggest that while tooth reduction progresses, the empty alveoli are partially modifed into structures accommodating blood vessels that nourish the rhamphotheca, probably representing a functional compensation for the insufficient blood supply in toothed jaw bones.

Grant Information
National Natural Science Foundation of China (41602013) and Project of High-level Teachers in Beijing Municipal Universities (IDHT20180518)

Technical Session IX (Friday, October 19, 2018, 10:45 AM)

THE PROOF IS IN THE POOPING: FIRST COPROLITES FROM BONE-CRACKING DOGS PROVIDE NEW INSIGHT INTO BONE CONSUMPTION IN *BOROPHAGUS* AND THEIR UNIQUE ECOLOGICAL NICHE

WANG, Xiaoming, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; WHITE, Stuart C., University of California at Los Angeles, Los Angeles, CA, United States of America; BALISI, Mairin, University of California Los Angeles, Los Angeles, CA, United States of America; BIEWER, Jacob, California State University, Fullerton, Fullerton, CA, United States of America; SANKEY, Julia, California State University, Stanislaus, Turlock, CA, United States of America; GARBER, Dennis, Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; TSENG, Z. Jack, State University of New York at Buffalo, Buffalo, NY, United States of America

Borophagus (Carnivora, Canidae), first described by E. D. Cope more than 100 years ago, is an extinct top predator in the late Cenozoic of North America with some of the most robust teeth and jaws known among canids. Since the discovery of its first fossils, it has been known as the 'hyaenoid' dog of the New World due to its massive bone-crushing cheek teeth, much like those in contemporary hyenas in Africa and Asia. Direct fossil evidence of hyena-like bone consumption, however, is hitherto unknown. We report rare coprolites (fossilized feces) of *Borophagus parvus* from the late Miocene Mehrten Formation of northern California, and for the first time describe unambiguous evidence that large amounts of bone were ingested by these predatory canids. Surface morphology, micro-CT analyses, and contextual information in depositional environment and cranial and dental adaptations reveal that these bone-crushing canids 1) deposited their droppings in concentrations, consistent with scent-marking behavior (latrines) used by living social carnivorans; 2) consumed skeletons, based on the large number of bones found inside the coprolites; 3) lacked a highly acidic digestive tract like that found in modern spotted hyenas, i.e., borophagines retained a conservative digestive system that was unable to completely decimate bones in the manner spotted hyenas do, based on the undissolved (intact) bones inside the coprolites; 4) reached the size of obligatory large-prey hunters with a body weight estimated to be ~24 kg, using teeth and limb bones as proxies; and 5) hunted prey around 35 to more than 100 kg, but also opportunistically fed on smaller prey, such as birds and beavers, based on the size of a large rib fragment that was preserved in a coprolite. *Borophagus*, like all living canids that hunt prey larger than itself, potentially hunted in collaborative social groups. The distinctive morphological traits associated with the bone-cracking ecomorphology (robust and bulbous premolars, deepened zygomatic arches, arched frontal region, and expanded frontal sinus) are either poorly developed or absent in extant carnivorans (coyotes, foxes, cougars) found today in the geographic regions previously occupied by *Borophagus*. Combined with the potentially significant role of megafaunal decomposers, such as extant spotted hyenas, in accelerating nutrient cycling pathways and bypassing invertebrate and microbe decomposers in the detrital food web, the extinction of *Borophagus* may have had a much more significant impact on food web dynamics than previously recognized.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A NEW SPECIES OF THE LAMNIFORM SHARK *PAROTODUS* FROM THE OLIGOCENE OF JAPAN

WARD, David J., Orpington, United Kingdom; BERNARD, Emma, Natural History Museum, London, United Kingdom

The genus *Parotodus* is a lamniform shark ranging from the Eocene to the Pliocene. Its teeth are rare and are usually found in mid to outer shelf deposits. In Japan it occurs in rocks of early Oligocene to late Pliocene age.

Three fossil shark teeth were collected from the Yukiaino Sandstone Member, Karatsu Formation in Saga Prefecture, south-western Japan. They were referred to the genus *Parotodus* because they could be distinguished from other lamniform sharks by the following combination of characters: absence of serrated cutting edges; presence of broad neck; U-shaped basal edge of the root and development of the lingual protuberance of the root.

These teeth were originally identified as *Parotodus benedenii*, a Neogene species, based on their size and shape. However, two of the specimens possess a small pair of lateral cusplets similar to those on the middle Eocene species *P. mangyshlakensis*. Given that there is an observed increase in size and progressive loss of lateral cusplets is a trend in *Parotodus*, we hypothesize that our Japanese specimens are a new species intermediate in morphology between *P. mangyshlakensis* and *P. benedenii.* These have been described as a new species, currently in press, and to which some early Oligocene specimens described from Belgium have been referred.

The recorded occurrences of *Parotodus* teeth in the fossil record match closely those of the *Otodus* lineage (formerly *Carcharocles*). Teeth of *Parotodus* rarely show the compression fracture damage to the crown tip commonly seen in other large lamniform sharks, suggesting that their preferred diet lacked solid bone. This leads on to speculate that *Parotodus* predated large sharks including the giant megatooth shark *Otodusmegalodon.*

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

NEW GEOCHEMICAL DATA SUPPORTS EPISODES OF HYPEREUTROPHY TO EXPLAIN THE TAPHONOMIC SIGNAL OF THE CLEVELAND-LLOYD DINOSAUR QUARRY, UPPER JURASSIC MORRISON FORMATION

WARNOCK, Jonathan, Indiana University of Pennsylvania, Indiana, PA, United States of America; PETRICKO, Justin, Indiana University of Pennsylvania, Indiana, PA, United States of America; PETERSON, Joseph E., University of Wisconsin Oshkosh, Oshkosh, WI, United States of America

The Cleveland-Lloyd Dinosaur Quarry (CLDQ), Upper Jurassic Morrison Formation, is the densest concentration of predatory dinosaur bone known. CLDQ is unusual in that it has a high predator to prey ratio (3:1) and is dominated by *Allosaurus fragilis*. Furthermore, the taphonomy of CLDQ is complex. The quarry represents an ephemeral pond, but contains no typical pond fauna. Calcite/barite nodules have been found surrounding some bones, and pyrite has been identified within some bones. Despite the large number of individuals represented, scavenging traces are extremely rare. Photogrammetric data suggest multiple events of post-mortem transport and dispersal processes led to the emplacement of the bones. Intramatrix bone fragment analyses suggest that the deposit represents a mix of small bone chips formed during dry periods that intermixed with fresh carcasses during flood events. Trace metal data, in addition to calcite/barite nodules and pyrite, suggest periods of hypereutrophy during *Allosaurus* deposition, explaining the lack of scavenging and pond fauna.

Here we present new geochemical data from CLDQ. Bone and sediment samples were collected from CLDQ for x-ray fluorescence. Sediment samples were collected at the bone/sediment contact, as well as in transects moving away from the bones, allowing for the analysis of elemental concentrations relative to distance from the bone. Two patterns of elemental concentrations were found. Some elements, e.g., Fe and Mg, were found to be at low concentrations in the bone but higher concentrations in the surrounding sediments. This signature is interpreted as diagenetic. A second set of elements, e.g., Pb and Cr, was seen to be most enriched in the bone, declining in concentration with increased distance. These elements are hypothesized as having accumulated via bioaccumulation. *Allosaurus* is an upper level predator of the Late Jurassic and as such would likely have accumulated metals within its tissues through life. As a large number of *Allosaurus* carcasses decomposed in the CLDQ pond, some of these metals would have been released. However, since the carcasses are the hypothesized source of the metals, the concentrations remain greatest in the bone. If all metals detected within the bone were diagenetically emplaced, a single pattern of elemental concentrations would be expected. This data supports the hypothesis that during periods of *Allosaurus* deposition, decay of large quantities of organic matter would have led to hypereutrophy of the CLDQ pond, thereby inhibiting pond life and scavenging of the remains.

Romer Prize Session (Thursday, October 18, 2018, 11:15 AM)

GROWTH RATES AND AGE DISTRIBUTION OF DIFFERENT JURASSIC SAUROPOD TAXA: IMPLICATIONS FOR LIFE HISTORY TRAITS AND ECOLOGY BASED ON DORSAL RIB HISTOLOGY

WASKOW, Katja, University of Bonn, Bonn, Germany

Sauropod dinosaurs are not only the largest terrestrial vertebrates that ever lived, they also had the largest size difference between hatchlings and adults among amniotes. Therefore, their life history traits and growth rates are of special interest to evolutionary ecologists. Skeletochronology, using histological growth marks in long bones like humeri and femora, is frequently used to construct growth curves in dinosaurs and other tetrapods, plotting age vs. bone size. However, this approach is difficult in sauropods because formation rates of primary and secondary bone tissue in the long bones are too high to produce and preserve lines of arrested growth (LAGs) in all but the outermost cortex. Previous studies have shown in contrast that sauropod dorsal ribs commonly preserve a remarkably complete growth record. We analyzed the growth record preserved in ribs of 15 Jurassic diplodocoid and macronarian sauropod taxa represented by 63 individuals (including 13 type specimens) from 13 localities. Sexual and skeletal maturity, two major life history events, are clearly visible in each individual rib growth record, expressed as two successive significant decreases in annual bone apposition rate and thus growth rate. The formation of an external fundamental system (EFS) represents the second decrease. The cycles in the EFS itself, however, were excluded from skeletal maturity estimates because EFS cycles were formed after skeletal maturity was reached and do not record a significant body size gain. Independent of body size, the analysis shows that diplodocoid sauropods have higher growth rates and shorter growth times than their sister taxon, the macronarians. On average, diplodocoids reached sexual maturity after 12 to 14 years of growth and skeletal maturity at 20 to 22 of age, while macronarians took 16 to 18 years to become sexually mature, reaching skeletal maturity at age 30 to 34. This difference is useful for taxonomic assignment of indeterminate sauropod rib material to one of the sister clades. The age distribution in our sample is adult-dominated, suggesting that large sauropods may have inhabited different environments than their juveniles, and that these environments were more conducive to fossil preservation. The only exception is an assemblage of dwarfed sauropods from the Mother´s Day Quarry (Wyoming, U.S.A.) with a heterogenous age distribution including several juveniles. This suggests that niche partitioning between ontogenetic stages might be triggered by body size rather than byphylogeny.

Grant Information

Two year DFG (Deutsche Forschungsgemeinschaft) grant within the 3rd funding period of DFG Research Unit 533 “Biology of the Sauropod Dinosaurs: The Evolution of Gigantism”.

Podium Symposium (Friday, October 19, 2018, 10:15 AM)

HIGH-DIMENSIONAL SHAPE ANALYSIS OF ENDOCASTS AND BRAIN RECONSTRUCTIONS REVEALS THE PRECISE APPLICABILITY OF ENDOCASTS AS A NEUROANATOMICAL CORRELATE IN ARCHOSAURS

WATANABE, Akinobu, New York Institute of Technology College of Osteopathic Medicine, Old Westbury, NY, United States of America; GIGNAC, Paul M., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America

The braincase contains crucial osteological correlates for neuroanatomy, particularly for inferring the brain morphology of fossil vertebrates. As molds of this internal space, cephalic endocasts allow the examination of brain structures, sizes, and shapes. Over the last two decades, the use of virtual endocasts constructed from computed tomography (CT) data has drastically facilitated paleoneurological research. Nevertheless, the validity of such investigations pivots on the accuracy of these neuroanatomical approximations. Previous accounts have reported close volumetric correspondence between endocasts and the enlarged brains of modern mammals and birds, while dismissing other vertebrate groups as having poor brain-endocast resemblance due to prominent epidural space. These observations, however, have relied largely on sampling mature specimens despite the likelihood that the brain-endocast correspondence changes through ontogeny. Moreover, although size is an important metric, volumetric measurements are limited in characterizing morphology, potentially obscuring more nuanced and localized morphological discrepancies that may exist. Here, we employ traditional µ-CT imaging and diffusible iodine contrast-enhanced (dice)CT on the same ontogenetic series of two model archosaur taxa—the American alligator (*Alligator mississippiensis*) and the domestic chicken (*Gallus gallus*)—to create endocasts and brains from the same individuals. Using a high-dimensional geometric morphometric framework, we test whether brain-endocast dissimilarity: (1) exists in archosaurs; (2) changes through ontogeny; and (3) is comparable to multiple levels of intra- and interspecific variation in brain shape. Results indicate that endocasts are distinct in shape from brains, particularly in the hindbrain, although the regions occupied by the cerebrum and optic lobes exhibit close resemblance. In addition, the overall shape discrepancy decreases throughout ontogeny in both taxa, implying that endocasts are better brain proxies in more mature individuals. Alarmingly, we find that the brain-endocast shape difference is comparable to intra-, and even interspecific variation in neuroanatomical shape. Nevertheless, the overall patterns of shape variation are similar between endocranial and brain data. Taken together, the study demonstrates the unique potential of combining high-fidelity soft- and hard-tissue data and the need for mindful applications of osteological correlates in paleontological research.

Grant Information

National Science Foundation (DEB 1406849 to AW; DEB 1457180, EAGER 1450850 to PMG); Mary Dawson Grant (to AW); Jurassic Foundation (to AW)

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

MULTITUBERCULATE MAMMALS FROM THE MID-CRETACEOUS (EARLY CENOMANIAN) WAYAN FORMATION OF SOUTHEASTERN IDAHO

WEAVER, Lucas N., University of Washington, Seattle, WA, United States of America; WILSON, Gregory P., University of Washington, Seattle, WA, United States of America; KRUMENACKER, L. J., Idaho State University, Pocatello, ID, United States of America; MOORE, Jason R., University of New Mexico, Albuquerque, NM, United States of America; VARRICCHIO, David J., Montana State Univ, Bozeman, MT, United States of America

The middle Cretaceous (approximately Albian–Cenomanian, 113 Ma to 94 Ma, hereafter referred to as 'mid-Cretaceous') represents a pivotal interval in the evolutionary history of the Multituberculata. Multituberculates were one of the most evolutionarily successful clades in mammalian history with a fossil record extending from the Middle Jurassic (ca. 166 Ma) through the late Eocene (ca. 35 Ma). Most multituberculates from the Middle Jurassic to Early Cretaceous fall within the “Plagiaulacida,” a paraphyletic grade characterized by a suite of multituberculate plesiomorphies. In the mid-Cretaceous a clade more deeply nested within multituberculates, the Cimolodonta, began to diversify and eventually came to dominate mammalian communities of the Late Cretaceous and early Paleocene. Although these broad strokes of multituberculate evolutionary history are well documented, the only fossil assemblage detailing this mid-Cretaceous rise of the Cimolodonta comes from the Mussentuchit Member of the Cedar Mountain Formation in central Utah. Here, we report on a new multituberculate assemblage from the Wayan Formation of southeastern Idaho, which represents the second and northernmost record of multituberculate mammals from the mid-Cretaceous of North America.

The Wayan assemblage consists of isolated cimolodontan premolars and molars. Like the Mussentuchit local fauna, most of the cimolodontan material is attributable to taxa within the basal, paraphyletic “*Paracimexomys”* group; however, one lower fourth premolar has been assigned to the genus *Cimolodon*, which belongs to the Cimolodontidae. The presence of *Cimolodon* in the Wayan assemblage represents the earliest occurrence of this genus and the first appearance of a recognized cimolodontan family in the fossil record. Two species from the Mussentuchit local fauna appear to be present in the Wayan multituberculate assemblage, whereas the other “*Paracimexomys”* group specimens differ morphologically from any known mid-Cretaceous multituberculate species. The differences in the Wayan and Mussentuchit multituberculate faunas could be due to temporal, geographic, or taphonomic differences between the two assemblages or some combination of the three. Further sampling of the Wayan Formation and other mid-Cretaceous terrestrial deposits is needed to better understand this critical interval in multituberculate evolution.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

EVIDENCE OF TOOTH DECAY IN AN OLIGOCENE URSID FROM SOUTH DAKOTA AND IMPLICATIONS OF DIETARY TRENDS IN SMALL CANIFORMIA

WELSH, Ed, Interior, SD, United States of America; BOYD, Clint A., North Dakota Geological Survey, Bismarck, ND, United States of America; PAGNAC, Darrin, South Dakota School of Mines and Technology, Rapid City, SD, United States of America

A re-evaluation of fossil canid specimens from the early Whitneyan Cedar Pass local fauna (Poleslide Member, Brule Formation) at Badlands National Park in South Dakota has revealed a rich diversity of small caniform carnivores. A specimen here identified as *Drassonax* sp. (Ursidae, Amphicynodontinae) was recently discovered among a set of specimens previously misidentified as canids. *Drassonax* is a relatively rare component of the White River Chronofauna, with only three fragmentary specimens previously known from the Orellan of Colorado, Nebraska, and South Dakota. Thus, this specimen marks the first Whitneyan record of this taxon. The newly identified specimen consists of a left dentary with p3–4, m2, and associated skull fragments. Examination of the dentition revealed five well-developed dental caries on the m2. The development of these dental 'cavities' is advanced, exhibiting discoloration and breakdown of the enamel into cavernous excavations within the dentin. These dental pathologies observed in *Drassonax* are consistent with prior observations of dental caries in modern ursines. The presence of these advanced dental pathologies in a specimen with unworn teeth suggests that this Whitneyan specimen of *Drassonax* had a diet that contained a significant amount of fermentable sugars and carbohydrates.

Podium Symposium (Wednesday, October 17, 2018, 2:45 PM)

HIGH VARIATION IN GROWTH DURATION AND GROWTH RATE IN THE EARLY ANCESTORS OF CROCODYLIA

WERNING, Sarah, Des Moines University, Des Moines, IA, United States of America; TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America

Extant crocodylians are characterized by slow growth and low metabolic rates compared to birds and mammals, a condition shared with all other extant reptiles and historically considered plesiomorphic for the clades Archosauria, Pseudosuchia (“croc-line” archosaurs), and Crocodylomorpha. In contrast, the osteology and histology of Triassic pterosaurs and dinosaurs suggest relatively elevated growth and metabolic rates in early avemetatarsalians (“bird-line” archosaurs), but the condition at the base of that clade was unclear. Recent studies identified osteohistological correlates of faster growth and higher metabolism in several stem archosaurs, non-crocodylomorph pseudosuchians (*Effigia*, *Poposaurus*), and the avemetatarsalian *Teleocrater*. These data suggest that elevated rates were plesiomorphic for Archosauria and Pseudosuchia, but it is not known when (phylogenetically or temporally) the extant condition evolved.

To bracket the origin of extant crocodylian growth and metabolic strategies, we histologically sampled femora from taxa representing lineages outside Crocodylia: phytosaurs, aetosaurs, shuvosaurids, rauisuchians, early crocodylomorphs, and crocodyliforms. When possible, we included individuals from more than one locality to assess levels of histological variation. We examined microstructural characters known to vary with growth/metabolic rate in living tetrapods (density and organization of blood vessels, osteocytes, and collagen fibers; number of annual growth lines; annual bone deposition rate). Within taxa, histology and inferred growth rate often varied among localities, with variation highest in Triassic taxa outside Crocodylomorpha. Clades previously hypothesized to grow slowly based on 1–2 samples often yielded evidence of much faster growth when larger samples were examined. For example, bone deposition rates in some phytosaurs were ~10 times higher than extant *Alligator*. Histological signatures of faster growth (in some cases comparable to dinosaurs of similar size) were present in small-bodied crocodylomorphs (*Macelognathus*) and crocodyliforms (*Fruitachampsa*) and even some notosuchians; mainly taxa whose osteology suggests a much different posture or ecology vs extant crocodylians. Our results support the hypothesis that the early ancestors of crocodylians were more similar to avemetatarsalians

in their growth dynamics and metabolism than to their extant descendants, and suggest the evolution of crocodylian physiology was far more complex than previously appreciated.
Grant Information
NSF EAR-1123642 (AHT); NSF EAR-1349654 (AHT); NSF EAR-PF 1250123 (SW)

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

FROM THE FIELD TO THE FOSSILS: VIRTUAL FIELD EXPERIENCES IN THE KETTLEMAN HILLS, SAN JOAQUIN VALLEY, CALIFORNIA

WHITE, Lisa D., University of California, Berkeley, Berkeley, CA, United States of America; HOLROYD, Patricia A., University of California Berkeley, Berkeley, CA, United States of America; BOESSENECKER, Robert W., College of Charleston, Charleston, SC, United States of America

The estuarine and nearshore marine deposits from the Plio–Pleistocene Etchegoin, San Joaquin, and Tulare formations of the Kettleman Hills of central California host rich fossil deposits that document faunal turnover and sedimentary changes associated with the regression of the California interior sea. Whereas physical access to the fossil sites is highly restricted, Virtual Field Experiences (VFEs) are unique educational tools that capture the physical context in which geological and primary paleontological data are collected and bring the field experience to life in the classroom. Using the outcrops themselves as the focal point, we integrated imagery of the field context with field notes and other supporting materials. Fossil content from existing museum collections, including a recently adopted orphan collection from San Francisco State University, were used to illustrate the taxonomic diversity and change in composition in the succession of Plio–Pleistocene faunas.

To create the VFE, gigapixel images and video clips were taken on site and integrated into panoramas that allow users to zoom into and navigate along outcrops to seek and find specimens in situ. The outcrop-level content is then combined with explanatory text, images of specimens from the collections, and video to explore different concepts. The Kettleman Hills VFEs are divided into five modules: *Explore Geology*, *Explore Sediments*, *Explore Fossils*, *Field to Museum*, and *What is a Fossil*? Users can explore the modules in any order and with practically any level of background. VFEs increase the value of fossil collections by connecting the collections to their field sites, and adding context and opportunities for public outreach. Gigapixel-resolution images, high quality panoramas, photographs and video clips, supported by explanatory text, bring to life a range of features to general audiences. The digital integration of images and data from selected field areas of the Kettleman Hills in the San Joaquin Valley of California invites access to images of museum specimens.

Units in the Kettleman Hills accumulated during a time of significant plate motion, climate and sea level change, and this backdrop allows students to investigate questions such as "Why are marine fossils present in a dry and arid modern environment?" Guided by these and other overarching questions that were vetted by a teacher advisory board, access to these unique fossil locales creates special opportunities to engage the public in the scientific value of fieldwork in areas that are no longer readily accessible.

Grant Information
Support for this project is provided by NSF DBI (DBI-1502500, DBI-1503065, DBI-1503545, DBI-1503611, DBI-1503613, DBI-1503628 & DBI-1503678) and NSF CSBR-1561759.

Technical Session XII (Friday, October 19, 2018, 1:45 PM)

ECOLOGICAL BIOGEOGRAPHY OF EXTANT NORTH AMERICAN LIZARDS IN RELATION TO CLIMATE AND PHYSIOGRAPHY: A MODERN COMPARATIVE DATASET FOR PALEOBIOLOGY AND CONSERVATION

WHITING, Evan T., University of Minnesota, Minneapolis, MN, United States of America; FOX, David L., University of Minnesota, Minneapolis, MN, United States of America

Lizards (non-ophidian squamates) are one of the most speciose groups of terrestrial vertebrates. With over 6,500 recognized species, modern lizards occupy a wide array of habitats and ecological niches. Many extant clades of lizards have a good Cenozoic fossil record, but have been underutilized in paleoecology. Understanding the relationships between modern lizards and their environments could provide a useful baseline for making paleoecological and paleoenvironmental inferences, as well as for future conservation efforts. At least 20% of extant lizard species globally are threatened with extinction before the end of the 21st century, largely due to anthropogenic climate change. We analyzed continent-scale spatial patterns of lizard species richness and ecological traits (e.g., diet, habitat preference) in relation to climatic and physiographic variables across continental North America, using a grid of 150x150 km equal-area quadrats. Species richness has a statistically significant negative correlation with latitude (R^2>0.40, p<0.001), although richness is spatially heterogeneous across Mexico and Central America. A statistically significant multiple linear regression model (R^2>0.50, p<0.001) for species richness as a function of the environmental variables suggests that topographic relief and actual evapotranspiration are the most important environmental factors explaining North American lizard species richness. Multiple linear regression models of species richness in ecological categories on the environmental variables are also significant, have high explanatory power, and indicate that topographic relief is an important factor explaining the distributions of viviparous, arboreal, and saxicolous taxa, all of which mostly occur below ca. 30°N latitude. Most species in our data set are invertivorous/insectivorous, but those that fall into other dietary categories (e.g., herbivorous) also have higher richness below ca. 30°N latitude. Our analyses indicate that the distributions of extant North American lizard species and their ecological traits are closely linked with spatial variation in environmental parameters. This information could be used to aid in quantitative paleoecological and paleoenvironmental reconstructions for fossil sites with lizard assemblages that are taxonomically similar to modern communities. Further analysis and exploration of our data set may yield additional insights into future extinction risk for extant species across different regions of North America.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

THE LATE JURASSIC SAUROPOD DINOSAUR *"MOROSAURUS" AGILIS* MARSH 1889 REEXAMINED AND REINTERPRETED AS A DICRAEOSAURID

WHITLOCK, John A., Mount Aloysius College, Cresson, PA, United States of America; WILSON, Jeffrey A., University of Michigan, Ann Arbor, MI, United States of America

The holotypic materials of the sauropod "*Morosaurus*" *agilis*—a partial skull, proatles, and first three cervical vertebrae—have been a taxonomic and phylogenetic mystery since their initial description by O. C. Marsh in 1889 and redescription by C. W. Gilmore in 1907. Although most species of *Morosaurus* were subsumed into *Camarasaurus* in 1919, "*M.*" *agilis* was left in the defunct genus without a proper taxonomic assignment. Similarities have been noted between "*M.*" *agilis* and other Morrison sauropod taxa, including *Camarasaurus*, *Haplocanthosaurus*, *Diplodocus*, and Brachiosauridae, but it has largely been excluded from phylogenetic analyses.

Here, we present new data following additional preparation and study that suggest "*M.*" *agilis* is a dicraeosaurid, closely allied with materials from the Morrison Formation previously assigned to *Diplodocus, Apatosaurus* and the recently described juvenile sauropod *Kaatedocus*. This presence of multiple dicraeosaurid species in the Morrison reinforces hypotheses of a North American origin for both Dicraeosauridae and the more inclusive clade Flagellicaudata.

Technical Session XIX (Saturday, October 20, 2018, 2:45 PM)

A PERMANENT LIGAMENTOUS TOOTH ATTACHMENT IN GORGONOPSIANS EXPANDS THE PHYLOGENETIC AND ECOLOGICAL DISTRIBUTION OF A GOMPHOSIS IN SYNAPSIDS

WHITNEY, Megan R., University of Washington, Seattle, WA, United States of America; SIDOR, Christian A., University of Washington, Seattle, WA, United States of America; LEBLANC, Aaron R., University of Alberta, Edmonton, AB, Canada

Until recently, a ligamentous tooth attachment (i.e., gomphosis) was considered a uniquely mammalian feature, with earlier synapsid forerunners employing a plesiomorphic hard tissue attachment (i.e., ankylosis). Recent work on tooth attachment across a range of non-mammalian synapsids, however, has revealed a much more nuanced and complex evolution in the acquisition of a gomphosis, including its appearance in many more taxa as well as its evolution through heterochrony. Herbivory coupled with tooth-to-tooth occlusion is often considered a driving factor in the evolution of a gomphosis, where increased oral processing would favor a compliant, flexible tooth attachment to absorb forces on the tooth. Here we test the association between herbivory and the evolution of a gomphosis by examining tooth development and attachment in the dominant carnivores of the late Permian, the gorgonopsians.

Six gorgonopsian jaws with in situ teeth were thin sectioned. These jaws ranged broadly in size (e.g., canines measured 14 to 43 mm mesiodistally) and included incisor, canine, and post canine tooth positions. Each tooth position in all of the jaws preserves a narrow space (generally ranging from 100 to 250 um) between the root and its surrounding alveolar bone. Embedded in both the outermost tooth tissue (i.e., cementum) and alveolar bone are Sharpey's fibers running perpendicular to the long axis of the tooth. These histological features are evidence for a ligamentous attachment. Fusion between bone and tooth was never observed. As such, we propose that these gorgonopsians employed a permanent gomphosis, similar to mammals.

These results continue to build on a body of evidence that a mammal-like tooth attachment strategy evolved much earlier and more frequently along the synapsid lineage than previously considered. The acquisition of this trait in gorgonopsians is particularly interesting given their carnivorous ecology, which suggests that this gomphosis is not necessarily linked to herbivory or occlusion. Instead, we propose that multiple feeding ecologies could lead to the evolution of a permanent gomphosis.

Grant Information
NSF EAR-1337569, NSF DEB-1701383

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

STABLE ISOTOPE ECOLOGY OF MIDWESTERN PROBOSCIDEANS DURING THE LATE PLEISTOCENE: IMPLICATIONS FOR LIFE HISTORIES AND LANDSCAPE CHANGES

WIDGA, Chris, East Tennessee State University, Gray, TN, United States of America; SAUNDERS, Jeffrey, University of Arizona, Tucson, AZ, United States of America; HODGINS, Greg, University of Arizona, Tucson, AZ, United States of America; LENGYEL, Stacey, East Tennessee State University, Gray, TN, United States of America; WALKER, J. D., University of Kansas, Lawrence, KS, United States of America; WANAMAKER, Alan, Iowa State University, Ames, IA, United States of America

A total of 93 direct-dated mammoths and mastodons from the Midwest show distinct trends in stable carbon and nitrogen isotopes of bone collagen ($\delta^{13}C_{coll}$ and $\delta^{15}N_{coll}$, respectively) over the last 50,000 years. Before the last glacial maximum (LGM), mammoths exhibit $\delta^{13}C_{coll}$ values between -22.0‰ and -16.7‰, while mastodons, although overlapping, were generally more negative (-21.9‰ to -19.9‰). Both taxa show $\delta^{15}N_{coll}$ values from 4.8‰ to 9.2‰ for this period. During and after the LGM, both taxa show overlapping $\delta^{13}C_{coll}$ ranges (-14.9‰ to -22.6‰); however, mastodons exclusively fill a low $\delta^{15}N_{coll}$ niche (<5‰) during the Bølling–Allerød interval (14.7–12.9 ka) just prior to extinction. This expansion of dietary niche corresponds to the development of a non- analogue, mesic, *Fraxinus-Picea* woodland throughout the southern Great Lakes. Although this landscape was occupied by both *Mammuthus* and *Mammut*, isotopic results suggest that only the latter was able to take advantage of certain low $\delta^{15}N_{coll}$resources.

These regional trends complement samples from serially micro-milled mammoth teeth. A suite of stable isotopes ($\delta^{13}C$, $\delta^{18}O$, $^{87}Sr/^{86}Sr$) collected from pre-LGM tooth enamel (Jones Spring, Hickory Co., MO) suggest that *Mammuthus* in this area could move up to 250 km over the course of many years but did not engage in significant seasonalmigrations.

Grant Information
Funding for this study was provided by NSF grants #1050638, #1049885, and #1050261, and the Illinois State Museum Society.

Technical Session X (Friday, October 19, 2018, 11:30 AM)

CARBON ISOTOPE STRATIGRAPHY AND MAMMAL TURNOVER THROUGH POST-PETM HYPERTHERMALS IN THE FIFTEENMILE CREEK AREA (BIGHORN BASIN, WYOMING)

WIDLANSKY, Sarah J., University of New Hampshire, Durham, NH, United States of America, 03824; SECORD, Ross, University of Nebraska Lincoln, Lincoln, NE, United States of America; CHEW, Amy E., Brown University, Providence, RI, United States of America; CLYDE, William C., University of New Hampshire, Durham, NH, United States of America

The Fifteenmile Creek area of the central Bighorn Basin has produced over 400 early Eocene fossil localities with more than 32,000 individual specimens. Fossil mammal communities from this region show two distinct episodes of faunal turnover that have been indirectly correlated to carbon isotope records further north in the basin. These episodes were suggested to correspond to the Eocene Thermal Maximum 2 (ETM2) and H2 hyperthermals, smaller magnitude global warming events following the Paleocene–Eocene Thermal Maximum (PETM). Despite the extensive fossil record from Fifteenmile Creek, there have not been any stable isotope stratigraphies from the same area that can be directly correlated to these faunal events to test whether the climatic and biotic changes are coincident in time. The goal of this study is to test whether these faunal events coincide with post-PETM hyperthermals by establishing a new carbon isotope record through the Fifteenmile Creek area. We collected a stratigraphically representative set of soil carbonate nodules from seven new sections in the Fifteenmile Creek area. Sampling sites had a sub-meter scale stratigraphic sampling resolution where possible, and were correlated to existing fossil localities that span the expected stratigraphic range associated with post-PETM hyperthermals. We then measured the stable carbon and oxygen isotopes from primary micritic carbonate on three nodules from each sample site. These data show negative carbon isotope excursions in three stratigraphic intervals, potentially capturing the I1 hyperthermal as well as ETM2 and H2. Minimum excursion $\delta^{13}C$ values are between -11.6‰ and -12.8‰ and are approximately 1.5‰–3‰ depleted in ^{13}C relative to non-excursion values. Consistent with other terrestrial records, these data show more extreme excursions than those from marine records of Eocene hyperthermals, suggesting potential amplification in terrestrial responses to carbon cycle perturbations. The final results of this study will aid in understanding how different parts of the Earth system respond to large-scale disturbances in the carbon cycle and ultimately help us understand how mammals responded to rapid climate change in the past, with important implications for predicting their future response to climate change.

Grant Information
National Geographic Grant: 9969-16

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

BITE FORCE AND CRANIAL KINESIS IN *TYRANNOSAURUS REX*

WIDRIG, Klara, McGill University, Montreal, QC, Canada; LARSSON, Hans C., McGill University, Montreal, QC, Canada

All birds and most reptiles have some form of cranial kinesis. Bird antecedents, the non-avian theropod dinosaurs, exhibit many avian traits, blurring the dinosaur-bird transition, yet few analyses have addressed their potential for cranial kinesis. The possibility that non-avian theropods exhibited some degree of cranial kinesis merits close examination to trace the origin and evolution of this complex, biomechanical trait. *Tyrannosaurus rex* is examined here because it is known from many well-preserved specimens, has extensive anatomical descriptions, and is expected to be a conservative exemplar due to its large size. The presence of an articular condyle on the proximal end of the quadrate, which allows the quadrate to rock backward and forward along the quadratosquamosal joint in extant taxa, has been cited to suggest *T. rex* had limited streptostyly. This in turn could have driven palatal kinesis by translating the palatal bones anteriorly, which would have forced each maxilla slightly laterally. This study examines whether streptostyly and palatal kinesis could occur by this mechanism through the construction of a physical model using 3D printing technology. It was found that palatal kinesis is indeed possible in the model and necessary to maintain alignments of the upper and lower jaws. Forward movement of the quadrate during jaw closure corrects the animal's overbite, and the anterior displacement of the palatal bones and anterolateral translation of the quadrate-articular joint widens both the upper and lower jaws. The model was also used to reconstruct jaw musculature in clay, and bite forces were calculated via three-dimensional static equilibrium analysis. Maximal bite forces were achieved with the jaws closed and quadrate rotated anteriorly, suggesting that palatal kinesis may have also been used to maximize bite forces throughout the range of jaw motion. This model helps explain many of the bone contact morphologies and suggests such forms of cranial kinesis may be widespread throughout non-avian theropods.

Grant Information
This research was supported by an NSERC grant.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

DINOSAUR EGGS CAME IN VARIOUS COLORS AND PATTERNS

WIEMANN, Jasmina, Yale University, New Haven, CT, United States of America; YANG, Tzu-Ruei, Universität Bonn, Bonn, Germany; NORELL, Mark A., American Museum of Natural History, New York, NY, United States of America

Birds are the only living amniotes with colored eggs. Colored eggs have been considered an avian innovation, which emerged rapidly into the vast diversity of egg color and pattern known in the modern bird fauna. All the variation in egg color is based on only two pigments: red protoporphyrin, and blue biliverdin. A recent study demonstrated the presence of both of the pigments responsible for avian egg color in fossilized nonavian dinosaur eggshell. This raises a fundamental question: Did modern birds inherit egg color from their nonavian dinosaur ancestors, or did egg color evolve independently multiple times? Here we present a phylogenetic assessment of nonavian dinosaur eggshell color. Analyzing eggshells representing all major clades of nonavian and avian dinosaurs, we discovered a single evolutionary origin of dinosaur egg color in nonavian dinosaurs. Pigment surface maps revealed spots and speckles. Eggshell pigment depth profiles elucidate pigment deposition strategies. Statistical evaluation corroborates egg color in nonavian dinosaurs being a true, rather than a taphonomic signal. The diversity in color patterns found in non-avian dinosaur eggshells challenges that known from modern bird fauna, indicating the presence of far more complex reproductive behaviors in non-avian dinosaurs than previously known. Birds were not the first amniotes with colored eggs.

Grant Information
This research was supported by the Stephen Cohen Award for Student Research 2015 (Society of Vertebrate Paleontology).

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

ORGANIC PHASE (EXTRACELLULAR MATRIX, OSTEOCYTE, BLOOD VESSEL) PRESERVATION IN FOSSIL TETRAPOD BONE: TEMPORAL AND ENVIRONMENTAL PATTERNS OF PRESERVATION

WIERSMA, Kayleigh, University of Bonn, Bonn, Germany; LÄBE, Sashima, University of Bonn, Bonn, Germany; KOSCHOWITZ, Marie, University of Oxford, Oxford, England; LAMBERTZ, Markus, University of Bonn, Bonn, Germany; SANDER, P. M., University of Bonn, Bonn, Germany

Hard tissues, such as bones and teeth, fossilize well, and provide the exceedingly rich fossil record of vertebrate evolution. In addition to their shape, the histological structure of bones is also preserved. Bone is a composite material consisting of an inorganic phase (IP) of about 70% by volume and an organic phase (OP) of 30% by volume. The OP consists mainly of collagen and is also known as the extracellular matrix (ECM).

Since the 1960s, soft tissues and bone proteins have been detected in fossilized dinosaur bone, eroding the dogma that the OP is completely destroyed during fossilization. However, only recently were organic remains such as osteocytes, blood vessels, and sometimes ECM successfully liberated from fossilized bone by dissolution in weak organic acids. This discovery, however, led to a controversy over whether these organic remains represent original soft tissue preservation or biofilms produced by bone-degrading bacteria. Although evidence in favor of the interpretation of the remains as altered bone OP keeps accumulating, the controversy led to the realization that material nature of fossil bone remains poorly characterized.

We obtained a comprehensive sample of fossil tetrapod bone, covering the full range of tetrapod diversity and tetrapod-bearing depositional environments. The 40 samples range in age from 310 million years to 1,000 years old. The aim of our research is to develop hypotheses about the processes leading to the preservation of the OP and its degradation products and thus the conditions that are conducive to OP preservation.

The bone samples were carefully digested in EDTA over a period of days and weeks, liberating osteocytes and sometimes blood vessels and ECM in the residue of 18 of the 40 samples. After the dissolving process, the residues were stored in a buffer solution. Microscope slides of the residue were created by washing the organic remains with ethanol, isopropyl alcohol, and xylene, and sealed with a fixing agent.

The oldest preserved OP is from the Early Permian, and no bias towards more recent time periods is apparent. Remarkably, the fossil bone samples that preserved OP best are not from conservation deposits, but from regular fluvial and marine facies without any particular predictive factors for OP preservation. In particular, the lack of OP preservation in laminated anoxic sediments that preserves soft parts well, such as the Eocene Lake Messel oil shales and the Jurassic marine Posidonienschiefer Formation, is puzzling.

Grant Information

Funded by DFG Research Unit 2685 'Die Grenzen des Fossilberichtes'

Podium Symposium (Wednesday, October 17, 2018, 1:45 PM)

THE EVOLUTION OF CROCODYLIFORM CRANIAL SHAPE IN A PHYLOGENETIC CONTEXT

WILBERG, Eric, Stony Brook University, Stony Brook, NY, United States of America; TURNER, Alan H., Stony Brook University, Stony Brook, NY, United States of America; SMAERS, Jeroen, Stony Brook University, Stony Brook, NY, United States of America Crocodyliforms have a rich fossil record, attained global distribution, and filled a wide variety of ecological niches throughout their history. The group has explored a broad range of cranial morphologies through time, particularly in relation to rostral and supratemporal fossa (STF) form. These two character complexes are functionally related, with the snout acting as the prey capture apparatus and the STF as the origin for the pseudotemporalis and/or adductor mandibulae externus profundus musculature. A correlation between STF size and snout shape has been previously suggested (e.g., taxa with long slender snouts tend to have larger STF, possibly related to the importance of the aforementioned muscles in their prey capture strategy). To investigate evolutionary patterns of these cranial modules, we quantified snout and supratemporal fossa shape using sliding semilandmark- based geometric morphometric methods. We then modeled the evolution of these modules across an 80-tip time-calibrated phylogeny of Crocodyliformes, testing for differences in allometric patterning (using new functions in the R package bayou and phylogenetic ANCOVA as implemented in evomap). Our results indicate a significant shift in the covariation of STF relative to snout length at the origin of Eusuchia. In comparison with non-eusuchian crocodyliforms, eusuchians exhibit less change in STF size relative to snout length. This shift in phenotypic covariation is potentially related to a change in pattern (but not strength) of developmental integration between these modules.

As these modules are related to feeding, this shift in phenotypic covariation may indicate an important transition in the evolution of the crocodyliform feeding apparatus at the origin of Eusuchia. That non-eusuchian crocodyliforms tend to have a larger STF suggests a reliance on muscles occupying the dorsal temporal fenestra, while the relatively smaller STF of eusuchians may mark a shift to an increased role of the pterydoideus musculature responsible for the extreme bite forces of extant crocodylians. If such a model holds true, it may serve to best explain the observed shift in covariation between these modules. The timing of this transition in our analysis matches closely with a previous study modeling the evolution of bite force in the group based on a different osteological proxy. Collectively this suggests that the modern crocodylian feeding apparatus developed around the origin of the crown group, coincident with the establishment of the eusuchian secondary palate.

Grant Information
National Science Foundation grant NSF-DEB 1754596

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

NEW *ICTIOBUS* SPECIES (CYPRINIFORMES, CATOSTOMIDAE) FROM THE LATE MIOCENE (CLARENDONIAN) OGALLALA FORMATION, BEAVER COUNTY, OKLAHOMA

WILBERT, Greg A., University of Oklahoma, Norman, OK, United States of America; FREDERICKSON, Joseph A., Norman, OK, United States of America; CZAPLEWSKI, Nicholas J., University of Oklahoma, Norman, OK, United States of America; SMITH, Kent S., Oklahoma State University, Tulsa, OK, United States of America

The Ogallala Formation is a collection of fluvial and lacustrine sediments deposited in the high plains of North America during the late Miocene and early Pliocene. Most famous for its highly diverse mammalian fauna, the Ogallala Formation also represents an important record for aquatic taxa as well, including in Oklahoma *Atractosteus*, ?*Esox*, *Ictalurus*, *Micropterus*, ?*Aplodinotus*, *Alligator,* turtles, molluscs, freshwater sponges, and diatoms. Here, we describe a new species of buffalo fish (genus *Ictiobus*), from the Late Miocene (Clarendonian) of western Oklahoma. This specimen was found in a diatomite derived from a brackish lake (due to underlying Permian salt beds), discovered in approximate articulation, upside down, and lacking the caudal half of the postcranial skeleton. The skull preserves roughly 15 elements, along with remnants of the dorsal spines, fin rays, and multiple cycloid scales covering portions of the skeleton. The opercular series on each side lay open, with the dorsal skull bones (frontal, parietal, and supraoccipital) remaining in full articulation. The dentary, premaxilla, and other rostral skull bones are deflected laterally and preserved next to elements of the skull roof. Generally, the bones are well-preserved except where a dense root-mass plane has intersected the skeleton and base of the skull. The genus *Ictiobus* is represented by five extant species: *I. bubalus, I. cyprinellus, I. labiosus, I. meridionalis,* and *I. niger,* ranging from Central America to Canada, as well as one Pliocene species, *I. aguilerae* from Hidalgo, Mexico. This new Oklahoma specimen can be differentiated from the living species based on its serrated cleithrum, smooth anterior end of the frontal-parietal fontanelle, and the sharp angular interior margin of the preopercle. The addition of this new species adds valuable data for the early evolution of the genus, including potentially important implications for the biogeography of living *Ictiobus*.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

PREVENTATIVE MAINTENANCE AT THE MAMMOTH SITE: EXCAVATION AND STABILIZATION METHODS FOR AN ACTIVE IN-SITU BONEBED

WILKINS, William J., The Mammoth Site of Hot Springs,SD, Inc., Hot Springs, SD, United States of America; BUGBEE, Monica, The Mammoth Site of Hot Springs,SD, Inc., Hot Springs, SD, United States of America; STORMS, Elizabeth, The Mammoth Site of Hot Springs,SD, Inc., Hot Springs, SD, United States of America

The Mammoth Site (The MS) of Hot Springs has been undergoing near constant investigation since 1974. Excavation continues today with both summer internship participants as well as on-site volunteer based programs. Most new discoveries of mammoth and other Pleistocene taxa produced by ongoing investigation are left in situ for observation by visiting scholars, scientists, and the public. From initial discovery to present, excavation practices and excavators have played a key role in direct outreach to the public, as well as significantly contributing to the long-term stability and management objectives for in situ excavation.

Excavation methods have varied from year to year as research goals have changed along with the physical conditions of The MS. Methodology in the 1970s was salvage driven, focusing on exposing and recovering fossils prior to backfilling between field seasons. Having transitioned to an in situ excavation in the mid-1980s, The MS sinkhole effectively acts as an exhibit space, a natural preparation laboratory, and collections archive. Current excavation techniques are slower and geared toward promoting stability of exposed specimens in a dynamic environment. This means that excavation methods have shifted to a finer scale and require attention to detail in order to produce quality display items for the visiting public. Excavators observe and react to changing sediment patterns by shifting to finer tools and techniques as they approach potential objects in the matrix, reducing the chance for large discovery marks. Small fractures resulting from the ongoing seasonal shrinking and swelling of clays indicate areas where excavators may preemptively apply appropriate consolidation and support structures. These techniques help prevent damage and present a more aesthetically pleasing and morphologically valuable new specimen.

Existing in situ bones are always affected by nearby excavation in some way; however, careful methods of digging can be applied to minimize destabilization of supporting matrix. Careful observation of support pedestals allows for selective excavation of destabilized sediments preventing 'tear-away' destruction of fossils. Where needed, in situ specimens may be fitted with clay-support structures maintaining specimen integrity until the eventual removal of the fossil. These preemptive and reactive steps in turn lead to increased longevity of important specimens maintained in The MS in situ collection.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

FIRST OCCURRENCE OF *BOREALOSUCHUS* AND OTHER CROCODYLIFORM FOSSIL MATERIAL FROM THE UPPER CRETACEOUS TWO MEDICINE FORMATION OF NORTHWESTERN MONTANA

WILLIAMS, Scott A., Museum of the Rockies, Montana State University, Bozeman, MT, United States of America, 59717; BROCHU, Christopher A., Department of Earth and Environmental Sciences, University of Iowa, Iowa City, IA, United States of America; TREMAINE, Katie M., Department of Earth Sciences and Museum of the Rockies, Montana State University, Bozeman, MT, United States of America; CARR, Richard, Department of Earth Sciences and Museum of the Rockies, Montana State University, Bozeman, MT, United States of America; VARRICCHIO, David J., Department of Earth Sciences, Montana State University, Bozeman, MT, United States of America; SCANNELLA, John, Museum of the Rockies, Montana State University, Bozeman, MT, United States of America

The Campanian Two Medicine Formation (TMF) is a series of fluviolacustrine deposits formed in seasonal, semi-arid uplands between approximately 82 and 75 Ma. Although it has been actively sampled and researched over four decades, yielding extensive fossil fauna including dinosaurs, pterosaurs, champsosaurs, turtles, lizards, mammals, invertebrates, and insect traces, there are no reports of crocodyliforms. This differs from correlative units like the Judith River Formation and members of the Belly River Group.

Museum of the Rockies (MOR) collected several crocodyliform specimens (MOR 552, MOR 690, MOR 719 and MOR 10845) from the TMF. These specimens range in completeness from a nearly complete right dentary (MOR 719) and right maxilla (MOR 10845) to incomplete skeletons with partial limbs, vertebral elements, osteoderms, and cranial material (MOR 552, MOR 690). While two of these specimens were collected from "Jack's Birthday Site", a well-sampled bonebed in the Upper TMF of northwestern Montana, the most diagnostic specimen, MOR 552, was collected from a nearby TMF locality. MOR 552 is a disarticulated but associated specimen comprised of several partial cranial elements including: frontal-postorbital, maxilla, premaxilla, left dentary, right and left surangulars, a right angular, and articular. Postcranial elements include partial femora, partial left tibia, and presacral, sacral, and caudal vertebrae, as well as assorted osteoderms. Plesiomorphic states common to several eusuchian lineages are preserved, including confluent third and fourth dentary alveoli. Although similar to the Campanian alligatoroid *Leidyosuchus*, we refer this specimen to *Borealosuchus* based on a diagnostic surangular that extends all the way to the posterior end of the retroarticular process.

With the identification of MOR 552 and the collection of the other MOR specimens, not only can we report the first occurrence of fossil crocodyliforms within the TMF, but also the first Campanian occurrence of *Borealosuchus* in the Western Interior. Additionally, given the difference in paleoclimate from the Two Medicine Formation and its equivalent Campanian formations, which possess a wider crocodyliform diversity, this suggests that *Borealosuchus* was better adapted for more arid and seasonal climates.

Poster Session (Wednesday–Saturday, October 17–20, 2018, 4:15–6:15 PM)

EVALUATING COMMUNICATION OF EVOLUTIONARY THEORY WITHIN EXHIBITS AT THE STERNBERG MUSEUM OF NATURAL HISTORY

WILLIAMS, Trevor M., Fort Hays State University, Hays, KS, United States of America

An ongoing study at the Sternberg Museum of Natural History (FHSM) is performing the first formal evaluation of the museum's exhibits through a two-part survey given to visiting adults. Two of the museum's exhibits contain references to concepts of evolutionary theory within their label text, which include: (1) predator-prey interaction; (2) convergence; (3) extinction; and (4) transitions. The survey asks visitors open-ended questions about these four evolution concepts before and after visiting the museum. As a natural history museum (NHM), FHSM serves an important role in educating the visiting public about the physical sciences, which includes evolutionary theory. This evaluation study will determine if the exhibits in question are properly communicating evolutionary theory to visitors.

The pre-survey establishes the visitor's background knowledge, demographic information, education level, and prior experience with the museum. Questions asked in the post-survey are the same as those in the pre-survey. Answers to the questions in the pre- and post-survey are compared to determine if there was any significant change in how the visitor conceptualized the stated scenario. Visitors' answers to the survey questions are transcribed digitally and coded using qualitative data analysis. Keywords and phrases within written answers are coded to one of the three conceptual models used to explain evolution: (1) intuitive misconceptions developed during childhood; (2) supernatural intervention in the origins of life; and (3) informed scientific knowledge. If the exhibits are performing their intended purpose, then visitors will show a higher affinity to answering survey questions with the scientific conceptual model after visiting the museum. Evolutionary and religious terms are avoided in the questions to avoid priming visitors into answering with a different conceptual model than the one they would normally use. Answers are also screened for misconceptions that compromise the exhibits' educational objectives.

This study is part of an effort to further develop evaluation techniques for education of evolutionary theory for adults. Current research on evolution education focuses on children or college students in a classroom setting. Only a few studies have been performed that measure shifts in NHM visitors' conceptual understanding of evolutionary processes through exposure to exhibits. Preliminary results show an increase in U.S.A.ge of the scientific conceptual model after visiting FHSM's exhibits, but support for this trend is weak.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PALEOENVIRONMENT INTERPRETATION OF FOSSILIFEROUS MUDROCK WITHIN THE POJOAQUE MEMBER (MIOCENE) OF THE TESUQUE FORMATION IN THE EASTERN-CENTRAL ESPAÑOLA BASIN, NEW MEXICO

WILLIAMSON, Garrett R., Enid, OK, United States of America; GREEN, Hunter, Texas Tech University, Lubbock, TX, United States of America; WALSH, Tim, Wayland Baptist University, Plainview, TX, United States of America

The Pojoaque Member (Miocene) of the Tesuque Formation in the study area near Española, NM was divided by previous authors into two paleodrainage systems characterized as a basin-margin facies (Lithosome A) deposited on an alluvial slope and a basin-floor facies (Lithosome B) deposited on a floodplain. Fossil rich beds have been discovered within the basin-floor facies almost exclusively in thin (< 2m) localized maroon-red and pale green mudrock beds proximal to channel sandstone deposits. This study used geochemical data (X-Ray diffraction and Inductively Coupled Plasma) along with field observations and recently collected turtle fossils to identify the paleoenvironments in which these fossiliferous beds were deposited and possibly understand why they are fossil rich.

In the study area, the bulk of Lithosome B is composed of mudrock with some channel sandstones, thin nonmarine limestones, and scattered interbedded tuff layers. Geochemical analyses were run on samples collected from: (1) distinct beds across an almost complete measured section of the Pojoaque Member; (2) one specific bed that was subjected to high resolution sampling (13 samples @25 cm intervals) because it has historically produced a large amount of fossil material; and (3) a single bone sample from the same bed. Six beds from the measured section were identified to be fossiliferous. Chlorite is almost exclusively found within these fossiliferous beds which may correlate to fossil abundance and the kaolinite found within these beds may be a weathered decay product of the original chlorites. Chlorites were likely transported across the Peñasco Embayment from the metamorphic regions of the emerging Picuris Mountains to the northeast. These

fossiliferous beds are interpreted to be ephemeral lakes or ponds within an anastomosing river system due to: (1) ephemeral lakes being formed under predominantly stagnant water condition causing little alteration and therefore closely resembling source-rock composition, which may be why chlorite is almost exclusively found within these beds; (2) the presence of barite in the bone sample which can be interpreted as a chemical precipitate in evaporitic conditions; and (3) recently discovered fossil turtles (Testudines, Emydidae, Deirochelyinae) interpreted as pond dwelling animals which have not been previously documented from this area.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

THE BEGINNING OF THE AGE OF MAMMALS: NEW INSIGHTS ON THE RISE OF PLACENTALIA BASED ON A PRELIMINARY COMPREHENSIVE PHYLOGENY

WILLIAMSON, Thomas E., New Mexico Museum of Natural History, Albuquerque, NM, United States of America; BRUSATTE, Stephen, University of Edinburgh, Edinburgh, United Kingdom; JANECKA, Jan E., Duquesne University, Pittsburgh, PA, United States of America; SHELLEY, Sarah L., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America; SPAULDING, Michelle, Purdue North Central, Westville, IN, United States of America; WIBLE, John R., Carnegie Museum of Natural History, Pittsburgh, PA, United States of America

The Cenozoic radiation of mammals was a profound moment in vertebrate evolution; however, many aspects of this radiation remain poorly understood, largely because phylogenetic and macroevolutionary studies have sampled heavily from Mesozoic and Eocene taxa, but mostly ignored mammals from the Paleocene. In order to address this deficit, we are building a comprehensive higher-level phylogeny consisting of anatomical and genetic data for a large number of mammalian taxa (including extinct and extant forms). This phylogeny will incorporate an unprecedented number of Paleocene taxa, including many enigmatic forms that have formerly been relegated to classical 'wastebasket' groups of mammalian paleontology, such as “Condylartha” and “Cimolesta.” This project will incorporate a wealth of fossil specimens, including many that have been collected from the Paleocene Nacimiento Formation of the San Juan Basin, northwestern New Mexico. The Nacimiento Formation contains the longest and most complete record of mammalian succession through the early Paleocene. These fossils are being studied using a variety of new techniques, such as high-resolution CT scanning, that are revealing new details of the anatomy and bringing new insights into the life history, functional morphology, and evolutionary history of these archaic animals. Preliminary results of our comprehensive phylogeny of Paleocene mammals build upon previous large datasets, and our working data set now includes most Paleocene lineages—(262 taxa [58 extant and 204 extinct]) to be scored for over 2,000 morphological characters. Molecular data from the extant taxa, over 35,000 base pairs from 26 nuclear genes, will ultimately also be included. Current results are based on use of maximum parsimony, but later analyses will also use maximum likelihood and Bayesian methodology. Our preliminary results, from a more restricted data set, find that many Paleocene taxa are stem members of major extant clades (e.g., Primates, Afrotheria, Laurasiatheria, Carnivoramorpha, Euungulata). When coupled with the high-resolution geochronological record being developed from the Nacimiento Formation record, our analyses show that many major mammalian clades probably originated very early in the Paleogene.

Grant Information
NSF (DEB 1654952 and EAR 1325544 to TEW and SLB, DEB 1654949 to JRW and SLS, DEB 1655795 to MS, and DEB 1654964 to JEJ), BLM to TEW and SLB, and ERC (#75226 and Starting Grant to SLB)

Technical Session XIV (Saturday, October 20, 2018, 8:30 AM)

A NEW, BASAL ACTINOPTERYGIAN FROM NOVA SCOTIA: STEM GROUP SURVIVORSHIP IN THE EARLY CARBONIFEROUS

WILSON, Conrad D., University of Calgary, Calgary, AB, Canada; PARDO, Jason D., University of Calgary, Calgary, AB, Canada; ANDERSON, Jason S., University of Calgary, Calgary, AB, Canada

The vertebrate fossil record of the earliest Carboniferous is notoriously poorly sampled, obscuring a critical interval in vertebrate evolution and diversity. Recent studies of diversity across the Devonian–Carboniferous boundary have proposed a vertebrate mass extinction at the end- Devonian, and recent phylogenies suggest that the origin of the actinopterygian crown may have occurred in the earliest Carboniferous, as part of a broader recovery fauna. However, the data necessary to test this are limited. We present a partial actinopterygian skull, including diagnostic elements of the posterior braincase, from the Tournaisian Horton Bluff Formation of Blue Beach, Nova Scotia. The braincase surprisingly shows a confluence of characters common in Devonian taxa but absent in Mississippian forms, such as an open spiracular groove; lateral dorsal aortae that pass through open broadly separated, parallel grooves in the ventral otoccipital region, posterior to the articulation of the first infrapharyngobranchial and an intertemporal–supratemporal complex.

Phylogenetic analysis places it deep within the actinopterygian stem, among Devonian moythomasiids and mimiids, suggesting more phylogenetically inclusive survivorship of stem group actinopterygians across the end-Devonian mass extinction. With a high lineage survivorship in tetrapods and lungfish across the Devonian–Carboniferous boundary and high vertebrate diversity at Tournaisian localities, this hints at a more gradual turnover between Devonian and Carboniferous vertebrate faunas.

Grant Information
Research was supported by NSERC Discovery grant nos 327756-2011 and 2017-04821 to Jason S. Anderson.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

CROSS-SECTIONAL GEOMETRY OF THE FORE AND HIND LIMBS OF *JOBARIA TIGUIDENSIS* AND THE EVOLUTION OF MESAXONY AND ENTAXONY IN SAUROPODS

WILSON, Jeffrey A., University of Michigan, Ann Arbor, MI, United States of America; VANDER WEELE, David J., University of Michigan, Dearborn Heights, MI, United States of America; ROUNTREY, Adam N., University of Michigan, Ann Arbor, MI, United States of America

Sauropod dinosaurs are characterized by numerous features associated with large body size and a quadrupedal, columnar posture, many of which diagnose Sauropoda and its subgroups. These include straight-shafted limb bones with articular ends capped by a thick layer of cartilage, overall lengthening of the forelimb, and reduction in the size of muscular attachments. Because body mass is proportional to volume (length^3) but bone strength is proportional to cross-sectional area (length^2), modifications to limb bone geometry affect support and locomotion at large body size. However, few studies have investigated how sauropod limb bone cross-sectional geometry varies along the proximodistal axis of fore and hind limbs, across the transverse plane within each limb, and between serially homologous limbs and developmental limb units (stylo-, zeugo-, autopod).

We measured cross-sectional limb geometry in the sauropod *Jobaria tiguidensis*, which is known from several articulated skeletons from the Tiourarén Formation of Niger. Photogrammetric techniques were used to generate high-resolution, scaled, three-dimensional meshes of each limb element. A stack of virtual sections cut orthogonal to the long axis at 1 mm intervals was created for each bone in Amira. The cross-sectional area of each slice was measured in ImageJ, aggregated in R, and exported to Excel. The resultant data show how bone distribution varies within, across, and between fore and hind limbs and limb elements in *Jobaria*. The forelimb is 83% the length of the hind limb, most of which is accounted for in the stylopod. Zeugopods are nearly the same length, and the metacarpus is slightly longer than the metatarsus. Combined cross-sectional area of limb elements decreases distally in both forelimb and hind limb, with a sharp drop between stylopod and zeugopod (fore: 60%, hind: 80%) and a subtle drop between zeugopod and autopod (fore: 92%, hind: 82%). The forelimb is mesaxonic, with similar cross-sectional area of stylopod, zeugopod, and autopod on either side of the limb axis in the transverse plane. In contrast, the hind limb is entaxonic, with substantially more bone deployed medial to the limb axis.

Differences in fore and hind limb bone cross-sectional geometry may be related to the magnitude and position of loading at the shoulder and hip joints. The forelimb bears a smaller proportion of body weight loaded near the limb axis at a joint supported by a muscular sling, whereas the hind limb bears a proportionally greater load emplaced medial to the limb axis at a joint fused to the sacrum.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

'PENDULAR' SWINGS IN THE EVOLUTION OF CENTROSAURINE CRANIAL ORNAMENTATION

WILSON, John P., Badlands Dinosaur Museum, Dickinson, ND, United States of America; FERGUSON, Ashley L., Idaho State University, Pocatello, ID, United States of America; GARDNER, Jacob D., Montana State University, Bozeman, MT, United States of America

The Late Cretaceous Western Interior of North America hosted the vivid evolution of numerous clades of ornamented dinosaurs. Among these, ceratopsids are primarily characterized by their diverse and diagnostic horns and frills, and are basally split between Chasmosaurinae and Centrosaurinae. Within Centrosaurinae, Eucentrosaura (Centrosaurini plus Pachyrhinosaurini) is the most thoroughly sampled, with well-constrained stratigraphic distribution. The basal half of this clade (*Spinops*; *Coronosaurus*; *Centrosaurus*; *Styracosaurus*) express simple nasal (though hypertrophied in *Styracosaurus*) and supraorbital horncores, whereas their parietals are widely disparate, with greatest complexity in *Styracosaurus*. Conversely, the derived eucentrosaurans (*Einiosaurus*; *Achelousaurus*; *Pachyrhinosaurus*) exhibit complex nasal and supraorbital bosses, which undergo considerable ontogenetic change, and comparatively simpler, conserved parietals. A new taxon (MOR 492) from the Two Medicine Formation is a possible anagenetic intermediate between *Styracosaurus* and *Einiosaurus*, with simple facial ornamentation and a partially simplified parietal.

In Eucentrosaura, we identify a shift in socio-sexual selection from a parietal- to facial-based strategy, accompanied by pendulum-like swings between simplicity and complexity of these ornamental structures. Selection is inferred as heaviest on structures which are most disparate between stratigraphically successive taxa, while conserved morphologies indicate less pressure. When selection acts on the parietal in basal eucentrosaurans, it becomes complex (culminating in *Styracosaurus*); when selection shifts to the facial ornamentation in derived eucentrosaurans, the parietal simplifies (elimination of P1, reduction of P4, P5) and facial complexity increases, with steep ontogenetic trajectories. In our morphometric analyses, basal eucentrosauran parietals are disparate and derived eucentrosauran parietals cluster; facial ornamentation reflects an opposite trend, consistent with our hypotheses. Phylogenetic analysis recovers Eucentrosaura as a single clade united by MOR 492, where successively derived taxa match their stratigraphic occurrence, rather than basally split as in previous studies. This supports the hypothesis that selection shifts between ornamental structures, rather than divergent clades having opposing ornamental trends. These observations provide insight into the evolutionary dynamics of socio-sexual signaling structures in dinosaurs.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

PELYCOSAURIAN "LINEAGES": A META-ANALYSIS OF THREE DECADES OF PHYLOGENETIC RESEARCH

WILSON, Winston M., New York City, NY, United States of America; ANGIELCZYK, Kenneth D., Field Museum, Chicago, IL, United States of America; PEECOOK, Brandon, Field Museum, Seattle, WA, United States of America; LLOYD, Graeme T., Macquarie University, Macquarie University, Australia

Pelycosaur-grade synapsids comprise the first major radiation of Synapsida, and their phylogenetic relationships have been the subject of over three decades of research in a cladistic framework. In this time three major "lineages" of shared character-taxon matrices have been created, each with distinct sets of characters and taxa which have been analyzed using different tree-construction methods. The majority of papers analyzing "pelycosaur" phylogeny belong to one of these research lineages. Papers rarely cross over to another lineage, but occasionally borrow a few characters from other research lineages. This bias in the sources of "pelycosaur" phylogenetic datasets means that there have been fewer truly independent tests of hypothesized relationships within the group than the number of published analyses would suggest, and that our understanding of "pelycosaur" phylogeny may be less certain than is sometimes portrayed. Here, we use a novel method to create a "pelycosaur" metatree to summarize our current understanding of the group's phylogeny. We also perform a bipartite network analysis to describe relationships between individual datasets and to characterize distinct research lineages.

The topology of our metatree shows the most similarity to the results of the largest research lineage, reflecting the large contribution those papers made to the underlying dataset. We recover a monophyletic Caseasauria and Eupelycosauria. Relationships within eupelycosaur subclades also generally match previous hypotheses from the largest lineage. However, within Caseasauria, a monophyletic Eothyrididae falls within Caseidae, reflecting the influence of multiple dataset lineages on recent work on the group. The bipartite network analysis confirms the division of datasets into three main lineages. Moreover, the matrices in the older lineages are more conservative, with fewer character additions or deletions, whereas those in the newest lineage are more variable. Our results reveal how scientific practice has influenced our understanding of "pelycosaur" phylogeny, and suggest that the construction of additional, independent datasets will be an important step in further testing conventional wisdom and traditional phylogenetichypotheses.

Technical Session XII (Friday, October 19, 2018, 2:30 PM)

FIRST 3D ENAMEL SURFACE TEXTURE ANALYSIS OF EXTANT REPTILES: ESTABLISHING A REFERENCE DATA SET FOR DIET RECONSTRUCTION OF EXTINCT SAUROPSIDS

WINKLER, Daniela E., Johannes Gutenberg University Mainz, Mainz, Germany; SCHULZ-KORNAS, Ellen, Max Planck Institute for Evolutionary Anthropology, Leipzig, Germany; KAISER, Thomas M., University of Hamburg, Hamburg, Germany; TÜTKEN, Thomas, Johannes Gutenberg University Mainz, Mainz, Germany

Teeth are usually the best-preserved fossil remains of vertebrates as dental enamel is the material most resistant against alteration. Dietary reconstruction based on tooth morphology and wear has always been a key component in palaeontological research. However, for 2D microwear and 3D microtexture analyses, reference datasets for extant species with known dietary habits are needed in order to establish feeding hypotheses for extinct taxa. To date, the majority of dental wear studies have focused on mammals, as these methods were initially applied to examine diet and ecology in primates, cetartio- and perissodactyls. Before the rise of mammals, the vast majority of Amniota did not show distinctive oral food processing through mastication, but rather employed a crop and swallow ingestion with short food-to-tooth contacts. Extant non-avian Sauropsida ("reptiles") still rely on this simple food intake strategy, regardless of their dietary preferences. In order to establish 3D surface texture analysis for application to extant and extinct non-avian Sauropsida as well as other homodont tetrapod taxa (e.g., Synapsida), we have compiled a large dataset of 3D enamel surface textures of 234 teeth from 54 specimens belonging to 17 extant squamatan taxa, representing eight different dietary traits. A combination of roughness (ISO 25178), flatness (ISO 12781), furrow, and scale- sensitive fractal analysis (SSFA) surface texture parameters significantly separate faunivores from herbivores and distinguish durophagous and frugivorous taxa. We found a broad overlap in textures between insectivores and omnivores, but these dietary groups are nonetheless separable by the height parameters Sp and Sz as well as in furrow parameter madf. The algae-eating marine iguana is well distinguished but nested within unspecialised herbivores, while beaded lizards, which feed primarily on eggs and hatchlings, form a distinctive group within the faunivore parameter space. Finally, we tested for variability in texture parameters within the same jaw and found them to be independent of tooth position. Our results indicate that short tooth-to-food contact in reptiles is sufficient to create characteristic wear patterns that allow for dietary discrimination, thus enabling us for the first time to pursue palaeodietary reconstruction through enamel surface texture analysis based on a modern reptilian reference dataset. This study further demonstrates the feasibility of using isolated teeth from reptilian and possibly other homodont taxa for dietaryreconstruction.

Grant Information
This project is funded by the European Research Council under the European Union's Horizon 2020 research and innovation program, ERC Grant VERTEBRATE HERBIVORY (no. 681450).

Romer Prize Session (Thursday, October 18, 2018, 10:15 AM)

THE INTERVERTEBRAL DISK GAVE REPTILES IMPROVED AXIAL MOBILITY—MORPHOLOGICAL, HISTOLOGICAL, AND PHYLOGENETIC EVIDENCE FOR INTERVERTEBRAL DISKS IN FOSSIL NON-MAMMALIAN AMNIOTES.

WINTRICH, Tanja, University Bonn, Bonn, Germany

Changes in the vertebral column are one of the major trends in the evolution of vertebrates. From the morphological perspective, the vertebral centra differ in the different clades of vertebrates. In amniotes, four different centrum shapes are typically recognized: amphicoelous, platycoelous, procoelous, and ophistocoelous, with the latter two representing ball- and-socket joints. The notochord, which is an ancestral feature of all vertebrates and present in amniote embryos, developmentally contributes to the adult vertebral column of mammals as the nucleus pulposus (NP) which is the internal part of the intervertebral disk of mammals (intervertebral disk proper), but not present in birds. The NP has large cartilage cells of notochordal origin and is surrounded by the annulus fibrosus which consists of fibrocartilage. The intervertebral disk is situated between the cartilaginous endplates of the vertebral centra and is encased by ligaments connecting the vertebrae.

Conventional wisdom holds that reptiles cannot have an intervertebral disk. However, based on histology and morphology, we posit that the intervertebral disk proper is not a mammalian autapomorphy and show that an intervertebral disk is present in many fossil and a few recent reptile clades. On the one hand, we found soft tissue preservation in the intervertebral spaces in the articulated anterior dorsal vertebral column of a Jurassic ichthyosaur which clearly shows the presence of intervertebral disks. There appears to be a large NP with notochordal cells surrounded by the annulus fibrosus. On the other hand, we observed different cartilage cell types that indicate the presence of intervertebral disks in sauropterygians, choristoderes, basal archosauromorphs, and dinosaurs. Furthermore, our hypothesis is supported by vertebral centrum morphology because in platycoelous vertebrae lacking an NP, intervertebal movement would be restricted to translation, resulting in a stiff vertebral column.

We offer an evolutionary scenario, wherein the plesiomorphic amphicoelous vertebra, the notochord becomes constricted, forming a spherical accumulation of notochordal cells, the NP. The evolution of the NP was thus prerequisite for the evolution of the platycoelous centrum, which in turn was prerequisite for the evolution of a synovial intervertebral joint in pro- and opisthocoelous vertebrae. These results take us closer to understanding the evolution and development of the amniote vertebralcolumn.

Technical Session XVIII (Saturday, October 20, 2018, 3:30 PM)

A TIME-CALIBRATED PHYLOGENY OF NORTH AMERICAN ARVICOLINE RODENTS: INSIGHTS INTO DIVERSIFICATION AND TAXONOMY

WITHNELL, Charles B., University of Texas at Austin, Austin, TX, United States of America

The study of fossil arvicoline rodents has largely been immune to modern phylogenetic methods because, more often than not, all we have are isolated molars with few preserved apomorphic characters. This, combined with species richness and homoplasy caused paleontologists to rely on 'expertograms' as a source for phylogenetic hypotheses, rather than modern analytical approaches. Molecular data provide a powerful tool for assessing phylogenetics of arvicoline rodents. I generated a phylogenetic hypothesis based on molecular data from GenBank that includes all 36 extant North American species of arvicolines. I present the first time-calibrated phylogeny of North American arvicoline rodents using Bayesian methods.

A robust phylogeny with time calibration allows me to test hypotheses concerning the timing of the diversification of clades. I exemplify this with the clade *Microtus*. My time-calibrated phylogeny suggests that the crown clade of North American endemic *Microtus* diversified at least 2.5 Ma. The oldest occurrence of *Microtus* in the North American fossil record is based on a lower first molar with three closed triangles (*Allophaiomys*) from the Nash Fauna at 2.1 Ma. The maximum documented age of *Microtus* sensu stricto (five closed triangles on lower m1) is at 1.2 Ma. My data suggests that *Allophaiomys pliocaenicus* may be a member of the crown clade, which would provide a close correspondence between the fossil record and the time-calibrated molecular phylogeny. The alternative is that we are missing a fossil record of approximately a million years. Broader implications for this include confirmation that the dominant in-group molar morphology of five closed triangles evolved after the diversification of the clade and implies that the taxonomic recognition of *Microtus pliocaenicus* is warranted.

Podium Symposium (Friday, October 19, 2018, 8:30 AM)

FLESHING OUT THE PAST BY ENHANCING RADIOGRAPHIC CONTRAST IN THE PRESENT: SPICECT, DICECT, AND VASCULAR INJECTION OF EXTANT DIAPSIDS TO BETTER UNDERSTAND DINOSAUR BIOLOGY

WITMER, Lawrence M., Ohio University Heritage College of Osteopathic Medicine, Athens, OH, United States of America; RIDGELY, Ryan C., Ohio University Heritage College of Osteopathic Medicine, Athens, OH, United States of America; PORTER, Wm. R., Ohio University Heritage College of Osteopathic Medicine, Athens, OH, United States of America; CERIO, Donald G., Ohio University, Athens, OH, United States of America

Fossil vertebrates tend to preserve just the hard parts like bones and teeth. Time has stripped the biology from the fossils, challenging our ability to understand the function, physiology, and behavior of extinct organisms. As a result, paleontologists have long sought to reconstruct the soft-tissue attributes of extinct species. Studying the soft tissues of the extant outgroups that phylogenetically bracket the extinct taxa has provided a window into the past, with successes being achieved using dissection and other traditional techniques. However, the jump to 3D modeling and simulation-based hypothesis testing requires anatomical detail that standard x-ray computed tomography (CT scanning) cannot fully provide due to a lack of soft-tissue contrast. The goal of this presentation is to present our team's efforts to enhance soft-tissue contrast in CT of extant diapsids as a means to reconstruct soft-tissues in fossils. The use of contrast media such as iodine and barium that absorb x-rays dramatically increases anatomical resolution. Our team has been using diffusible iodine-based contrast-enhanced computed tomography (diceCT) to stain and visualize a diversity of soft-tissue systems (e.g., muscles, nerves, brain, epithelia, glands) in the heads of extant diapsids. We also recently developed a more rapid iodine-based technique called spiceCT that involves selectively perfusing (the "sp" in spiceCT) specimens by injecting iodine into the vascular system, yielding excellent results in hours rather than the days, weeks, or months required for diffusion-based techniques like diceCT. Likewise we have developed a barium-based technique called differential-contrast dual-vascular injection (DCDVI) to explore arterial and venous circulation. These techniques have allowed us to clarify the relationships between soft and hard tissues using µCT and diagnostic (hospital) CT, providing better osteological correlates for restoring soft-tissue attributes of fossils. Examples include studies of the evolution of: (1) the brain and neural tissue that provide insight into sensorineural evolution (diceCT); (2) the eyeball and orbital soft tissues that test hypotheses on the visual apparatus of extinct birds and other dinosaurs

(spiceCT); and (3) the vascular system that shed lights on the physiological evolution of thermal strategies in dinosaurs (DCDVI), among others.

Grant Information
Funding provided by the National Science Foundation (IOB-0517257, IOS-1050154, IOS-1456503) and the Ohio University Heritage College of Osteopathic Medicine

Technical Session II (Wednesday, October 17, 2018, 8:15 AM)

A BIZARRE NEW ICTHYOSAUR FROM THE BLUE LIAS FORMATION (LOWER JURASSIC, HETTANGIAN–SINEMURIAN) OF THE UNITED KINGDOM PROVIDES EVIDENCE FOR MOSAIC ICHTHYOSAUR TURNOVER ACROSS THE TRIASSIC/JURASSIC BOUNDARY

WOLNIEWICZ, Andrzej S., University of Oxford, Oxford, United Kingdom; MOTANI, Ryosuke, University of California - Davis, Davis, CA, United States of America; BENSON, Roger B., University of Oxford, Oxford, England

Ichthyosaurs were a successful clade of Mesozoic marine reptiles. Their morphological and taxonomic diversity is thought to have been severely affected by the Triassic–Jurassic extinction event, with only one clade of ichthyosaurs, the parvipelvians, surviving into the Early Jurassic and undergoing an adaptive radiation during the recovery phase of the extinction event. This hypothesis is supported by phylogenetic analyses, which consistently place the Jurassic and Cretaceous ichthyosaur taxa in a derived clade (Neoichthyosauria). Most of our knowledge of the Early Jurassic ichthyosaur fauna comes from the Lower Lias Group ichthyosaur fossils are abundant in museum collections but relatively remains incompletely understood due to the lack of detailed descriptions of their anatomy. Here, we report a new genus and species of parvipelvian ichthyosaur from the Blue Lias Formation (Lower Jurassic, Hettangian–Sinemurian) of the United Kingdom, based on two specimens previously assigned to *Ichthyosaurus*. The new taxon possesses three unambiguous autapomorphies: an overbite comprising ca. 25% of preorbital length, a posteroventral process of the postorbital and a posterodorsal process on the ascending ramus of the jugal. The new taxon also possesses an unusual combination of anatomical characters, including plesiomorphic features, such as the presence of the anterior terrace of the supratemporal fenestra and a posteroventral process of the jugal, and characters present in derived parvipelvians, such as a single foramen for the internal carotid artery in the basisphenoid. Phylogenetic analysis recovers the new taxon as an early-diverging parvipelvian outside of Neoichthyosauria. The phylogenetic position of the new taxon relative to the Late Triassic early-diverging parvipelvians *Macgowania* and *Hudsonelpidia* provides evidence for the previously unrecognized survival of a basal parvipelvian lineage into the Early Jurassic and, together with other recent discoveries, suggests a mosaic pattern of turnover among ichthyosaur lineages across the Triassic-Jurassic boundary.

Grant Information
This study was supported by a Natural Environment Research Council (NERC) Studentship (award no NE/L50/530/1) to A.S.W.

Technical Session XV (Saturday, October 20, 2018, 11:45 AM)

STRUCTURE FROM MOTION PHOTOGRAMMETRY ENHANCES NATIONAL PARK SERVICE VERTEBRATE FOSSIL DOCUMENTATION, PRESERVATION, RESEARCH, AND EDUCATION

WOOD, John R., National Park Service, Lakewood, CO, United States of America; SANTUCCI, Vincent L., National Park Service, Washington, DC, United States of America; WOLIN, Jeff, National Park Service, Florissant, CO, United States of America; MEACHEN, Julie, Des Moines University, Des Moines, IA, United States of America; MATTHEWS, Neffra A., US Bureau of Land Management, Denver, CO, United States of America; BREITHAUPT, Brent H., Bureau of Land Management, Laramie, WY, United States of America

Structure-from-motion (SfM) photogrammetry methods are an increasingly common component of vertebrate paleontological research and resource management. The National Park Service (NPS) is striving to develop a robust SfM program to support park units with documentation efforts, training for staff, and building capacity for 3D data processing. We report on ways that SfM techniques have been applied to in situ body and trace fossil discoveries, monitoring of paleontological localities, and digitization of fossil specimens in museum collections, including whole fossil mounts on exhibit. The capacity within the NPS for photogrammetry to support vertebrate paleontological research is also enhancing collaborative efforts with new fossil discoveries in NPS areas. The recently reported Pleistocene vertebrate trace fossils at White Sands National Monument (WHSA) are an excellent example of fossils and geologic setting best documented through the use of SfM. Traditional methods of documentation or collection were difficult in the gypsiferous sand. Photogrammetry has also enabled detailed track mapping and surface topology of large (6 m high) vertically oriented track blocks, such as the John Wesley Powell track block in Glen Canyon National Recreation Area. The derived 3D data has broad research utility including comparative anatomy, remote analysis, and distance learning. Photogrammetry data are also easily adapted for 3D replica making. Use of such models allows outreach to current and new park audiences, as well as those with visual impairments and others that benefit from interaction with tactile elements. Rapid prototyping (e.g., 3D printing) technology employs newer materials and come with lower costs when compared to traditional replication methods. Photogrammetry also facilitates interagency collaboration. In addition to the multi-disciplinary research team at WHSA, NPS staff collaborated with Bureau of Land Management staff and researchers from Des Moines University with documenting fossil excavation work within Natural Trap Cave. This effort captured the excavation area, as well as the geologic context of the cave. The resulting 3D model of the cave will also be the basis for a virtual reality environment which can present the vertebrate remains recovered from the cave and place them into the context of the cave. New applications for 3D data and SfM photogrammetry methods will continue to expand within fossil vertebrate research. The NPS intends to be at the forefront of developing SfM methods for vertebrate paleontology.

Grant Information
Portions of this work benefited from support either directly or indirectly from grants issued by the National Science Foundation.

Technical Session XVI (Saturday, October 20, 2018, 12:00 PM)

THE ENIGMATIC UPPER CRETACEOUS PACHYCEHALOSAURINE *SPHAEROTHOLUS*: NEW INSIGHT INTO ITS DEVELOPMENTAL LIFE HISTORY AND DIVERSITY

WOODRUFF, D. Cary, University of Toronto; Royal Ontario Museum; Great Plains Dinosaur Museum, Toronto, ON, Canada; EVANS, David, Royal Ontario Museum; University of Toronto, Toronto, ON, Canada; GOODWIN, Mark B., University of California Berkeley, Berkeley, CA, United States of America

The dome-headed pachycephalosaurs represent one of the most bizarre and iconic of dinosaur clades, and some of the most debated pachycephalosaurid work relates to their ontogeny and taxonomic diversity. Pachycephalosaurid diversity in the Maastrichian of North America has been particularly controversial, with numerous published perspectives on the role of ontogeny and variation in defining several key taxa, in particular *Pachycephalosaurus*. The validity and composition of species within the genus *Sphaerotholus* has been equally controversial. The type species, *S. goodwini*, is universally considered a valid taxon. However, debate has centered on the validity of *S. buchholtzae*, which has been considered a junior synonym of '*Prenocephale' edmontonensis*, and whether '*P*'. *edmontonensis* is a distinct member of the genus *Sphaerotholus*. Here we use a combination of morphometrics, histology, and phylogenetic analysis to resolve these debates.

The best-represented member of the genus is *S. buchholtzae*, known from nearly 20 cranial domes. An ontogenetic assessment of *S. buchholtzae* reveals that like other members of this clade, the frontoparietal dome inflates throughout ontogeny. In immature individuals, the dome is asymmetrical in lateral view and posteriorly inflated, with doming progressing anteriorly and circumferentially to form the symmetric and widened dome in mature specimens. Other ontogenetic indicators include obliteration of tesserate surface texture, blunting of the primary peripheral nodes, and decreasing void space within the dome.

Interestingly, linear bivariate analysis finds *S. edmontonensis* nested tightly amongst *S. buchholtzae*, seemingly supportive of the hypotheses that *S. edmontonensis* is not valid and/or an immature *S. buchholtzae*. However, three-dimensional geometric morphometrics, the first ever for Pachycephalosauria, not only substantiates the morphospace distinctness for each species, but also tightly encapsulates ontogenetic series amongst taxa. Phylogenetic analysis recovers a *Sphaerotholus* lineage with *S. goodwini* as sister taxon to a clade formed by *S. edmontonensis* and *S. buchholtzae*.

The stratigraphic, phylogenetic, morphometric, and ontogenetic data supports the validity of both *S. edmontonensis* and *S. buchholtzae*, and their placement within the genus *Sphaerotholus.* The morphologic similarities of *S. edmontonensis* to immature *S. buchholtzae* together with its slightly older geological age, suggests that *S. edmontonensis* and *S. buchholtzae* may be part of an anagenetic lineage.

Technical Session XVI (Saturday, October 20, 2018, 8:15 AM)

FEMUR AND TIBIA OSTEOHISTOLOGY CONFIRMS THE JUVENILE STATUS OF TWO MEDIUM-SIZED LATEST CRETACEOUS TYRANNOSAURIDS AND INDEPENDENTLY TESTS THE '*NANOTYRANNUS*' HYPOTHESIS

WOODWARD, Holly N., Oklahoma State University Center for Health Sciences, Tulsa, OK, United States of America; TREMAINE, Katie, Montana State University, Bozeman, MT, United States of America; WILLIAMS, Scott A., Museum of the Rockies, Montana State University, Bozeman, MT, United States of America; HORNER, John R., Horner Science Group, Bozeman, MT, United States of America; MYHRVOLD, Nathan P., Intellectual Ventures, Bellevue, WA, United States of America

Two mid-sized tyrannosaurid skeletons, collected from the Hell Creek Formation in Montana, are reposited at the Burpee Museum of Natural History (BMRP). Because *Tyrannosaurus rex* is the only mega-carnivore known from the latest Cretaceous of Montana, and due to shared morphologic features, BMRP 2002.4.1 and BMRP 2006.4.4 are generally considered juvenile *T. rex.* However, some researchers suggest they represent mature individuals of the contested tyrannosaurid taxon, '*Nanotyrannus lancensis*', as its somewhat smaller holotype skull (CMNH 7541) shares many morphological characters with the skull of BMRP 2002.4.1. Regardless of taxonomy, ontogenetic details of any tyrannosaurid genus remain poorly understood due to a lack of histological sampling, which would permit assessments of growth rate and maturity status; the BMRP specimens were examined with these aims in mind. Tibiae and femora diaphyseal transverse sections in circularly-polarized light reveal a matrix of fibrous, birefringent laminae containing rounded to elongate osteocyte lacunae, and primary osteons comprised largely of isotropic lamellae with rounded lacunae. Osteocyte lacuna density is uniformly high throughout the cortices and the rich network of vascular canals are arranged in longitudinal, laminar, reticular, and sub-plexiform orientations; although canal orientation and bone fiber arrangement varies locally about the transverse sections. Cortical structures observed in longitudinal sections are consistent with a woven-parallel fibered complex and longitudinal arrangement of lamellae comprising primary osteons. Zonal thickness between annual cyclical growth marks varied rather than decreasing progressively from inner to outer cortex, which is consistent with observations from larger *T. rex* specimens. If all cyclical growth marks are accounted for, BMRP 2002.4.1 was 13 years of age, and BMRP 2006.4.4 was 14 years of age at death, but based on bone tissue and vascular canal patterns, there is no indication that either individual was skeletally mature when it died. This histological assessment aimed to permit a better understanding of tyrannosaurid ontogeny, and in doing so, independently tested and rejected the hypothesis that BMRP 2002.4.1 and BMRP 2006.4.4 are individuals of '*Nanotyrannus*' because of their histologically juvenile status. Instead, the parsimonious conclusion is that BMRP 2002.4.1, BMRP 2006.4.4, and CMNH 7541 are immature *Tyrannosaurus rex*.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

NEW SCINCOMORPHAN AND PLATYNOTAN LIZARDS FROM THE UPPER CRETACEOUS (CAMPANIAN) SAN JUAN BASIN, NEW MEXICO, U.S.A.

WOOLLEY, Charles H., University of Southern California, Los Angeles, CA, United States of America; SERTICH, Joseph, Denver Museum of Nature & Science, Denver, CO, United States of America

Recent microvertebrate collection efforts by the Denver Museum of Nature and Science in the upper Campanian (75.5–73 Ma) Fruitland and Kirtland formations of northwestern New Mexico have significantly increased the taxonomic diversity of lizards in a historically poorly understood squamate assemblage. New lizard specimens from the "Hunter Wash Local Fauna" of the upper Fruitland and lower Kirtland formations include:

(1) the first reported Campanian contogeniid outside of the paracontemporaneous Kaiparowits Formation of Southern Utah; (2) the first described non-chamopsiid scincomorphan morphotypes from the Campanian of New Mexico; and (3) the first reported predatory lizard (Platynota) morphotypes from the Campanian of New Mexico. The increase in lizard diversity in the "Hunter Wash Local Fauna" is a major contribution to our growing understanding of Late Cretaceous lizard taxonomy, distribution, and diversity in the Western Interior of North America (Laramidia). Collectively, the described specimens represent family-level diversity similar to that seen in other Campanian foreland basin deposits of the Western Interior, such as the mid-paleolatitude Kaiparowits Formation of Southern Utah, the higher paleolatitude Dinosaur Park Formation of Southern Alberta, and the lower paleolatitude Aguja Formation of West Texas. The presence of Contogeniidae in the Kaiparowits, Fruitland, and Kirtland formations may represent a unique mid-paleolatitude distribution for the family in Campanian Laramidia, whereas Platynota and other scincomorphans exhibit a more cosmopolitan distribution across the landmass. The taxonomic and biogeographic data presented herein provide a framework for comparison to previous dinosaur-based hypotheses concerning tetrapod distribution and dispersal in the Late Cretaceous of North America. Most importantly, the latitudinal disparity in the 14 paracontemporaneous lizard assemblages in Campanian Laramidia present an as-yet unutilized model to examine the degree to which terrestrial latitudinal diversity gradients in tetrapod groups fluctuate through time in response to climatic, sea-level, and geological changes.

Grant Information

NSF EAR 1647841 and NSF OPP 1341475 (to Nathan D. Smith, Dinosaur Institute, Natural History Museum of Los Angeles County)

Technical Session I (Wednesday, October 17, 2018, 10:30 AM)

DEFINING DINOSAUR NEONATAL BODY SIZE USING OSTEOHISTOLOGICAL EVIDENCE

WOSIK, Mateusz, New Mexico Museum of Natural History and Science, Albuquerque, NM, United States of America; WHITNEY, Megan, University of Washington, Seattle, WA, United States of America; CURRY ROGERS, Kristina, Macalester College, St. Paul, MN, United States of America; WOODWARD, Holly, Oklahoma State University, Tulsa, OK, United States of America; EVANS, David C., Royal Ontario Museum, Toronto, ON, Canada

The earliest life histories of extant vertebrates are punctuated by a transition in bone deposition immediately after birth/hatching and indicated in teeth and bones as a 'neonatal' or 'hatching' line. Recent studies have noted comparable features in perinatal dinosaurs, allowing approximation of hatchling size. Here we investigate embryonic and perinatal bone histology in extant ratites (emu, ostrich) and non-avian dinosaurs (hadrosaurid, hypsilophodontid, sauropod) in order to qualitatively compare the osteohistological signal of hatching.

In ratites, femora and tibiotarsi were thin-sectioned at mid-diaphysis from a series of 13 individuals with known age bracketing the hatching period. In dinosaurs, stylopodial and zeugopodial elements for 17 individuals were similarly thin-sectioned and categorized by size and association with eggshell material. Regardless of taxonomic identity, embryos exhibited highly cancellous and disorganized woven-fibered/parallel-fibered bone complex, whereas perinates have a parallel-fibered/fibro-lamellar bone complex with longitudinally or radially orientated vascular canals. Perinates preserve a narrow zone of reduced vascularity typically coinciding with a darkened band. This circumferentially oriented zone is intraspecifically consistent with known hatchling sizes for ratites and partitions the embryonic and perinatal bone regions, although with some degree of circumferential variation. Therefore, we suggest this is an osteohistological indicator for hatching and tentatively define it as the embryonic-perinatal interface (EPI).

Clarification of the biological meaning of the EPI is important because it provides an accurate neonatal size for growth rate analyses and may convey significant insight for osteohistological cues related to precocity. Further investigation is required to outline the relationships of the EPI to biomechanical, nutritional, environmental, and phylogenetic effects.

Poster Session IV (Saturday, October 20, 2018, 4:15 – 6:15 PM)

EFFECTIVENESS OF HARVESTER ANT MOUNDS AS SAMPLE SOURCES BASED ON GEOGRAPHIC COMPARISON OF OXFORDIAN (JURASSIC) MARINE FAUNA, WYOMING, U.S.A.

WRIGHT, Susannah, University of Wyoming, New Carlisle, OH, United States of America

The nests, also called anthills, of the Western Harvester Ant (*Pogonomyrmex occidentalis*) are valuable sources for small fossil material but are often underutilized in spatial and temporal investigations. This pilot study investigated the ability of fossils recovered from anthills to reflect broad paleoenvironmental trends. To explore the environmental sensitivity of fossil material collected from anthills, I examined small marine fossil material from anthills in the lower Redwater Shale Member (Oxfordian) of the Sundance Formation to test if the taxa reflect a previously hypothesized shallowing-eastward trend of the Sundance Sea. To do this, quart-sized samples of anthill material were collected from four different locations in Wyoming. These samples were washed, dried, sieved, and sorted, then each taxon was weighed. To obtain relative abundances, the weights of each taxon were divided by the cumulative masses of all taxa collected at each location. These values were then compared between locations to identify any existing trends.

No unexpected or unpredicted taxa were observed, which suggests that the anthill material was effectively constrained within the Redwater Shale. However, the data revealed no distinct trends, nor did it provide any definite reflection of the shallowing-eastward model. More conclusive results may be obtained with a larger sample size and area, and further studies may test anthill material in a temporal context instead of a spatial one. Additional investigation and understanding of the inherent biases associated with anthill mounds will result in more effective implementation of this method in the future.

Technical Session VIII (Thursday, October 18, 2018, 4:00 PM)

THE ORAL APPARATUS OF MARSUPIALS IS MORE INTEGRATED BUT NOT LESS MORPHOLOGICALLY DIVERSE THAN THAT OF PLACENTAL CARNIVORES

WROE, Stephen, University of New England, Armidale, Australia; SANSALONE, Gabriele, University of New England, Armidale, Australia

Different clades can display extremely different levels of morphological, taxonomical, and ecological variability. Understanding the factors promoting or decreasing organismal variability is a central question for paleobiologists. To answer this question, researchers have focused on identifying the key innovations that have determined patterns of radiation in specific clades. In this context, developmental constraints can have a major impact on morphological variability (e.g., disparity) and the evolutionary trajectories of shape change. Phenotypic integration, or covariation among traits, has been shown to play an important role in shaping organismal disparity at both micro- and macro-evolutionary scales. A longstanding proposition in the field of mammalian evolution has been that morphological variability among marsupials was limited by developmental constraints, in particular, constraints on the marsupial oral apparatus linked to the need for the embryo to access the mother's teat early in its ontogeny. In this study, we apply a recently proposed Geometric Morphometric approach (i.e., global integration) to investigate phenotypic integration intrinsic to a particular structure, in order to compare morphological disparity in the oral apparatus of marsupial and placental carnivores. Our results show that the marsupial oral apparatus is significantly more integrated than that of placentals; however, at least when fossil specimens are included, morphological disparity among marsupials was not significantly different to that found in placentals. Our findings underscore the importance of including fossil material in evolutionary studies and show that phenotypic integration alone cannot explain the lower morphological variation of extant marsupials. We suggest that extrinsic variables, such as habitat fragmentation, are likely to have played a key role in limiting marsupial disparity.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

TOOTH CYCLING CONTROL: GROWTH RATE AND REPLACEMENT PATTERN IN LIVING ALLIGATORS WITH IMPLICATIONS FOR DENTITION PATTERN IN MESOZOIC BIRDS

WU, Yun-Hsin, University of Southern California, Los Angeles, CA, United States of America; WU, Ping, University of Southern California, Los Angeles, CA, United States of America; CHIAPPE, Luis M., Natural History Museum of Los Angeles County, Los Angeles, CA, United States of America; BOTTJER, David J., University of Southern California, Los Angeles, CA, United States of America; CHUONG, Cheng-Ming, University of Southern California, Los Angeles, CA, United States of America

The existence of tooth replacement in birds has been recognized since the late 19th century, when toothed Hesperornithiformes from the Cretaceous of North America were first described. However, although many birds in the Mesozoic possessed teeth, the evolution of their dentition has remained minimally explored. Here we use *Alligator mississippiensis* as a model to understand the patterns and growth rate of avian toothreplacement.

Modern birds lack teeth, and crocodilians are their living toothed sister group. Moreover, crocodilians and numerous species of extinct Mesozoic birds have conical, non-ziphodont teeth with similar tooth attachment. Crocodilians, including alligators, have an alternating replacement pattern similar to some non-avian theropods. Each tooth position contains a tooth family unit composed of three members: functional tooth, replacement tooth, and dental lamina. To monitor the cyclic tooth growth and replacement in living alligators, we used a Rigaku CT Lab 90 to scan six juvenile *A. mississippiensis* every four weeks for eight months. We measured the length of functional teeth, the length of replacement teeth, and the depth of alveoli in all three tooth-bearing bones: premaxilla, maxilla, and dentary. It has been proposed that the alternating tooth replacement pattern in alligators can be explained by a wave of replacement stimulated by the signals for forming new teeth following a mesial to distal direction in a tooth row. We performed tooth extraction on three of the individuals to see how tooth removal influences replacement patterns. Our results reveal significant differences in the length of functional teeth, the length of replacement teeth, and the depth of alveoli in different tooth-bearing bones. We further quantified the alternating tooth replacement pattern and tooth growth rate. These data show a reversed pattern between functional teeth and replacement teeth, with a relatively medial record of the alveoli through the jaws.

We utilized microCT images to track the growth and replacement patterns to provide insights into the dental development of Mesozoic birds. We hope to combine these analyses with CT data from avian fossils to contribute to the poorly known evolution of avian dentition. Our study will generate the following novel results: (1) control of tooth cycling in living juvenile alligators; (2) insight on tooth cycling in non-avian theropods; and (3) integrate with Mesozoic bird analysis to learn the dentition pattern.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

NEW GEOMYOIDEA FROM THE MIOCENE CAVE BASIN FAUNA OF OREGON

WYATT, Megan R., University of Oregon, Eugene, OR, United States of America; HOPKINS, Samantha S., University of Oregon, Eugene, OR, United States of America

Oregon contains a rich fossil record of Oligo-Miocene flora and fauna, giving us a glimpse into complex ecological interactions in deep time. The Mascall Formation of central Oregon is one of the best- preserved middle Miocene mammal assemblages in the

Northwest. Past work on the Mascall Formation has found a rich carnivore and large herbivore fauna, but because the formation has not yet been extensively screenwashed, there is only a very limited small mammal fauna. Recent work has described sciurids, a marsupial, and eulipotyphlans from new screenwashing localities in the Mascall Formation of the Crooked River Basin. In studying the geomyoid cheek teeth found in the screening, we identified *Harrymys magnus*, an indicator that the Cave Basin assemblage, which is laterally correlative with previously described Mascall assemblages, is Hemingfordian in age like the Hawk Rim assemblage nearby and unlike the Mascall Formation assemblages in the John Day Basin to the north. The Cave Basin assemblage also has occurrences of *Perognathus* and *Mojavemys* as well as some poorly preserved taxa that cannot yet be identified to genus. Species identification for these teeth will provide a baseline for future research of Oregon Miocene faunal ecology and move us one step closer to understanding the diverse middle Miocene terrestrial fauna of the Northwest.

Technical Session XIII (Friday, October 19, 2018, 2:45 PM)

SKULL ELONGATION IN STEM ARCHOSAUR CRANIAL DISPARITY: RE-EVALUATING *DOSWELLIA SIXMILENSIS* (ARCHOSAURIFORMES: PROTEROCHAMPSIA) TO EXAMINE PHYLOGENETIC DISTRIBUTION OF MORPHOLOGICAL DISPARITY

WYND, Brenen M., Virginia Tech, Blacksburg, VA, United States of America; NESBITT, Sterling J., Virginia Tech, Blacksburg, VA, United States of America; HECKERT, Andrew B., Appalachian State Univ, Boone, NC, United States of America

The Triassic Period (252 – 200 Ma) records a great expansion of saurian diversity and disparity, particularly in skull morphology. There is a growing consensus that stem archosaurs exhibit substantial cranial disparity, especially by taxa either shortening or elongating the skull. This disparity is exemplified in the North American Late Triassic proterochampsians by the 'short-faced' *Vancleavea* and the 'long-faced' doswelliids. To critically investigate skull elongation and character evolution in these proterochampsians, we evaluate the enigmatic taxon, *Doswellia sixmilensis*, known from much of a skull, cervical centra and osteoderms from the Bluewater Creek Formation of New Mexico. We redescribe *D. sixmilensis* on the basis of extensive repreparation of the skull material to identify cranial elements, morphological details previously not described, and cranial suture patterns. As such, we reinterpret what was previously regarded as the antorbital fenestra to be the orbit and, as a consequence, the identification of bones and the diagnosis of the taxon must be substantially modified. For the first time, we scored *D. sixmilensis* into the phylogeny of a working dataset of archosauromorphs, consisting of 676 characters and 118 taxa. We recover *D. sixmilensis* within the clade Proterochampsia, possibly as a close relative of *Proterochampsa*, or alternatively closely related to *Doswellia kaltenbachi*, though these relationships are not well supported. What is clear, is that *D. sixmilensis* shares character states with typical proterochampsians (e.g., rimmed orbit) that are not found in *D. kaltenbachi*. The differences between these species of *Doswellia* hint at unrecognized diversity within this clade at low paleolatitudes. More specifically, *D. sixmilensis* exhibits an elongate snout with a suite of unique character states, including the lack of an antorbital fenestra, a premaxilla with a rounded anterior margin, and an increased number of teeth, some of which are shared with phytosaurs. From this it is clear that stem archosaurs experimented with the anterior half of their skulls with a combination of unique and convergent character states.

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

UTILIZING 3-D PRINTING OF DIGITAL MORPHOLOGICAL DATA TO TEST THE MECHANICAL PERFORMANCE OF TEMPOROMANDIBULAR JOINT TRABECULAR BONE STRUCTURE IN CARNIVORANS

WYSOCKI, M. Aleksander, University at Buffalo, Buffalo, NY, United States of America; TSENG, Z. Jack, University at Buffalo, Buffalo, NY, United States of America

Recent results from geometric morphometrics and finite element analysis suggest that carnivoran cranial structure-performance linkages are significantly associated with both feeding and non-feeding variables. Because skulls fulfill multiple functional roles, complex structure-function relationships hinder the ability to definitively classify feeding ecology using overall cranial morphology. Instead, performance measures from specific structures that are involved in feeding behaviors may hold the key to determining feeding ecology. Temporomandibular joint (TMJ) trabecular bone, which undergoes compressive loading during mastication, might offer a useful performance measure for evaluating feeding ecology. Trabecular bone structures were examined across 40 species that are representative of the phylogenetic and ecological diversity of Carnivora. Utilizing a CT database from the American Museum of Natural History built under an NSF-funded project (DEB-1257572), 3D model construction, 3D printing, and material testing, measures of morphology and mechanical performance were obtained for plastic models of mandibular condyle trabecular bone structure. Additional ecological data were compiled from the PanTHERIA database. The results indicate that relative fill volume, relative structural complexity, elastic modulus, and relative maximum compressive strength of trabecular bone structure are not significantly related to phylogeny or ecology. Also, results show that elastic modulus and relative maximum compressive strength are positively correlated with relative fill volume, but negatively correlated with relative structural complexity. Trabecular structure volume and maximum compressive strength are significantly related with body size and the relationships do not significantly differ from isometry. In contrast, positive size allometry occurs for structural complexity. The results of these computational analyses suggest that the structure-performance relationships in TMJ trabecular bone of Carnivora are not sensitive to the feeding ecological categories examined, and that both non-feeding ecological variables and size allometry confound paleontological reconstructions of feeding ecology using structure-performance linkages.

Grant Information
This project is funded by National Science Foundation grant DEB-1257572 to Z.J. Tseng, J.J. Flynn, C. Grohe, and M. Spaulding.

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

LARGEST FRESHWATER TURTLE FROM THE CRETACEOUS OF NORTH AMERICA: STABLE ISOTOPE COMPOSITION OF THE TOXICHELYID-LIKE TURTLE FROM THE KAIPAROWITS FORMATION

YAMAMURA, Daigo, University of Arkansas Fort Smith, Fort Smith, AR, United States of America; SUAREZ, Celina A., University of Arkansas, Fayetteville, AR, United States of America; TITUS, Alan, Bureau of Land Management, Kanab, UT, United States of America; MANLOVE, Hunter, University of Texas, Austin, TX, United States of America

The Late Campanian Kaiparowits Formation (74–76.5 Ma) is a very fossiliferous sedimentary sequence in south-central Utah. Although the majority of the Kaiparowits Formation was deposited in a fluvial-lacustrine environment, the lower portion of the middle member exhibits potential marine influence. In 2014, an extensive bonebed was found in a conglomeratic sandstone unit of fluvial origin, known as the "Rainbows and Unicorns" quarry. The quarry has yielded a wide variety of turtle taxa including a probable two meter diameter toxichelyid-like taxon that may be the largest freshwater turtle ever collected from the terrestrial Cretaceous of North America. Alternatively, the toxichelyid-like taxon may be of marine origin, similar to *Archelon* since it is located near the base of the marine-influenced middle member. In an effort to test for a marine origin of the toxichelyid-like turtle, stable isotope O-isotopic compositions of phosphate ($\delta^{18}O_p$) of the shell was analyzed against other freshwater turtles from the site. The oxygen isotope composition of the bone phosphate does not show a significant difference from other freshwater turtles found in the quarry, including a smaller baenid, *Neurankylus* (large baenid), *Gilmoremys* (a smaller trionychid), and a larger unidentified trionychid. The oxygen isotope composition of their drinking/ living water ($\delta^{18}O_w$) calculated from $\delta^{18}O_p$ are -10.9 ± 1.57‰, -11.8 ± 1.35‰, -11.0 ± 2.54‰, -12.9 ± 2.45‰, and -11.2 ± 1.03‰ for the large toxichelid-like taxon, the small baenid, *Neurankylus*, *Gilmoremys*, and the larger trionychid respectively. The stable isotope data support that the toxichelyid-like taxon is a freshwater turtle. In addition, potential difference in diet will be investigated using the carbon isotope composition ($\delta^{13}C$) of the carbonate component of shell.

Grant Information
BLM L17AC00096

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

ANATOMY OF THE MALLEUS AND ECTOTYMPANIC IN *HYAENODON MUSTELINUS* (MAMMALIA, HYAENODONTA)

YAN, Xiaoke, The Webb Schools, Claremont, CA, United States of America; BASE, Juliana M., The Webb Schools, Claremont, CA, United States of America; BORTHS, Matthew R., Ohio University, Athens, OH, United States of America; FARKE, Andrew A., Raymond M. Alf Museum of Paleontology, Claremont, CA, United States of America

The delicate bones of the mammalian ear region provide information on hearing capabilities and evolutionary relationships, yet are infrequently described in fossils owing to inaccessibility, poor preservation, and technical limits of preparation and digital scanning. This is particularly true for the iconic carnivorous mammal *Hyaenodon*, a widespread faunal element in many North American and Eurasian assemblages from the Eocene through Miocene. Despite its ubiquity, the biogeography and relationships of *Hyaenodon* are underexplored. Of its auditory ossicles, only the incus has been described previously, from a specimen referable to *H. exiguus* (late Oligocene, France). No auditory ossicles have been described for any North American *Hyaenodon*, and the ectotympanic has not been described previously in *H. mustelinus*. Here, we describe a malleus and ectotympanic of *Hyaenodon mustelinus*, from a nearly complete associated skeleton of a subadult from the Brule Formation of Niobrara County, Wyoming (RAM 14347, Raymond M. Alf Museum of Paleontology).

The malleus of RAM 14347 has a maximum length of 4.95 mm from manubrium to head. Two articular facets for the incus mark the head; the flattened superior facet is distinctly larger than the convex inferior facet. This matches with the dual facets observed in *H. exiguus*, suggesting consistency of the morphology across *Hyaenodon*, and a different morphology from that seen in *Nandinia* (palm civet) or most carnivorans. The muscular process on the medial surface is quite small by comparison to specimens of many extant carnivorans (e.g., *Felis*). The manubrium of the malleus in *H. mustelinus* is relatively short and broad, as compared to the conditions in *Felis* and *Nandinia*.

The ectotympanic in RAM 14347 is a bony ring, forming approximately 320 degrees of a complete circle, with a maximum diameter of 8.8 mm. The inner diameter is grooved, most prominently anteriorly and posteriorly. The posterior crus of the ectotympanic is wider than the anterior crus. Internally, each crus is hollow, but this space does not communicate externally.

The morphology of the malleus and ectotympanic can now be used, like the incus, to investigate the preferred habitat of *Hyaenodon*, to reconstruct relationships within the widespread genus as ear ossicles and other basicranial structures are modeled using non-invasive scanning techniques, and to test whether Hyaenodonta is monophyletic and belongs within Ferae or on a different branch of the mammalian family tree.

Grant Information
David B. Jones Foundation, US NSF grant DBI-1612062

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

INTRATOOTH ISOTOPE PROFILES OF FOSSIL SUIDS FROM THE KOOBI FORA FORMATION (EAST TURKANA, KENYA) INDICATE SEASONALLY STABLE C_4 DIETS BUT SEASONALLY VARIABLE BODY WATER OR HYDROCLIMATE

YANG, Deming, Stony Brook University, Stony Brook, NY, United States of America; UNO, Kevin, Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY, United States of America; CERLING, Thure, University of Utah, Salt Lake City, UT, United States of America

Previous studies investigating the changing environment in eastern Africa have employed stable light isotope analysis in tooth enamel for paleoenvironmental reconstruction. Despite an extensive isotopic record of the Pleistocene fossil fauna, most studies have utilized a single sample from each tooth, which usually averages the animal's diet over the time represented in the sample. Intratooth isotope profiles can reveal seasonal changes in diet and body water, which can serve as a proxy for environmental seasonality in rainfall

or vegetation. Most suids in the early Pleistocene have high-crown molars or long canines (tusks), both of which are ideal for intratooth profiles.
The goal of this study is to investigate intra-individual variability in carbon isotopes as a proxy for dietary and habitat heterogeneity and in oxygen isotopes as a proxy for body water and rainfall seasonality. We selected three canines of *Kolpochoerus*, and three third molars each from *Metridiochoerus* and *Notochoerus* from Upper Burgi and KBS members of the Koobi Fora Formation (~2.1–1.5 Ma). We investigated their dietary response to seasonality by examining carbon and oxygen isotopes in enamel that was sequentially sampled along the growth axis of each tooth.
The $\delta^{13}C$ values of almost all suid individuals indicate that they were predominantly C_4 grazers throughout the year, with a small degree of intra-individual variation in $\delta^{13}C$ (Δ = ~1‰ to 2‰), whereas a much greater range is observed in $\delta^{18}O$ (Δ = ~1‰ to 7‰). This wide range of intra-individual variation in $\delta^{18}O$ is greater than that of extant warthogs and bushpigs from Kenya, Malawi, and Congo (Δ = ~2‰ to 6‰), using similar sampling methods.
Intratooth profiles of fossil suids can provide insights into vegetation and hydroclimate variations of hominin fossil sites. This preliminary dataset allows for limited interpretation of long-term climatic trends, but additional samples will be analyzed, which we anticipate will shed light on paleoenvironments across space and time in the Koobi Fora Formation, and the suggested faunal turnover at ~1.8 Ma. Similar methods can be extended to other fossil mammals, particularly those with hypsodont or continuously growing teeth/tusks.
Grant Information
DY thanks The Leakey Foundation, the University of Utah, and the Turkana Basin Institute for sponsoring this project.

Romer Prize Session (Thursday, October 18, 2018, 8:00 AM)

CLUTCH ARCHITECTURE, NEUTRON TOMOGRAPHY, AND ELEMENTAL MAPPING REVEAL HATCHING ASYNCHRONY AND COMMUNALNESTING IN OVIRAPTORID DINOSAURS AND HIGHLIGHT THEIR PECULIAR REPRODUCTIVE BIOLOGY
YANG, Tzu-Ruei, Universität Bonn, Bonn, Germany
Oviraptorid dinosaurs left a superb record of skeletal fossils, clutches, and eggs that inform on their reproductive biology. The association of an adult "sitting" on a clutch is well known from several Mongolian fossils, and previous studies concluded that oviraptorids exhibited monochronic ovulation, communal nesting, brooding, and polygamy. However, detailed documentation of such occurrences has been lacking. Careful analysis of complete oviraptorid clutches now reveal a clutch architecture of three to four superimposed rings of eggs arranged in pairs. The blunt ends of the eggs are inclined at an angle of >40 degrees towards the clutch center devoid of eggs.
Whereas isolated embryo-containing eggs have been reported, such eggs preserved in a clutch could provide much additional information on oviraptorid breeding biology, such as on breeding patterns and hatching hierarchy. Only one partial clutch of embryo-containing eggs has been reported. This material from Mongolia consists of four eggs that lack unequivocal evidence for origination from a single clutch, however. We report a new, better preserved partial clutch with three embryo-containing eggs, a single egg and a pair, from the Late Cretaceous Nanxiong Formation of Jiangxi Province, China. Based on egg arrangement and geopetal features, there were at least two rings, and the single egg is from the upper ring. The single egg thus was laid later than the pair below. This accords with the observation, based on partial preparation of the embryos, that the embryo in the single egg is at an earlier developmental stage than those in the pair, and thus would have hatched later than its putative siblings, an adaptation known as "hatching asynchrony" in extant birds. The observation of different developmental stages is corroborated by neutron tomographic imaging and differences in eggshell resorption of the single egg vs. the pair. Hatching asynchrony could have been caused by sequential laying of eggs by a single female or by multiple females contributing to the clutch sequentially. The latter hypothesis is supported by elemental analyses of eggshells from the same clutch that shows inter-pair differences in phosphorus distribution, which is an indicator of female age. Oviraptorid hatching asynchrony, the only known in nonavian dinosaurs, is inconsistent with the putative brooding behavior because brooding would have synchronized egg development, independently of egg parentage. Available evidence thus points to a unique reproductive biology of oviraptorids lacking modern analogs.
Grant Information
Deutsche Forschungsgemeinschaft Forschergruppe 2685; Jurassic Foundation; Research grant of FRMII, Heinz Maier-Leibnitz Zentrum (MLZ), Garching, Germany

Poster Symposium (Wednesday–Saturday, October 17–20, 2018, 4:15 – 6:15 PM)

A SMALL CROCODYLIFORM (ARCHOSAURIA, CROCODYLOMORPHA) FROM THE EARLY CRETACEOUS JEHOL BIOTA OF CHINA, WITH HINDLIMBS ADAPTED FOR CURSORIAL LOCOMOTION
YI, Hongyu, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, China
Crocodyliforms are hitherto unknown from the Early Cretaceous Jehol Biota of northeastern China. In the Jehol Biota, the "Mesozoic Pompeii", various vertebrates, insects, and plants were rapidly buried during cycles of volcanic activities and exquisitely preserved in the lacustrine deposits of the Yixian Formation and Jiufotang Formation. Here a new crocodyliform is described from the Yixian Formation in Jianchang County of Liaoning Province. The specimen (IVPP V18004) preserved an incomplete yet articulated postcranial skeleton including nine dorsal, 2–3 sacral, and 24–25 caudal vertebrae, as well as the pelvis and hindlimbs. No osteoderm was observed. The last five dorsals are associated with no ribs or highly reduced, spur-shaped ribs. The calcaneum shows a posteriorly projecting tuber that is typical of crocodylomorphs. Metatarsals II–IV are elongate and subequal in length. The fifth metatarsal is reduced as in modern crocodilians. The combined morphology of a rib-free "lumbar" region, unfused sacral vertebrae and a calcaneal tuber suggests crocodylomorph affinity and precludes affinities to lepidosaurs, choristoderes, pterosaurs, birds, or dinosaurs. Within the Crocodylomorpha, the hindlimb of the new specimen is unusually proportioned, with the femur being shorter than the tibia and fibula. This contrasts with neosuchians and resembles a basal crocodyliform, *Shantungosuchus chuhsienensis*, from the Early Cretaceous of Shandong province that is south of Liaoning. However, the new specimen differs from *S. chuhsienensis* in a prominent expansion in the proximal head of the tibia. A more rigorous phylogenetic analysis is necessary to evaluate the position of the new specimen and the incompletely preserved *S. chuhsienensis*. The femur measures about 33 mm long, and the tibia and fibula about 35 mm. The size and proportion of the hindlimb indicates a small, cursorial animal whose habitat was likely terrestrial. This new Jehol individual shows that small-bodied basal crocodyliforms were more widely distributed in northern China than previously known. The unusual limb proportion adds information to understanding posture evolution in basal crocodyliforms. The Lower Cretaceous beds in Jianchang County, from which the new specimen was discovered, have yielded several semi-aquatic choristoderes. This lends weight to the hypothesis of niche partitioning between crocodyliforms and choristoderes in Mesozoic faunas.
Grant Information
The Strategic Priority Research Program (B) of the Chinese Academy of Sciences (XDB18030504); the National Natural Science Foundation of China (Grant No. 41702020 & 41688103)

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

A NEW SAUROPOD FROM THE LATE JURASSIC OF MONGOLIA
YOSHIDA, Junki, Sapporo, Japan; TSOGTBAATAR, Chinzorig, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; KOBAYASHI, Yoshitsugu, Hokkaido University museum, Sapporo, Japan; KHISHIGJAV, Tsogtbaatar, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia
In the Late Jurassic, eastern Asia was an isolated continent, known as the Asian continent, and had endemic sauropods, mamenchisaurids. Fossil records of mamenchisaurids are rich in the southern China (southern Asian continent) but rare in the northern area, where only two genera are known from northern China (*Xinjiangtitan* and *Mamenchisaurus sinocanadorum*). A previous study reported a pes of a mamenchisaurid from the Upper Jurassic Dariv Formation of Mongolia, but its phylogenetic status was not tested.
In 2002, a partial sauropod skeleton, represented by a cervical vertebra, caudal vertebrae, and pelvis, was discovered from the Upper Jurassic Dariv Formation and shows unique features, such as triangular transverse process of anterior caudal vertebra tapering distally, and ventral position of transverse process of anterior caudal, suggesting it is a new taxon. Our phylogenetic analysis confirms that the Dariv form is a mamenchisaurid and demonstrates that it is a sister taxon to the least inclusive clade of *Yuanmousaurus* and *Xinjiangtitan* from the Middle Jurassic. This result suggests that basal mamenchisaurids were distributed in southern Asian continent, and derived mamenchisaurids were present in both northern (the Dariv form and *Xinjiangtitan*) and southern (*Yuanmousaurus*) regions of the continent.
The pelvis of the Dariv form also shows noteworthy traits for its locomotion: a ventral expansion of the preacetabular process, an elongate pubic peduncle of the ilium, and a prominent ambiens process of the pubis, and tuberosities on postacetabular process of the ilium and the main body of the ischium. These traits are muscle attachment sites of the extensor and flexor muscles of the hip and knee joints, suggesting that the Dariv form had a more powerful stroke of hindlimb than other members of mamenchisaurids.
Grant Information
Funded by the Young Explorer Grant in Asia of the National Geographic Society

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A BASAL CERATOPSIAN DINOSAUR FROM THE EARLY CRETACEOUS OF MONGOLIA AND THE EARLY EVOLUTIONARY HISTORY OF THIS GROUP
YU, Congyu, American Museum of Natural History, NEW YORK, NY, United States of America; TSOGTBAATAR, Chinzorig, Mongolian Academy of Sciences, Ulaanbaatar, Mongolia; ZORIGT, Badmaa, Montana State University, Bozeman, MT, United States of America; NORELL, Mark, American Museum of Natural History, NEW YORK, NY, United States of America
During the last 20 years, several basal ceratopsian dinosaurs have been recovered from Late Jurassic/Early Cretaceous sediments in Asia, including *Yinlong*, *Archaeoceratops*, *Liaoceratops*, etc. These new discoveries help us reconstruct the early evolutionary history of ceratopsian dinosaurs and these basal taxa show distinct differences compared to more derived species in both Asia and North America.
Here we report a new basal ceratopsian dinosaur based on a partial skull and some post-cranial elements discovered from supposed Early Cretaceous strata in Baruunbayan locality, Ömnögovi aimag, Mongolia. The new specimen shares a combination of features between basal ceratopsians and those of more derived taxa. The partial skull preserved most of its roof elements but lacks the parietal and most of its frontal. The specimen is diagnosed by the following unique features: a high premaxilla with four enlarged cylinder-shaped premaxillary teeth, a trapezoidal antorbital fossa with poorly delineated anterior margin, very short dentary with an expanded and shallow groove on its lateral surface, a robust jugal with a bizarre foramen in its anterior interior part, and five equally spaced tubercles on the lateral ridge of surangular. Phylogenetic analysis suggests a basal position in the clade Ceratopsia of this specimen and its very close relationship with Psittacosauridae and Chaoyangsauridae.
The discovery of this specimen suggests that the diversity of early ceratopsian dinosaurs could be higher than previously expected, thus the evolutionary history was probably more complicated. Also, the locality of the new specimen shows a larger geological distribution of ceratopsian dinosaurs during the Early Cretaceous. Though not well dated, the occurrence of this specimen and other environmental factors represent the earliest Early Cretaceous age.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

CURVATURE OF MANUAL BONES OF MICRORAPTORINE THEROPODS: POSSIBLE IMPLICATION FOR ARBOREAL BEHAVIOR

YU, Yilun, Beijing, China; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

Microraptorinae is a recently discovered dromaeosaurid sub-clade that has generated hot debates on the origins of bird flight. Most microraptorine species are lightly-built and possess several features that have been considered by some studies to be flight- or arboreality-related, including large flight feathers attached to the hindlimbs and strongly curved pedal claws. Our recent examinations of manual morphology of some microraptorine specimens have revealed an interesting feature: the metacarpal and phalangeal bones of these microraptorines display ventral curvature of variable degree, a feature unknown in other non-avialan theropods, which in general have straight manual bones. We further compared the relative curvature of manual bones of the microraptorine *Graciliraptor lujiatunensis* and a few typical cursorial theropods using high-resolution polynomial curve fitting (HR-PCF.) method, and the results indicate that the manual bones of the former has much higher values than the latter. Given that strong curvature of forelimb bones, particularly of manual bones, is a good indicator for arboreality of modern primates, we suggest that curvature of the manual bones of microraptorine theropods may provide an additional line of evidence for the arboreality of some microraptorine theropods, though this need be further confirmed by collecting additional data and using other testing methods.

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

NEW LEPTICTIDS (MAMMALIA) FROM THE UINTAN (EOCENE) OF SAN DIEGO COUNTY, CALIFORNIA

ZACK, Shawn P., University of Arizona-College of Medicine, Phoenix, Phoenix, AZ, United States of America; PENKROT, Tonya A., Arizona State University, Phoenix, AZ, United States of America

Until recently, Uintan leptictids have been poorly documented, with only a single named species from the Cypress Hills region of Saskatchewan. Two new species were named in 2016, one from Wyoming and one from Utah, but Uintan leptictid diversity remains inadequately understood. Leptictids have been mentioned but not previously described from the Uintan of southern California. Here we report two taxa, both of which appear to be new, from deposits of the early Uintan Friars Formation in San Diego County, California.

The smaller of the two new species is primarily documented by a well-preserved specimen comprising a maxilla and associated dentaries that collectively preserve the upper and lower canines and complete cheek dentitions as well as the bases of the lower incisors. The new species is similar in size to *Palaeictops borealis*, but most specimens are slightly smaller. Comparable teeth differ most notably in having more transverse P5 and M1 with reduced parastylar regions. The new form is distinctive in having an inflated P4 and p4; the latter tooth is relatively tall for its length and has a weak protostylid.

The larger species is represented by a dentary with worn, poorly preserved p2 and p5–m3, a dentary fragment with erupting m3, and isolated teeth, most notably a well-preserved p5. This new species is similar in size to the recently named *Palaeictops robustus* but differs in having a more robust dentary and a more compact cheek dentition. The isolated p5 is distinctive in being noticeably exodaenodont and in having a massive paraconid equivalent in height to the talonid.

Overall, leptictid remains are extremely rare in faunas from the Friars Formation, comprising fewer than 50 out of more than 13,000 mammalian specimens from the unit. While the two species have not been recovered together from any single locality, they occur in strata of equivalent age, providing the first evidence for multiple, contemporaneous leptictid taxa coexisting in a single Uintan fauna. Taken together, they nearly double the known diversity of Uintan leptictids and indicate that the group remained relatively diverse during this interval, despite its poor fossil record.

Technical Session XVI (Saturday, October 20, 2018, 9:15 AM)

THE FIRST THEROPOD SKELETON FROM SWITZERLAND? A NEW TAXON IMPROVES OUR KNOWLEDGE OF THE EARLY EVOLUTION OF NEOTHEROPOD DINOSAURS

ZAHNER, Marion, Universty of Zurich, Zurich, Switzerland; BRINKMANN, Winand, Zurich, Switzerland

The Late Triassic and Early Jurassic theropod record has greatly improved over the last two decades, with a number of new fossils. But, many taxa are represented by only a few bones that are often hardly diagnostic. Specimens from Europe in particular are usually very fragmentary. In 2006 and 2009, a spectacular discovery was made in the Norian Gruhalde Member (Klettgau Formation) of the Gruhalde clay pit in Frick (Aargau, Switzerland), the most prolific European locality for Late Triassic saurischian dinosaurs. An impressively well preserved theropod skeleton (SMF 06-1 and 09-2) was excavated that pertains to a subadult individual of a new genus and species. The holotype material comprises parts of the postcranium, an almost complete skull, and stomach contents. From the latter, remains of the rhynchocephalian *Clevosaurus* have been identified. The Swiss specimen is not only important due to its excellent preservation, but also because of its distinctive morphological characters and their significance for a better understanding of early neotheropod evolution. In the material features occur that are typically found in either of two considered subgroups within Coelophysoidea: the coelophysids and the dilophosaurids. Whereas the former clade is rather stable and has been repeatedly confirmed in numerous analyses, the latter one is more controversially discussed. Traditionally, the Coelophysoidea merges most predatory dinosaurs that are more basal than tetanurans. But, whether this group is monophyletic or not is still an open question. The phylogenetic relationships of the Swiss theropod were tested in a comprehensive phylogenetic analysis focusing on taxa that are usually assigned to the Coelophysidae, and Dilophosauridae, as well as some averostrans. Similar to previous studies, the family Coelophysidae was always well supported. On the other hand, a dilophosaurid clade was only found when the majority of averostrans were excluded from the analysis. The new Swiss taxon was always recovered within Coelophysoidea *sensu lato*, and in this group as one of the basal most members of Neotheropoda other than Coelophysidae.

In sum, the new Swiss finding considerably increases the poor fossil record of Late Triassic European theropods and its unique combination of characteristic traits gives new insights concerning the early diversification and evolution of neotheropod dinosaurs. Furthermore, the preserved stomach contents provide an important contribution to the reconstruction of ancient food chains.

Poster Session I (Wednesday, October 17, 2018, 4:15 – 6:15 PM)

A DIMINUTIVE TYRANNOSAUROID FROM THE DAWN OF THE LATE CRETACEOUS IN NORTH AMERICA

ZANNO, Lindsay, North Carolina Museum of Natural Sciences, Raleigh, NC, United States of America; GATES, Terry A., NC State University, Raleigh, NC, United States of America; CANOVILLE, Aurore, NC Museum of Natural Sciences, Raleigh, NC, United States of America; TUCKER, Ryan, Stellenbosch Univ, RSA, Stellenbosch, South Africa; AVRAHAMI, Haviv M., Raleigh, NC, United States of America; MAKOVICKY, Peter J., Field Museum of Natural History, Chicago, IL, United States of America

Over a century of collection has yielded a diverse record of large-bodied, specialized tyrannosaurids from Campanian-Maastrichtian ecosystems of North America (NA). By contrast, the establishment and early evolution of intermediate tyrannosauroids on the continent remains obscure. This sampling disparity has crippled attempts to reconstruct patterns and processes associated with the inception of tyrannosaurs as apex predators within Late Cretaceous ecosystems. Here we report the discovery of a new species of small-bodied, gracile tyrannosauroid (NCSM 33392) from the Cenomanian-aged, lower Mussentuchit Member, upper Cedar Mountain Formation, Utah, establishing the earliest diagnostic tyrannosaur within NA Cretaceous ecosystems. The new taxon is represented by an isolated, yet associated, right hind limb, bearing a semicircular tuberosity craniomedial to the lesser femoral trochanter; and a compressed, subtriangular distal articular surface of MT IV with hypertrophied craniolateral aspect and deeply incised, striated groove. Analysis of co-occurring and bounding detrital zircon grain populations indicates a depositional age range of 96.3–93 Ma.

Femoral histology of NCSM 33392 shows parallel-fibered bone matrix dominated by longitudinal vascular canals, a single layer of lamellar endosteal tissue, and no evidence of remodelling, which is indicative of a skeletally immature individual, exhibiting a slow to moderate growth rate and a terminal age of 6–7 years. With an approximate subadult limb length of 1.2 meters, estimated skull length of 360–400 mm, and interpolated mass of 78 kg (range 53–85 kg), a mature individual of the new species would have most closely approximated other mid-Cretaceous species (e.g., *Xiongguanlong*, *Timurlengia*) in body size. Relative proportions suggests a gracile hind limb, concordant with *Alectrosaurus*, juvenile Campanian tyrannosaurids, and some NA ornithomimids.

Phylogenetic analyses using three recent datasets posit NCSM 33392 as an intermediate tyrannosauroid closely related to taxa from the mid-Cretaceous of Asia including *Xiongguanlong*, *Timurlengia*, *Alectrosaurus*, and undescribed materials from the Iren Dabasu Formation, as well as "relic" taxa from eastern NA (i.e., *Appalachiosaurus*, *Dryptosaurus*). These data support emplacement of non-tyrannosaurid tyrannosauroids in NA via Laurasian interchange prior to the dawn of the Late Cretaceous, and establish a phylogenetic predecessor for eastern NA taxa closer to the isolation of Appalachia during the terminal Cretaceous.

Grant Information
Canyonlands Natural History Association Discovery Pool 2014 & 2015

Poster Session II (Thursday, October 18, 2018, 4:15 – 6:15 PM)

A NEW DINOSAUR FOSSIL LOCALITY OF MID-CRETACEOUS AGE IN NORTHEASTERN CHINA

ZHANG, Lizhao, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; JIN, Changzhu, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China; YIN, Qingzhu, University of California-Davis, Davis, CA, United States of America; HUYSKENS, Magdalena, University of California-Davis, Davis, CA, United States of America; JIN, Dongchun, Yanbian Seismological Bureau, Yanji, China; ZHANG, Junlong, Institute of Earthquake Science, Beijing, China; JIN, Feng, Yanji Land Resources Bureau, Yanji, China; XU, Xing, Institute of Vertebrate Paleontology & Paleoanthropology, Beijing, China

Terrestrial vertebrate fossils are rich in the Cretaceous of northeastern China in general, but they are comparatively rare in deposits of mid-Cretaceous age. In 2016, we discovered a new dinosaur fossil locality in Longshan, Yanji City, Jilin Province, northeastern China. Two years' excavations resulted in the collection of numerous fossils of sauropods, theropods, ankylosaurs, ornithopods, crocodiliforms, and turtles as well. These fossils were mainly recovered from five layers in the Longshan locality. The third and fifth fossil-bearing layers are stable and continuous, while the other three are limited in distribution. The Longshan beds can be correlated to the lower part of Longjing Formation. Previous paleontological and radiochronological data suggested that the Longjing Formation was formed 100 Ma–91Ma. Our CA-ID-TIMS radiometric dating based on zircon samples collected from the fossil-bearing beds at the Longshan Locality produced a precise age of 101.039±0.061 Ma. The discovery of the Longshan dinosaur fauna is significant for understanding the mid-Cretaceous terrestrial ecosystem in northeastern Asia.

Grant Information
Supported by the Natural Science Foundation of China (NSFC 41688103)

Poster Session III (Friday, October 19, 2018, 4:15–6:15 PM)

NEW SPECIMENS OF THE FRESHWATER SINEMYDID TURTLE *ORDOSEMYS* WITH IMPLICATIONS FOR DIVERSITY, PALEOECOLOGY, AND PALEOGEOGRAPHY

ZHOU, Chang-Fu, Shandong University of Science and Technology, Qingdao, China; LI, LAN, Peking University, Beijing, China; LI, Da-Qing, Gansu Agricultural University, Lanzhou, China; WU, Wen-Hao, Jilin University, Changchun, China

Sinemydids, as a basal eucryptodiran group, are flourished in the Early Cretaceous fluvial/lacustrine strata in North China. Of these, *Ordosemys* is widely distributed from the eastern Xinjiang to the western Liaoning. Recently, new materials of *Ordosemys* collected

from Shandong, Jilin, and Liaoning provinces, further increase our understanding of its diversity, paleoecology, and paleogeography.

Four specimens of *Ordosemys* are firstly discovered from the Early Cretaceous Mengyin Formation of Ningjiagou site in Xintai, Shandong, and preserved together with a juvenile skeleton of the well-known *Sinemys lens*. These fossils are characteristic by having a longer supraoccipital crest, a circular shell, a preneural, a broad contact of peripheral 1 and costal 1, wide vertebrals, and well-developed vertebral plications. And also, they exhibit a possible plaeoecological variation in having the moderately elongate manus that is about 129% of the ulna in length, different from *O. liaoxiensis* and other sinemydids (e.g., *Xiaochelys* and *Changmachelys*), in which the manus is nearly twice the length of the ulna. Another three fossils of *Ordosemys* are firstly collected from the Early Cretaceous Hengtongshan Formation of Xingling site in Meihekou, Jilin, Northeast China. These specimens are assigned to *Ordosemys* by a circular shell, parallel-sided costals 3, wide vertebrals, and two median plastral fenestrae.

Furthermore, a new skeleton of *Ordosemys liaoxiensis* from western Liaoning is exceptionally preserved with the soft-tissue imprints around the tail and hindlimbs. The long tail is ornamented dorsally by scales arranged longitudinally, as the snapping turtles, different from the ring-like scales around the tail of the big-headed turtles. Around the hindlimbs, scales are less developed on the naked skin. The foot is paddle-like with webbed toes. These features indicate *O. liaoxiensis* resembles the snapping turtles in having a similar aquatic habit, which is possible for the whole group of *Ordosemys*.

These discoveries further enrich the taxonomical diversity of *Ordosemys* and well expands its paleogeographical distribution south to Shandong, and northeast to Jilin. Paleoecologically, *Ordosemys* has a similarity with the snapping turtles in the aquatic adaptation, and appears to be varied interspecifically. Therefore, in contrast with the other co-existed sinemydids (e.g., *Sinemys*, *Dracochelys*, *Wuguia*, and *Manchurochelys*), *Ordosemys* appears to have a much wider geographical distribution, possibly implying a paleoecological advantage.

Grant Information

The Shandong Provincial Natural Science Foundation (ZR2017MD031)

INDEX

(Page number follows author's name.)

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Y

Z

SAVE THE DATE

2019 Annual Meeting

OCTOBER 9 – 12, 2019

Brisbane Convention & Exhibition Centre

Brisbane, Queensland, Australia

SVP
SOCIETY OF VERTEBRATE PALEONTOLOGY