PROCEEDINGS

OF THE

Indiana Academy of Science

1900.

EDITOR, - - GEO. W. BENTON.

ASSOCIATE EDITORS:

C. A. WALDO,
C. H. EIGENMANN,
V. F. MARSTERS,
M. B. THOMAS,
W. A. NOYES,
STANLEY COULTER,
THOMAS GRAY,
JOHN S. WRIGHT.

INDIANAPOLIS, IND.
1901.

INDIANAPOLIS:
WM. B. BURFORD, PRINTER,
1901.

TABLE OF CONTENTS.

* Publication of the Proceedings of the Indiana Academy of Science began in 1891.

AN ACT TO PROVIDE FOR THE PUBLICATION OF THE REPORTS AND PAPERS OF THE INDIANA ACADEMY OF SCIENCE.

[Approved March 11, 1895.]

Preamble.

Whereas, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory body, assist in the direction and execution of any investigation within its province, without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State, and,

Whereas, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form, and,

Whereas, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement, therefore,

Publication of the reports of the Indiana Academy of Science.

Section 1. *Be it enacted by the General Assembly of the State of Indiana,* That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

Editing reports.

Sec. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such services, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports, shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less

Number of printed reports.

than 1,500 nor more than 3,000 copies of each of said reports shall be published, the size of the edition within said limits, to be determined by the concurrent action of the editors and the Commissioners of Public Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894.

Proviso.

Disposition of reports.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

Emergency.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage.

AN ACT FOR THE PROTECTION OF BIRDS, THEIR NESTS AND EGGS.

[Approved March 5, 1891.]

Birds.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That it shall be unlawful for any person to kill any wild bird other than a game bird, or purchase, offer for sale any such wild bird after it has been killed, or to destroy the nests or the eggs of any wild bird.

Game birds.

Sec. 2. For the purpose of this act the following shall be considered game birds: the Anatidæ, commonly called swans, geese, brant, and river and sea ducks; the Rallidæ, commonly known as rails, coots, mudhens, and gallinules; the Limicolæ, commonly known as shore birds, plovers, surf birds, snipe, woodcock and sandpipers, tattlers and curlews; the Gallinæ, commonly known as wild turkeys, grouse, prairie chickens, quail, and pheasants, all of which are not intended to be affected by this act.

Penalty.

Sec. 3. Any person violating the provisions of Section 1 of this act shall, upon conviction, be fined in a sum not less than ten nor more than fifty dollars, to which may be added imprisonment for not less than five days nor more than thirty days.

Permits.

Sec. 4. Sections 1 and 2 of this act shall not apply to any person holding a permit giving the right to take birds or their nests and eggs for scientific purposes, as provided in Section 5 of this act.

Permits to Science.

Bond.

Bond forfeited.

Sec. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science to any properly accredited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to said Board written testimonials from two well-known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege and pay to said Board one dollar to defray the necessary expenses attending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of such permit has killed any bird or taken the nests or eggs of any bird for any other purpose than that named in this section and shall further be subject for each offense to the penalties provided in this act.

Two years.

Sec. 6. The permits authorized by this act shall be in force for two years only from the date of their issue, and shall not be transferable.

Birds of prey.

Sec. 7. The English or European House Sparrow (Passer domesticus), crows, hawks, and other birds of prey are not included among the birds protected by this act.

Acts repealed. SEC. 8. All acts or parts of acts heretofore passed in conflict with the provisions of this act are hereby repealed.

Emergency. SEC. 9. An emergency is declared to exist for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

TAKING FISH FOR SCIENTIFIC PURPOSES.

Section 2, Chapter XXX, Acts of 1899, page 45, makes the following provision for the taking of fish for scientific purposes: "Provided, That in all cases of scientific observation he [the Commissioner of Fisheries and Game] shall require a permit from the Indiana Academy of Science."

OFFICERS, 1900-1901.

President,

MASON B. THOMAS.

Vice-President,

P. S. BAKER.

Secretary,

JOHN S. WRIGHT.

Assistant Secretary,

E. A. SCHULTZE.

Press Secretary,

GEO. W. BENTON.

Treasurer,

J. T. SCOVELL.

EXECUTIVE COMMITTEE.

M. B. Thomas,
P. S. Baker,
John S. Wright,
E. A. Schultze,
G. W. Benton,
J. T. Scovell,
D. W. Dennis,
C. H. Eigenmann,
C. A. Waldo,
Thomas Gray,
Stanley Coulter,
Amos W. Butler,
W. A. Noyes,
J. C. Arthur,
J. L. Campbell,
O. P. Hay,
T. C. Mendenhall,
John C. Branner,
J. P. D. John,
John M. Coulter,
David S. Jordan.

CURATORS.

BOTANY .... J. C. Arthur.
ICHTHYOLOGY .... C. H. Eigenmann.
HERPETOLOGY, MAMMALOGY, ORNITHOLOGY .... Amos W. Butler.
ENTOMOLOGY .... W. S. Blatchley.

COMMITTEES, 1900–1901.

PROGRAM.

R. J. Aley, Katherine Golden.

MEMBERSHIP.

A. W. Butler, M. J. Golden, Mel. T. Cook.

NOMINATIONS.

G. W. Benton, C. A. Waldo, M. E. Crowell.

AUDITING.

A. J. Bigney, E. E. Jones.

STATE LIBRARY.

A. W. Butler, Stanley Coulter, C. A. Waldo, J. S. Wright.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

J. C. Arthur, Stanley Coulter, J. S. Wright.

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, W. S. Blatchley.

EDITOR.

Geo. W. Benton, 525 N. Pennsylvania St., Indianapolis.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, V. F. Marsters, J. C. Arthur,
Donaldson Bodine, M. B. Thomas, Stanley Coulter.

RELATIONS OF THE ACADEMY TO THE STATE.

D. W. Dennis, A. W. Butler, R. W. McBride, G. W. Benton.

GRANTING PERMITS FOR COLLECTING BIRDS AND FISHES.

A. W. Butler, Stanley Coulter, W. S. Blatchley.

DISTRIBUTION OF THE PROCEEDINGS.

A. W. Butler, J. S. Wright, G. W. Benton.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885–6	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886–7	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887–8	J. P. D. John	Amos W. Butler			O. P. Jenkins.
1888–9	John C. Branner	Amos W. Butler			O. P. Jenkins.
1889–90	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890–1	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891–2	J. L. Campbell	Amos W. Butler			C. A. Waldo.
1892–3	J. C. Arthur	Amos W. Butler	Stanley Coulter. W. W. Norman.		C. A. Waldo.
1893–4	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894–5	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895–6	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896–7	Thomas Gray	John S. Wright	A. J. Bigney		W. P. Shannon.
1897–8	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.
1898–9	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899–1900	D. W. Dennis	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900–1901	M. B. Thomas	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.

CONSTITUTION.

ARTICLE I.

Section 1. This association shall be called the Indiana Academy of Science.

Sec. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigation and discussions as may further the aims and objects of the Academy as set forth in these articles.

Whereas, the State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or of one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

Section 1. Members of this Academy shall be honorary fellows, fellows, non-resident members or active members.

Sec. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and there-

after an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men, and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a President, Vice-President, Secretary, Assistant Secretary, Press Secretary, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-Presidents of the Academy, shall constitute an Executive Committee. The President shall, at each annual meeting, appoint two members to be a committee which shall prepare the programs and have charge of the arrangements for all meetings for one year.

SEC. 2. The annual meeting of this Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the

Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past Presidents, together with the officers and Executive Committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not specially provided for in this constitution, in the interim between general meetings.

Sec. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The President shall deliver a public address on the morning of one of the days of the meeting at the expiration of his term of office.

3. The Press Secretary shall attend to the securing of proper newspaper reports of the meetings and assist the Secretary.

4. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

5. No bill against the Academy shall be paid without an order signed by the President and countersigned by the Secretary.

6. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

7. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

FELLOWS.

R. J. Aley	*1898	Bloomington.
J. C. Arthur	1893	Lafayette.
P. S. Baker	1893	Greencastle.
George W. Benton	1896	Indianapolis.
A. J. Bigney	1897	Moore's Hill.
A. W. Bitting	1897	Lafayette.
Donaldson Bodine	1899	Crawfordsville.
W. S. Blatchley	1893	Indianapolis.
J. C. Branner	1893	Stanford University, Cal.
H. L. Bruner	1899	Irvington.
Wm. Lowe Bryan	1895	Bloomington.
Severance Burrage	1898	Lafayette.
A. W. Butler	1893	Indianapolis.
J. L. Campbell	1893	Crawfordsville.
John M. Coulter	1893	Chicago, Ill.
Stanley Coulter	1893	Lafayette.
Glenn Culbertson	1899	Hanover.
D. W. Dennis	1895	Richmond.
C. R. Dryer	1897	Terre Haute.
A. Wilmer Duff	1896	Worcester, Mass.
C. H. Eigenmann	1893	Bloomington.
A. L. Foley	1897	Bloomington.
Katherine E. Golden	1895	Lafayette.
M. J. Golden	1899	Lafayette.
W. F. M. Goss	1893	Lafayette.
Thomas Gray	1893	Terre Haute.
A. S. Hathaway	1895	Terre Haute.
O. P. Hay	1893	Washington, D. C.
Robert Hessler	1899	Logansport.
H. A. Huston	1893	Lafayette.
J. P. D. John	1893	Greencastle.
D. S. Jordan	1893	Stanford University, Cal.
Arthur Kendrick	1898	Terre Haute.
Robert E. Lyons	1896	Bloomington.
V. F. Marsters	1893	Bloomington.
C. L. Mees	1894	Terre Haute.
T. C. Mendenhall	1893	Worcester, Mass.
Joseph Moore	1896	Richmond.

* Date of election.

D. M. Mottier	*1893	Bloomington.
W. A. Noyes	1893	Terre Haute.
L. J. Rettger	1896	Terre Haute.
J. T. Scovell	1894	Terre Haute.
Alex. Smith	1893	Chicago, Ill.
W. E. Stone	1893	Lafayette.
Joseph Swain	1898	Bloomington.
M. B. Thomas	1893	Crawfordsville.
L. M. Underwood	1893	New York City.
C. A. Waldo	1893	Lafayette.
F. M. Webster	1894	Wooster, Ohio.
H. W. Wiley	1895	Washington, D. C.
John S. Wright	1894	Indianapolis.

NON-RESIDENT MEMBERS.

M. A. Brannon....Grand Forks, N. D.
D. H. Campbell....Stanford University, Cal.
B. W. Evermann....Washington, D. C.
Charles H. Gilbert....Stanford University, Cal.
C. W. Green....Stanford University, Cal.
C. W. Hargitt....Syracuse, N. Y.
Edward Hughes....Stockton, Cal.
O. P. Jenkins....Stanford University, Cal.
J. S. Kingsley....Tufts College, Mass.
D. T. MacDougal....Bronx Park, New York City.
Alfred Springer....Cincinnati, Ohio.
E. Vane Brumbaugh....Fayette, Iowa.
Robert B. Warder....Washington D. C.
Ernest Walker....Clemson College, S. C.

ACTIVE MEMBERS.

G. A. Abbott....Indianapolis.
Frederick W. Andrews....Bloomington.
George H. Ashley....Indianapolis.
George C. Ashman....Frankfort.
Edward Ayres....Lafayette.
Timothy H. Ball....Crown Point.
J. A. Bergström....Bloomington.

*Date of election.

Edwin M. Blake.................................Lafayette.
Lee F. Bennett.................................Valparaiso.
Charles S. Bond.................................Richmond.
M. C. Bradley.................................Bloomington.
Fred J. Breeze.................................Pittsburg.
O. W. Brown.................................Richmond.
A. Hugh Bryan.................................Indianapolis.
E. J. Chansler.................................Bicknell.
Walter W. Chipman.................................Warsaw.
Howard W. Clark.................................Culver.
George Clements.................................Crawfordsville.
Charles Clickener.................................Tangier.
Mel. T. Cook.................................Greencastle.
U. O. Cox.................................Mankato, Minn.
William Clifford Cox.................................Columbus.
Albert B. Crowe.................................Ft. Wayne.
M. E. Crowell.................................Franklin.
Will Cumback.................................Greensburg.
Edward Roscoe Cumings.................................Bloomington.
Alida M. Cunningham.................................Alexandria.
Lorenzo E. Daniels.................................Laporte.
Charles C. Deam.................................Bluffton.
Martha Doan.................................Westfield.
J. P. Dolan.................................Syracuse.
Herman B. Dorner.................................Lafayette.
Albert H. Douglass.................................Logansport.
Hans Duden.................................Indianapolis.
Joseph Eastman.................................Indianapolis.
E. G. Eberhardt.................................Indianapolis.
M. N. Elrod.................................Columbus.
Percy Norton Evans.................................Lafayette.
Samuel G. Evans.................................Evansville.
J. E. Ewers.................................
Carlton G. Ferris.................................Big Rapids, Mich.
E. M. Fisher.................................Urmeyville.
Wilbur A. Fiske.................................Richmond.
Austin Funk.................................New Albany.
Charles W. Garrett.................................Logansport.
Robert G. Gillum.................................Terre Haute.
Vernon Gould.................................Rochester.
J. C. Gregg.................................Brazil.
Alden H. Hadley.................................Richmond.
U. S. Hanna.................................Bloomington.
William M. Heiney.................................Huntington.
Victor K. Hendricks.................................Terre Haute.

Mary A. Hickman .... Greencastle.
J. A. Hill .... Peru.
John E. Higdon .... Indianapolis.
Frank C. Higgins .... Terre Haute.
John J. Hildebrandt .... Logansport.
Lucius M. Hubbard .... South Bend.
Alex. Johnson .... Ft. Wayne.
Edwin S. Johonnott, Jr. .... Terre Haute.
Ernest E. Jones .... Kokomo.
Chancey Juday .... Madison, Wis.
William J. Karslake .... Irvington.
D. S. Kelley .... Jeffersonville.
O. L. Kelso .... Terre Haute.
A. M. Kenyon .... Lafayette.
Ernest I. Kizer .... South Bend.
Charles T. Knipp .... Bloomington.
Thomas Large .... Madison, Wis.
John Levering .... Lafayette.
V. H. Lockwood .... Indianapolis.
William A. McBeth .... Terre Haute.
Robert Wesley McBride .... Indianapolis.
Rousseau McClellan .... Indianapolis.
Lynn B. McMullen .... Indianapolis.
James E. Manchester .... Vincennes.
G. W. Martin .... Nashville, Tenn.
Julius B. Meyer .... Lafayette.
O. M. Meyncke .... Brookville.
W. G. Middleton .... Richmond.
John A. Miller .... Bloomington.
W. J. Moenkhaus .... Huntingburg.
H. T. Montgomery .... South Bend.
Walter P. Morgan .... Terre Haute.
J. P. Naylor .... Greencastle.
Charles E. Newlin .... Irvington.
John F. Newsom .... Stanford University, Cal.
E. W. Olive .... Indianapolis.
D. A. Owen .... Franklin.
Rollo J. Peirce .... Logansport.
W. H. Peirce .... Chicago, Ill.
Ralph B. Polk .... Greenwood.
James A. Price .... Ft. Wayne.
Frank A. Preston .... Indianapolis.
A. H. Purdue .... Fayetteville, Ark.
Ryland Ratliff .... Bloomington.
Claude Riddle .... Lafayette.

D. C. Ridgley	Chicago, Ill.
Curtis A. Rinson	Bloomington.
Giles E. Ripley	Decorah, Ia.
George L. Roberts	Greensburg.
D A. Rothrock	Bloomington.
John F. Schnaible	Lafayette.
E. A. Schultze	Ft. Wayne.
John W. Shepherd	Terre Haute.
Claude Siebenthal	Indianapolis.
J. R. Slonaker	Bloomington.
Richard A. Smart	Lafayette.
Lillian Snyder	Rockville.
Retta E. Spears	Elkhart.
William Stewart	Lafayette.
J. M. Stoddard	Crawfordsville.
Charles F. Stegmaier	Greensburg.
William B. Streeter	Indianapolis.
Frank B. Taylor	Ft. Wayne.
S. N. Taylor	West Lafayette.
Erastus Test	Lafayette.
F. C. Test	Chicago, Ill.
J. F. Thompson	Richmond.
A. L. Treadwell	Oxford, Ohio.
Daniel J. Troyer	Goshen.
A. B. Ulrey	North Manchester.
W. B. Van Gorder	Worthington.
Arthur C. Veatch	Rockport.
H. S. Voorhees	Ft. Wayne.
J. H. Voris	Huntington.
Jacob Westlund	Lafayette.
Fred C. Whitcomb	Delphi.
William M. Whitten	South Bend.
Neil H. Williams	Indianapolis.
Guy Wilson	Greencastle.
Mae Woldt	Indianapolis.
William Watson Woollen	Indianapolis.
A. J. Woolman	Duluth, Minn.
J. F. Woolsey	Indianapolis.
A. C. Yoder	Vincennes.
O. B. Zell	Clinton.

Fellows	51
Nonresident members	14
Active members	137
Total	202

LIST OF FOREIGN CORRESPONDENTS.

AFRICA.

Dr. J. Medley Wood, Natal Botanical Gardens, Berea Durban, South Africa.

South African Philosophical Society, Cape Town, South Africa.

ASIA.

China Branch Royal Asiatic Society, Shanghai, China.

Asiatic Society of Bengal, Calcutta, India.

Geological Survey of India, Calcutta, India.

Indian Museum of India, Calcutta, India.

India Survey Department of India, Calcutta, India.

Deutsche Gesellschaft für Natur- und Völkerkunde Ostasiens, Tokio, Japan.

Imperial University, Tokio, Japan.

Koninklijke Naturkundige Vereeniging in Nederlandsch-Indie, Batavia, Java.

Hon. D. D. Baldwin, Honolulu, Hawaiian Islands.

EUROPE.

V. R. Tschusizu Schmidhoffen, Villa Tannenhof, Halle in Salzburg, Austria.

Herman von Vilas, Innsbruck, Austria.

Ethnologische Mittheilungen aus Ungarn, Budapest, Austro-Hungary.

Mathematische und Naturwissenschaftliche Berichte aus Ungarn, Budapest, Austro-Hungary.

K. K. Geologische Reichsanstalt, Vienna (Wien), Austro-Hungary.
K. U. Naturwissenschaftliche Gesellschaft, Budapest, Austro-Hungary.
Naturwissenschaftlich-Medizinischer Verein in Innsbruck (Tyrol), Austro-Hungary.

Editors "Termeszetrajzi Fuzetk," Hungarian National Museum, Budapest, Austro-Hungary.
Dr. Eugen Dadai, Adj. am Nat. Mus., Budapest, Austro-Hungary.
Dr. Julius von Madarasz, Budapest, Austro-Hungary.
K. K. Naturhistorisches Hofmuseum, Vienna (Wien), Austro-Hungary.
Ornithological Society of Vienna (Wien), Austro-Hungary.
Zoologische-Botanische Gesellschaft in Wien (Vienna), Austro-Hungary.
Dr. J. von Csato, Nagy Enyed, Austro-Hungary.

Malacological Society of Belgium, Brussels, Belgium.
Royal Academy of Science, Letters and Fine Arts, Brussels,, Belgium.
Royal Linnean Society, Brussels, Belgium.
Societé Belge de Geologie, de Paleontologié et Hydrologie, Brussels, Belgium.
Societé Royale de Botanique, Brussels, Belgium.
Societé Geologique de Belgique, Liège, Belgium.

Prof. Christian Frederick Lutken, Copenhagen, Denmark.

Bristol Naturalists' Society, Bristol, England.
Geological Society of London, London, England.
Dr. E. M. Holmes, British Pharm. Soc'y, Bloomsbury Sq., London, W. C., England.
Jenner Institute of Preventive Medicine, London, England.
Linnean Society of London, London, England.
Liverpool Geological Society, Liverpool, England.
Manchester Literary and Philosophical Society, Manchester, England.
"Nature," London, England.
Royal Botanical Society, London, England.

Royal Geological Society of Cornwall, Penzance, England.
Royal Microscopical Society, London, England.
Zoölogical Society, London, England.
Lieut.-Col. John Biddulph, 43 Charing Cross, London, England.
Dr. G. A. Boulenger, British Mus. (Nat. Hist.), London, England.
F. DuCane Godman, 10 Chandos St., Cavendish Sq., London, England.
Hon. E. L. Layard, Budleigh Salterton, Devonshire, England.
Mr. Osbert Salvin, Hawksford, Fernshurst, Haslemere, England.
Mr. Howard Saunders, 7 Radnor Place, Hyde Park, London W., England.
Phillip L. Sclater, 3 Hanover Sq., London W., England.
Dr. Richard Bowlder Sharpe, British Mus. (Nat. Hist.), London, England.
Prof. Alfred Russell Wallace, Corfe View, Parkstone, Dorset, England.

Botanical Society of France, Paris, France.
Ministérie de l'Agriculture, Paris, France.
Societé Entomologique de France, Paris, France.
L'Institut Grand Ducal de Luxembourg, Luxembourg, Lux., France.
Soc. de Horticulture et de Botan. de Marseille, Marseilles, France.
Societé Linneenne de Bordeaux, Bordeaux, France.
La Soc. Linneenne de Normandie, Caen, France.
Soc. des Naturelles, etc., Nantes, France.
Zoölogical Society of France, Paris, France.
Baron Louis d'Hamonville, Meurthe et Moselle, France.
Prof. Alphonse Milne-Edwards, Rue Cuvier, 57, Paris, France.
Pasteur Institute, Lille, France.

Bontanischer Verein der Provinz Brandenburg, Berlin, Germany.
Deutsche Geologische Gesellschaft, Berlin, Germany.
Entomologischer Verein in Berlin, Berlin, Germany.
Journal für Ornithologie, Berlin, Germany.
Prof. Dr. Jean Cabanis, Alte Jacob Strasse, 103 A., Berlin, Germany.
Augsburger Naturhistorischer Verein, Augsburg, Germany.
Count Hans von Berlspsen, Münden, Germany.
Braunschweiger Verein für Naturwissenschaft, Braunschweig, Germany.
Bremer Naturwissenschaftlicher Verein, Bremen, Germany.

Kaiserliche Leopoldische-Carolinische Deutsche Akademie der Naturforscher, Halle, Saxony, Germany.
Königlich-Sächsische Gesellschaft der Wissenschaften, Mathematisch-Physische Classe, Leipzig, Saxony, Germany.
Naturhistorische Gesellschaft zu Hanover, Hanover, Prussia, Germany.
Naturwissenschaftlicher Verein in Hamburg, Hamburg, Germany.
Verein für Erdkunde, Leipzig, Germany.
Verein für Naturkunde, Wiesbaden, Prussia.

Belfast Natural History and Philosophical Society, Belfast, Ireland.
Royal Dublin Society, Dublin.

Societa Entomologica Italiana, Florence, Italy.
Prof. H. H. Giglioli, Museum Vertebrate Zoölogy, Florence, Italy.
Dr. Alberto Perngia, Museo Civico di Storia Naturale, Genoa, Italy.
Societa Italiana de Scienze Naturali, Milan, Italy.
Societa Africana d' Italia, Naples, Italy.
Dell 'Academia Pontifico de Nuovi Lincei, Rome, Italy.
Minister of Agriculture, Industry and Commerce, Rome, Italy.
Rassegna della Scienze Geologiche in Italia, Rome, Italy.
R. Comitato Geologico d' Italia, Rome, Italy.
Prof. Count Tomasso Salvadori, Zoölog. Museum, Turin, Italy.

Royal Norwegian Society of Sciences, Throndhjem, Norway.
Dr. Robert Collett, Kongl. Frederiks Univ., Christiana, Norway.

Academia Real des Sciencias de Lisboa (Lisbon), Portugal.

Comité Geologique de Russie, St. Petersburg, Russia.
Imperial Academy of Sciences, St. Petersburg, Russia.
Imperial Society of Naturalists, Moscow, Russia.

The Botanical Society of Edinburgn, Edinburgh, Scotland.

John J. Dalgleish, Brankston Grange, Bogside Sta., Sterling, Scotland.

Edinburgh Geological Society, Edinburgh, Scotland.

Geological Society of Glasgow, Scotland.

John A. Harvie-Brown, Duniplace House, Larbert, Stirlingshire, Scotland.

Natural History Society, Glasgow, Scotland.

Philosophical Society of Glasgow, Glasgow, Scotland.

Royal Society of Edinburgh, Edinburgh, Scotland.

Royal Physical Society, Edinburgh, Scotland.

Barcelona Academia de Ciencias y Artes, Barcelona, Spain.

Royal Academy of Sciences, Madrid, Spain.

Institut Royal Geologique de Suède, Stockholm, Sweden.

Societé Entomologique à Stockholm, Stockholm, Sweden.

Royal Swedish Academy of Science, Stockholm, Sweden.

Naturforschende Gesellschaft. Basel, Switzerland.

Naturforschende Gesellschaft in Berne, Berne, Switzerland.

La Societé Botanique Suisse, Geneva, Switzerland.

Societé Helvetique de Sciences Naturelles, Geneva, Switzerland.

Societé de Physique et d' Historie Naturelle de Geneva, Geneva, Switzerland.

Concilium Bibliographicum, Zürich-Oberstrasse, Switzerland.

Naturforschende Gesellschaft, Zürich, Switzerland.

Schweizerische Botanische Gesellschaft. Zürich, Switzerland.

Prof. Herbert H. Field, Zürich, Switzerland.

AUSTRALIA.

Linnean Society of New South Wales, Sidney, New South Wales.

Royal Society of New South Wales, Sidney, New South Wales.

Prof. Liveridge, F. R. S., Sidney, New South Wales.

Hon. Minister of Mines, Sidney, New South Wales.
Mr. E. P. Ramsey, Sidney, New South Wales.
Royal Society of Queensland, Brisbane, Queensland.
Royal Society of South Australia, Adelaide, South Australia.
Victoria Pub. Library, Museum and Nat. Gallery, Melbourne, Victoria.
Prof. W. L. Buller, Wellington, New Zealand.

NORTH AMERICA.

Natural Hist. Society of British Columbia, Victoria, British Columbia.
Canadian Record of Science, Montreal, Canada.
McGill University, Montreal, Canada.
Natural Society, Montreal, Canada.
Natural History Society, St. Johns, New Brunswick.
Nova Scotia Institute of Science, Halifax, N. S.
Manitoba Historical and Scientific Society, Winnepeg, Manitoba.
Dr. T. McIlwraith, Cairnbrae, Hamilton, Ontario.
The Royal Society of Canada, Ottawa, Ontario.
Natural History Society, Toronto, Ontario.
Hamilton Association Library, Hamilton, Ontario.
Canadaian Entomologist, Ottawa, Ontario.
Department of Marine and Fisheries, Ottawa, Ontario.
Ontario Agricultural College, Guelph, Ontario.
Canadian Institute, Toronto.
Ottawa Field Naturalists' Club, Ottawa, Ontario.
University of Toronto, Toronto.
Geological Survey of Canada, Ottawa, Ontario.
La Naturaliste Canadian, Chicontini, Quebec.

La Naturale Za, City of Mexico.
Mexican Society of Natural History, City of Mexico.
Museo Nacional, City of Mexico.
Sociedad Cientifica Antonio Alzate, City of Mexico.
Sociedad Mexicana de Geographia y Estadistica de la Republica Mexicana, City of Mexico.

WEST INDIES.

Victoria Institute, Trinidad, British West Indies.

Museo Nacional, San Jose, Costa Rica, Central America.

Dr. Anastasia Alfaro, Secy. National Museum, San Jose, Costa Rica.

Rafael Arango, Havana, Cuba.

Jamaica Institute, Kingston, Jamaica, West Indies.

SOUTH AMERICA.

Argentina Historia Natural Florentine Amegline, Buenos Ayres, Argentine Republic.

Musée de la Plata, Argentine Republic.

Nacional Academia des Ciencias, Cordoba, Argentine Republic.

Sociedad Cientifica Argentina, Buenos Ayres.

Museo Nacional, Rio de Janeiro, Brazil.

Sociedad de Geographia, Rio de Janeiro, Brazil.

Dr. Herman von Jhering, Dir. Zoöl. Sec. Con. Geog. e Geol. de Sao Paulo, Rio Grande do Sul, Brazil.

Deutscher Wissenschaftlicher Verein in Santiago, Santiago, Chili.

Societé Scientifique du Chili, Santiago, Chili.

Sociedad Guatemalteca de Ciencias, Guatemala, Guatemala.

. . . PROGRAM . . .

OF THE

SIXTEENTH ANNUAL MEETING

OF THE

Indiana Academy of Science,

STATE HOUSE, INDIANAPOLIS,

December 26 and 27, 1900.

OFFICERS AND EX-OFFICIO EXECUTIVE COMMITTEE.

D. W. DENNIS, President. M. B. THOMAS, Vice-President. JOHN S. WRIGHT, Secretary.
E. A. SCHULTZE, Asst. Secretary. GEO. W. BENTON, Press Secretary.
J. T. SCOVELL, Treasurer.

C. H. EIGENMANN, C. A. WALDO, THOMAS GRAY, STANLEY COULTER, AMOS W. BUTLER, W. A. NOYES, J. C. ARTHUR, J. L. CAMPBELL, O. P. HAY, T. C. MENDENHALL, JOHN C. BRANNER, J. P. D. JOHN, JOHN M. COULTER, DAVID S. JORDAN.

The sessions of the Academy will be held in the State House, in the rooms of the State Board of Agriculture.

Headquarters will be at the Bates House. A rate of $2.00 and up per day will be made to all persons who make it known at the time of registering that they are members of the Academy.

Reduced railroad rates for the members can not be obtained under the present ruling of the Traffic Association. Many of the colleges can secure special rates on the various roads. Those who can not do this, could join the State Teachers' Association and thus secure a one and one-third round trip fare.

L. J. RETTGER,
SEVERANCE BURRAGE,
Committee.

GENERAL PROGRAM.

WEDNESDAY, DECEMBER 26.

Meeting of Executive Committee at the Hotel Headquarters ....8 p. m.

THURSDAY, DECEMBER 27.

General Session ....9 a. m. to 12 m.

Sectional Meetings...2 p. m. to 5 p. m.

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

PROFESSOR DAVID W. DENNIS,

At 11 o'clock Thursday morning.

Subject: "Photomicrography as It May be Practiced To-Day."

The following papers will be read in the order in which they appear on the program, except that certain papers will be presented "*parri passu*" in sectional meetings. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another whose time is approximately the same. Where no time was sent with the papers, they have been uniformly assigned ten minutes. Opportunity will be given after the reading of each paper for a brief discussion.

N. B.—By the order of the Academy, no paper can be read until an abstract of its contents or the written paper has been placed in the hands of the Secretary.

GENERAL.

1. The Leonids of 1900, 15 m........................John A. Miller.
2. Mosquitoes and Malaria, 10 m......................Robert Hessler.
*3. Outline of a Course of Reading on General Biological Problems, 10 m................................C. H. Eigenmann.
4. A Shell Gorget Found near Spiceland, Ind., 10 m......Joseph Moore.
5. A Harbor at the South End of Lake Michigan, 15 m..J. L. Campbell.

MATHEMATICS AND PHYSICS.

6. Some Properties of the Symmedian Point. 8 m.......Robert J. Aley.
7. Note on McGinnis's Universial Solution, 5 m.........Robert J. Aley.
8. Graphic Methods in Elementary Mathematics, 10 m..Robert J. Aley.
9. The Automatic Temperature Regulator, 6 m......Charles T. Knipp.
*10. Concerning the Sphere as a Space-Element, 10 m....D. A. Rothrock.
11. The Cayleyan Cubic, 20 m........C. A. Waldo and John A. Newlin.
12. The Use of the Bicycle Wheel in Illustrating the Principles of the Gyroscope, 15 m.......................Charles T. Knipp.
13. The Cyclic Quadrilateral, 10 m..........................J. C. Gregg.
14. Note on the Determination of Vapor Densities, 5 m.. Charles T. Knipp.

---

*Author absent, paper not presented.

15. An Improved Wehnelt Interrupter, 15 m.,
A. L. Foley and R. E. Nyswander.
16. A Method of Measuring the Absolute Dilatation of Mercury, 10 m ....A. L. Foley.
17. The Geodesic Line of the Space $ds^2=dx^2+\sin^2 x dy^2+dz^2$, 10 m ....S. C. Davisson.
18. The Friction of Railway Brake Shoes under Various Conditions of Speed, Pressure and Temperature, 10 m ....Richard A. Smart.
19. Diamond Fluorescence, 10 m..........................A. L. Foley.
20. A Theorem in the Theory of Numbers, 10 ....Jacob Westlund.
21. On the Decomposition of Prime Numbers in a Bi-Quadratic Number-Field, 10 m.....................Jacob Westlund.
22. Dissociation Potentials of Neutral Solutions of Lead Nitrate with Lead Peroxide Electrodes, 10 m...Arthur Kendrick.
23. Some Observations with Rayleigh's Alternate Current Phasemeter, 10 m.........................E. S. Johonnott, Jr.

CHEMISTRY.

24. A Demonstration Apparatus, 10 m...................P. N. Evans.
25. Methylation of Halogenamides with Diazomethane, 10 m ....James H. Ransom.
26. Note on the Apparent Deterioration of Formalin, 2 m.Thomas Large.

BOTANY.

27. Notes on the Examination of Vegetable Powders, 10 m ....John S. Wright.
28. The Staining of Vegetable Powders, 5 m...........John S. Wright.
29. Cryptogamic Collections Made During the Year, 8 m..M. B. Thomas.
30. Experiments with Smut, 8 m.......................M. B. Thomas.
31. The Flora of Lake Maxinkuckee, 15 m................J. T. Scovell.
32. Generic Nomenclature of the Cedar-Apples, 10 m.......J. C. Arthur.
*33. The Uredineae of Parke County, Indiana, 10 m.......Lillian Snyder.
34. Additions to the Flora of Indiana, 10 m.............Stanley Coulter.
*35. Seed Vitality in Native Plants, 10 m................Stanley Coulter.

* Author absent, paper not presented.

36. Some Midsummer Plants of Southeastern Tennessee, 10 m ....Stanley Coulter.
37. A Study of the Constituents of Corn Smut, 10 m.....William Stuart.
38. A Bacterial Disease of Tomatoes, 10 m.............William Stuart.
39. Device for Supporting a Pasteur Flask, 3 m....Katherine E. Golden.
40. Notes on the Microscopic Structure of Woods, 10 m ....Katherine E. Golden.
41. Movement of Protoplasm in the Hyphae of a Mould, 10 m.............................Katherine E. Golden.
42. Description of Certain Bacteria Obtained from Nodules of Various Leguminous Plants, 10 m.Severance Burrage.
43. A Few Mycological Notes for July and August, 1900 —Wells and Whitley Counties, 10 m...........E. B. Williamson.
*44. Notes on a Collection of the Fungi of Vigo County, 10 m., Fred Mutchler.

ZOOLOGY.

45. The Kankakee Salamander, 5 m.......................T. H. Ball.
46. The Eel Question and the Development of the Conger Eel, 10 m....................................C. H Eigenmann.
47. The Mounting of the Remains of Megalonyx Jeffersoni from Henderson, Kentucky, 10 m.............C. H. Eigenmann.
48. Contribution Toward the Life History of the Squeteague, 10 m...............................C. H. Eigenmann.
49. A New Oceanic Fish, 10 m.......................C. H. Eigenmann.
49. A New Genus of Oceanic Fishes, 10 m...........C. H. Eigenmann.
50. A New Species of Cave Salamander from the Caves of the Ozarks in Missouri, 10 m..................C. H. Eigenmann.
51. An Addition to the Fishes Occurring in Indiana, 10 m..L. J. Rettger.
*52. On the Function of the Blood-Sinuses of the Reptilian Head, with Exhibition of Photographs, 10 m.......H. L. Bruner.
*53. Protraction of the Lower Jaw as a Means of Closing the External Nares in Anura, 10 m................H. L. Bruner.
*54. Some Interesting Peculiarities in the Development of Hybrid Fishes, 15 m..........................W. J. Moenkhaus.

*Author absent, paper not presented.

*55. A Probable Hybrid Darter, 5 m.................W. J. Moenkhaus.
56. Some Observations of the Daily Habits of the Toad, 10 m ....J. R. Slonaker.
57. The Methods and Extent of the Illinois Ichthyological Survey, 5 m.................................Thomas Large.
58. Additions to the Indiana Lists of Dragon-Flies, with a Few Notes, 10 m...........................E. B. Williamson.

GEOGRAPHY AND GEOLOGY.

59. Eskers and Esker Lakes, 20 m........................C. R. Dryer.
60. Spy Run and Poinsett Lake Bottoms, 7., J. A. Price and Albert Shaaf.
61. Abandoned Meanders of Spy Run Creek, 5 m., J. A. Price and Albert Shaaf.
62. The Development of the Wabash Drainage System and the Recession of the Ice Sheet in Indiana. 20 m. . Wm. A. McBeth.
63. A Theory to Explain the Western Indiana Bowlder Belts, 5 m.................................Wm. A. McBeth.
64. Aids in Teaching Physical Geography, 10 m.........V. F. Marsters.
*65. Geography of Harper's Ferry Sheet (illustrated by model), 10 m..................................V. F. Marsters.
66. River Bends and Bluffs, 10 m.....................Wm. M. Heiney.
67. Notes on the Ordovician Rocks of Southern Indiana, 10 m ....Edgar R. Cumings.
68. Some Developmental Stages of Orthothetes minutus N. Sp., 10 m..............................Edgar R. Cumings.
†69. The Cold-Blooded Vertebrates of Winona Lake and Vicinity ....E. E. Ramsey.

---

* Author absent, paper not presented.

† The paper was announced in the program of 1899, but was not completed for publication until recently.

THE SIXTEENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The sixteenth annual meeting of the Indiana Academy of Science was held in Indianapolis, Thursday, December 27, 1900, preceded by a session of the Executive Committee of the Academy, 9 p. m., Wednesday, December 26.

At 9:15 a. m., December 27, President David W. Dennis called the Academy to order in general session, at which committees were appointed and other routine and miscellaneous business transacted. Following the disposition of the business, papers of general interest were read until 11 o'clock, at which time the retiring President, David W. Dennis, made his address: subject, "Photomicrography as It May Be Practiced To-Day."

At 2 p. m. the Academy met in two sections—biological and physico-chemical—for the reading and discussion of papers. President Dennis presided over the biological section, while Drs. J. L. Campbell and Thomas Gray in turn acted as chairman of the physico-chemical section. At 5 p. m. the section meetings adjourned and the Academy was assembled in general session for the transaction of business.

Adjournment, 5:30 p. m.

THE FIELD MEETING OF 1900.

The Field Meeting of 1900 was held in Terre Haute, Thursday, Friday and Saturday, May 24, 25 and 26.

Thursday evening members of the Executive Committee met in session at the Terre Haute House.

Friday was occupied by an excursion of the Academy to Alum Cave and vicinity. The party left Terre Haute by rail early in the morning, reaching Alum Cave about the middle of the forenoon, where the day was spent in visiting the mines and interesting coal fields of that vicinity. The return to Terre Haute was made in the evening. On Saturday excursions into the field were made in the neighborhood of Terre Haute.

The visiting members of the Academy gratefully acknowledge their indebtedness to the Terre Haute members, the members of the Terre Haute Science Club and their friends for the numerous thoughtful courtesies which made the Field Meeting of 1900 so pleasant and profitable.

PRESIDENT'S ADDRESS.

By D. W. Dennis.

Photomicrography as it May be Practiced To-Day.

The instrument with which my work in photomicrography is at present being done is in a compartment of the office of Dr. C. S. Bond, of Richmond, Indiana; it rests on a solid stone floor; the source of illumination is an arc light fed by a 52-volt alternating current. The tables, the optical bench, the microscope bench and all the illuminating accessories that it carries and the camera were furnished by the Bausch & Lomb Optical Company; the microscope stand and all its accessories were furnished by Zeiss; the stand is the 1899 model. The instrument is shown in Fig. 1. The objectives are the 70, 35, 16, 8, 4, and 2mm; the eyepieces are the 4, 6, and 8 compensating and the 4 projection eyepiece. The microscope stand is the property of the Earlham biological laboratory; all other parts, including the lenses, are the property of Dr. Bond, who not only by his financial assistance made it possible for me to have such an apparatus with which to work, but he has worked with me in all that I have done, and has carried out without regard to expense every suggestion that we could either of us make, with reference to the betterment of the instrument. The "we" which I use in my paper is not the conventional editor's we; it means the doctor and myself.

INTRODUCTORY.

The photomicrography of to-day at its best has been made possible by the growth of several different lines of work. The perfecting of the arc light is one of these; sunlight will do instead of this, but the uncertainty of being able to use it at any particular time is against it; the arc light is always ready; its brilliancy is always the same; photomicrographs of all diameters from 4,000 down can be made with it in from a very few minutes to a small fraction of one second. After one has fully mastered his apparatus and needs to use the light only for adjustment and exposure it is comparatively inexpensive.

The perfecting of the microscope in all its parts was necessary before the work of making photomicrographs of 1,000 diameters and upwards with such ease and certainty as to make them practicable for ordinary purposes was possible. Indeed, the proper focusing of the microscope has been made so easy by Zeiss's latest stand that it may be said that only within a few months past has the use of these high powers been available except in the hands of the foremost experts, and even these consumed so much time and made so many failures to every success that a good photomicrograph was as costly as it was rare; an entire revolution of the micrometer adjustment screw in Zeiss's new 1899 model stand for photomicrography lifts or lowers the tube only .04 of a millimeter, i. e., one-fiftieth of the entire focal distance, and since a movement through less than one degree is entirely practicable, the tube of the microscope can be raised or lowered one nine-thousandth of a millimeter, or one two hundred and twenty-five thousandth of an inch. This is one eighteen thousandth of its focal distance.

How correctly to illuminate the object is again a science in itself; unless this is done, the most complete and costly apparatus constructible or imaginable will not give one correct photomicrograph; if the illumination is nearly right the results will be entirely wrong; the object can be drowned in light or it can be surrounded with halos that will remind the operator of a medieval painting without a suggestion of the piety that should accompany the reminder.

The production of a good photomicrograph requires a working knowledge of photography; the use of the right developer, the right plate, the proper use of reduction and intensification of the negative—all affect details. Three or at least two experts have hitherto been necessary for the production of a good photomicrograph of 2,000 or more diameters—a physicist to illuminate it, a microscopist with a knowledge of the object to adjust and focus the microscope, and a photographer to expose, develop and print it. The introductions to all atlases of this sort that I have seen show that the skill of several men has been enlisted in their production.

Photomicrography has grown then with the growth of microscopy, photography, and optics; it has proposed problems to all these sciences which they have separately taken up and solved in its behalf.

To retrace the steps from Daguerre to the end of the century, from Newton to Abbe, from the Dutch spectacle maker to Zeiss, is the work of books, not addresses; the sacrifices and victories along these journeys may have been elsewhere equaled, they have not been surpassed.

THE APPARATUS IN GENERAL.

The apparatus consists of a table 43 inches long and 15½ inches wide on strong and adjustable iron supports. Upon this table rests the optical bench on four adjustable iron legs which permit it to slide back and forth on two iron tracks. This optical bench carries the arc lights and all other accessories for illumination, except those which are a part of the microscope; these are, naming them from the light forward, first the condenser, which consists of two convexo-concave lenses four inches in diameter mounted at the ends of a nickeled tube; the lens farthest away from the light is adjustable in the carrying tube. Then comes the cooling cell, the ray filters, the shutter, the biconcave lens and the field diaphragm (see Fig. 1); all these parts are carried on two nickeled iron rods, and are adjustable in height from right to left and from before backward on the table. A second table placed at the end of this of the same width and height resting also on adjustable iron supports, is 85 inches long and carries the microscope, which has as substage parts the Abbe with its iris diaphragm and an additional iris diaphragm immediately under the object for use when the Abbe is swung out. It carries also an extensible camera which can be drawn out so as to hold the ground glass and the photographic plate at any distance from the object between 20 and 75 inches.

As to the Support of the Microscope.

It has hitherto been regarded as in principle wrong to have the microscope on the same table with the camera; our experience convinces me that this is a good arrangement, if it is accompanied by the other precautions we now have for keeping the microscope steady. As we received our instrument the microscope bench was clasped by iron clamps to two nickeled iron tubes which extend the entire length of the camera table and carry also the camera. By this arrangement any shaking of the camera was communicated to the microscope directly and rendered the preservation of the focus during the replacement of the ground glass by the plate holder nearly impossible; not one in five of our exposures with this arrangement was successful; something had to be done; we could not put the microscope on a separate table without entirely changing the means of controlling the fine adjustment, which is regulated by a rod, with milled head fastened to the table under the camera and connected by a belt with the micrometer screw; furthermore, this exerted a slight pull on the microscope tube that rendered focusing very difficult; we overcame our difficulties by first placing four adjustable brass pillars under the microscope bench; the bench was now held down to the rods by the binding screws and its distance from the table was made absolutely the same by the brass supports; ordinary sliding of the camera in changing its length or putting in and taking out the plate holder does not in any way damage the focus. To brace the microscope tube against the pull of the focusing belt we supported it two and a half inches behind the milled head of the micrometer screw by an adjustable brass pillar reaching down to the camera table. Since making these additions we have not lost a single plate by change of focus. This result can be brought to pass in other ways, perhaps, but this is one good way and for the following reason is, I believe, the best way: We have fastened also to our camera table a brass rod inside of a brass tube, each provided at the focusing plate end of the camera with milled heads and at the microscope end with separate belts passing around the grooved heads that control the moveable stage, so that the operator six feet away can systematically search a field over, that is three-eighths of an inch in diameter. This is a convenience that comes near to being a necessity; it makes high power work as controllable and as speedy as low; it turns drudgery and annoyance into a pleasure; any one who ever undertook to center an object by giving directions to an assistant at the microscope must know its value. If an object is out of the field, finding it is hopeless in the old way; it is perhaps enough to say for our arrangement that it enables one person to do quickly and exactly what otherwise requires two at a cost of much time, labor and patience. The downward pull on the stage is counterbalanced by an adjustable brass support immediately under the controlling heads of the stage.

MAGNIFICATION.

The linear magnifications possible range from six and a half with the 70mm objective without an eyepiece to 5,500 with the 2mm objective and an 8 eyepiece. The following table shows the magnification at varying lengths of the camera with a few combinations. They were determined in every instance by measuring on the ground glass the projected image of a stage micrometer.

	Objective, 2 mm.			Objective, 4 mm.			Objective, 8 mm.			Objective, 16 mm.			Objective, 35 mm.			16 mm. Objective, Without Eyepiece.	70 mm. Objective, Without Eyepiece.
Camera extension, 25 inches	875	1260	1560	375	500	625	230	325	420	110	153	200	31	42	54	42	9½
Camera extension, 45 inches	1812	2560	3250	750	1062	1375	495	695	875	230	337	430	56	84	112	72	21
Camera extension, 65 inches	2750	3875	5000	1235	1625	2250	730	1062	1375	370	530	675	87	136	166	102	34
Eyepiece	4	6	8	4	6	8	4	6	8	4	6	8	4	6	8		

In will be seen by an inspection of the table that about 35 diameters can be obtained by using the 70mm lens and a camera extension of five and a half feet, or by using a 35mm lens and a 4 projection eyepiece with a camera extension of about 28 inches, or by using the 16mm lens and no eyepiece with a camera extension of 20 inches; each of these methods has of course its advantages, and disadvantages: the first gives a wider field than the last and a deeper focus. Fig. 3 was made in this manner; with the 16mm lens and no eyepiece only so much of the same object could be taken as lies between the points a and b in Fig. 3. The advantage this arrangement has to compensate for its smaller field and less deep focus is its greater resolving power; this principle holds whatever the combinations that produce any given power.

LEVELING.

The tables and the benches must all be exactly leveled; this is easily done by means of a spirit level and the adjustable feet on which they all rest. The cooling cell and condenser must also be level.

THE ILLUMINATION OF THE OBJECT.

(a) Centering.

It is necessary that all parts of this apparatus be most carefully centered. There are several good ways to do this. One is to place in every piece of the optical apparatus a pinhole diaphragm, which may be cut from black cardboard to fit each separate piece, one for the microscope to be substituted for the eyepiece, one for the Abbe and the field diaphragm, unless these parts are already provided with iris diaphragms, in which case they can be shut to a pinhole; one for the biconvex lens and one for the condenser. The instrument is sufficiently centered when a ray of light passes through this series of holes and falls on the center of the ground glass, when the camera is fully extended; these diaphragms should be saved so that proof of the centering can at any time be quickly made.

(b) The Image of the Light.

In order to make a good photomicrograph with an objective of 8mm focal length or less the image of the light should be thrown into the plane of the object. This can, the books say, "with no great difficulty," be effected by slipping the light and the condensing lenses back and forth on the optical bench; it would be safer to say that it *can* be done; when once a combination has been effected that produces this result the exact position of every optical part should be noted carefully. To facilitate this all makers of photomicrographic apparatus would do well to mark a scale on the tables or on the carrying rods so that all parts can be quickly brought into exactly the same relation to each other and to the object; after many failures and much loss of time in attempting to bring the same state of things to pass that had been previously successful, we had such scales put on our apparatus. Any arrangement of the optical parts will produce an image somewhere; this can be found by carrying a piece of white paper back and forth in the path of the light until the image of the light is found; light and condensers can then be removed until the image rests in the plane of the object to be photographed. In order to have an equally illuminated field it is a good thing to have the size of the equally bright part of the image somewhat larger than the field to be taken; different combinations of the condensers and different positions of these and the light with reference to the object will regulate the size. In work with low powers, 16mm and upwards, this image should fall on the objective instead of the object. If the beginner in his hurry to spoil some plates is satisfied with an approximation to this state of things, or if he lights up and proceeds by the try rule, his time will be lost along with his material.

(c) The Size of the Entering Cone of Light.

Three diaphragms should accompany every complete apparatus: One of these, the field diaphragm, should be placed near the double convex lens, and if possible on its microscope side. This must always be used in every exposure; a second is at the focus of the Abbe nearest the source of light, and need not be used when it is swung out; a third is brought on immediately under the object and is consequently open and not in use when the Abbe is; two of the three are accordingly required in every exposure, namely, the field diaphragm and the one before or the one behind the Abbe.

Only a careful study of the effect on the ground glass will avail in all cases for the regulation of these diaphragms. However, two valuable rules can be given: If the Abbe is not in use the diaphragm immediately under the object must be so closed as to cut off all but the field to be photographed; if the Abbe is being used its diaphragm must in general be large enough for the cone of light entering through it to fill one-third of the central bright portion of the objective; to ascertain whether this is so or not one looks into the microscope tube when the eyepiece is in with a lens such as is often used for focusing on the ground glass; this must be done with every objective used with the Abbe and the exact point to which the diaphragm is opened should be observed on its graduated scale and recorded; if this is not done, and guesses are relied on, hit and miss (mostly miss) results need only be expected. Too wide a diaphragm will drown the details in light; too small a diaphragm will surround all details with diffraction halos that will gain in ugliness as one learns them better.

(d) Ray Filters.

The various colors of white light have differing values for optical and photo-chemical purposes; they do not focus after being refracted at the same place. When the apparatus is so adjusted that the red, orange and yellow rays which mainly affect the eye are in average focus on the ground glass, the blue and violet rays, which mainly affect the sensitive plate, will be in focus enough nearer the object to spoil the picture. One good way to overcome this difficulty is to use a color screen, which cuts out the red and orange rays and at the same time the blue, indigo and violet rays at the other end of the spectrum, leaving the yellow-green waves of approximately the same wave-length to affect both the eye and the plate; without this precaution a good photomicrograph can not be made with daylight or the electric arc; such a color screen is best produced by placing in the path of the light a glass trough with parallel sides and about three-sixteenths of an inch thick, filled with the following solution:

160 grams of dry, pure copper nitrate.
14 grams of pure chromic acid.
125 cc. of distilled water.

This is Zettnow's filter. We have found great advantage, especially in photographing preparations stained with saffrannin or fuchsine, in adding a second trough filled with a dilute solution of Loeffler's methylene blue.

FOCUSING ON THE GROUND GLASS.

Much has been written about the proper focusing of the object. Our experience leads me to conclude that the real difficulty has always been that the machinery of the microscope was not sufficiently accurate, its parts were not sufficiently firm relatively, the microscope itself was not sufficiently supported against damaging strains and jars, and its fine adjustment screw was not sufficiently fine; we need nothing but a fine ground glass and the unaided eye for correct focusing; a plate glass and a focusing lens are generally recommended; they are scarcely a help; the difficulty vanishes with such stable and delicate machinery as puts control entirely in the hands of the one focusing.

POSITION OF THE SENSITIVE PLATE.

A pure scarecrow of the books is the oft repeated necessity of having the sensitive plate take the exact place of the ground glass; some one must have concluded that a want of coincidence in this respect spoiled his plates, and other essay mongers must have copied the conclusions. Doubtless he and they had spoiled plates, but the cause was not here; a variation of a quarter of an inch makes a perceptible difference in magnification, but not in sharpness, and no instrument probably ever varied so much as this.

EXPOSURE.

The time of exposure depends on so many things it is not possible to give any rules: The source of the light, its intensity, the number and character of the condensers, the number and character of the color screens, the width of the diaphragms, the character of the object, the objective and eyepiece used, the sensitiveness of the plate, and the freshness and strength of the developer, all materially affect the time. Any one can find out the time necessary by a few trials provided he understands development and is a good judge of a negative. If he has not these accomplishments he never can tell. Some kind of shutter with which to accurately measure fractions of a second is so useful as almost to be necessary in getting the right exposure; placing a ground glass in the path of the light near its source will multiply the time of exposure some twenty-five times and would be necessary in the absence of a shutter.

PLATES.

It should go without saying, perhaps, that plates giving correct color values should generally be used. We have used Cramer's isochromatic mediums and Carbutt's orthochromatic mediums and have found them satisfactory.

CHEAP APPARATUS.

I can think of no valid plea for cheap apparatus. Some men with cheap apparatus can, to be sure, do better work than others with the costliest. The difference does not lie in the apparatus; this good work is, however, done at an outlay in time, patience and material that renders it so costly in the end as to be impracticable. This is why photomicrography has not been more used in the past. Makers of apparatus are careful to advertise "any microscope stand can be used." This, except for low power work of the simplest character and second grade in quality, is a delusion. Internal reflections from the microscope tube, the objective and its fastenings injure more or less everything; moreover, the trouble necessary to adjust a microscope every time work is wanted is by far the costliest part of the work; a special stand with a large tube from the walls of which reflection is impossible and into which properly constructed objectives can be screwed without a graduating series of collars, mounted firmly on an unshakable foundation, dedicated to this one use, always ready, quickly capable of adjustment for any practicable powers, with a source of light that does not require long-time exposures, immediately adjacent to a properly equipped dark room, is not only the cheapest arrangement; it is the only arrangement that will for any considerable time be used by a busy man. The complete apparatus as I have described it should be supplemented by a firm, permanent, upright stand for copying all such slides as will not permit the microscope to be brought to the horizontal position. This is one exception to my general proposition that cheap apparatus is too expensive. The exception is, however, only apparent, for this is as good an arrangement for this class of work as it will admit of. This sort of camera should be at hand in every laboratory where there is any one competent to use it, for the things for which it is necessary can neither be sent away nor can they await a more favorable hour often. Such apparatus in convenient form has been exhibited and described before this Academy.

LIMITATIONS.

Photography has its limitations. The time of exposure can not be accommodated to a field unequally illuminated. A man ten feet from the camera and a background of forest and hills from a hundred to a thousand feet away can not all be in correct focus at once. Undesirable and immaterial parts of the field will be taken with the same fidelity as the parts wanted. Photomicrography shares all these limitations. With skill they can be reduced to a minimum. By repeated exposures of the same field all parts wanted can be presented in correct focus and together in their true relationship. Fig. 5 was focused for the centrosome in the larger cell; Fig. 6 for the centrosome in the smaller cell. By the use of a special stage, objects can often be tilted so as to bring related points into the same plane. When one side of a field is lighter than the other something can be done by stopping the development at proper stages, washing the negative off and developing the exposed parts by a local application of the developer. Immaterial parts can be cut out by the application of a reducing agent to the negative or the positive, or by matting out in the process of printing. Much has been said against the use of reduction, intensification, retouching or even spotting out, and many inartistic, not to say ugly, prints have been made that might easily and without damage to fidelity have been made tolerable, if not beautiful. By the adjustment of the light, by the kind of light used, by the character of the developer, by the intensity of development, by the time of exposure and by the quality of the plate, two prints of the same object can be made to tell different tales. Photomicrography is not a means of compelling men to tell the truth; no such means has ever been discovered; the usual bounty for veracity is still to be had at the old stand. Clumsily practiced it tells nothing; it is reliable when the photomicrographer is both truthful and capable. There is no more reason why it should be compelled to tell immaterial stories while it is telling material ones than that any other witness on any other stand should be. I have, notwithstanding all this, always followed the rule never to cut out or reduce anything whatever from the material portion of the field. I have often hunted for hours to find a section free from defects which told exactly the same story that another one told, the defects of which I could have removed harmlessly and easily.

ADVANTAGES OF PHOTOMICROGRAPHY.

One great advantage of photomicrography is that it leads to the preparation of better microscopic slides, because, in part, of the rule that does not permit the negative to be altered in its material parts; in part also because the damaging defect can not always be removed. Another advantage is that when correctly carried out it can tell nothing but the truth with reference to the parts in focus. It is maintained by good authority that it sometimes reveals things not visible to ordinary vision. I have often seen things in photomicrographs that had escaped my attention before, but always when I came to observe carefully again I was able to see them. A skillfully prepared photomicrograph shows details more distinctly, with greater contrast, than they have when one observes them through the microscope; I see no reason why if the proper conditions were at hand it may not reveal details beyond the reach of ordinary microscopic vision. A sensitive plate is not blinded by light or tired with long looking. Photomicrography is not here presented as a remedy for all ills; drawings have certain advantages; but every one can not draw, and careful drawings require much more time than photomicrography. The best of both is had when the details of photomicrography are supplemented by a constructive diagram which uites all in one.

In science teaching photomicrography fills a place that nothing else can. Few people comparatively ever use the microscope to any educational purpose; probably not more than a tenth of the students in our colleges and universities are familiar with anything more than its simplest revelations; popular courses are wanted in and out of the colleges; psychology, pedagogy, child study, and all organic studies call for illustrations of biological laws or histological relationships which concern them; for most of them it is photomicrography or drawings or both or nothing; and no one that has ever tried it will hesitate for a moment to say that the photomicrography must not be left out; it makes things real in a way that a diagram can not; it helps the interest, not indeed to the same extent that the microscope does, but to something like the same extent that the microscope would, if the student did not prepare his own object and if all the students could see the same thing at the same time through it and have the view explained while looking. I am sure that the histological lantern slide is with us to stay, and that the histological half-tone shortly will be.

KNOWLEDGE OF PHOTOGRAPHY.

Any one desiring to learn how to make good photomicrographs must procure a camera and learn how to make a good negative; it will not do for him to press the button and let some one else do the rest; he can not learn what a good negative is until he has made many and tested their printing qualities. When any one is a fair judge of the sort of lantern slide or print a negative will make he can then make a good one, and when he can at morning or at noon, on a clear or a cloudy day make a landscape negative and print it on glass or paper so well that his print compares favorably with the best of its class in the market, he may begin to experiment at photomicrography. He generally begins long before this and always produces and often publishes work that he never would have published could he have known what others were doing. Almost every photomicrographer has thrown away crop after crop of negatives which he formerly cherished as the best producible. At this stage he either quits or goes into a thorough study of the principles of photography on the simplest outdoor work; the production of high-power photomicrographs is the most difficult problem in photography and can only be done by good photographers who have had much experience also in low power work.

THE OBJECT TO BE PHOTOGRAPHED.

The photography of diatoms has flourished as a scientific fad for years. It is a special line of photography, calling for special illumination and specially prepared objectives: it calls for resolution, while general histological work requires penetration. It was for a long time a race with instrument makers to see which could resolve the finest striations; diatoms were used for test objects almost exclusively. It was gravely argued that a microscope that was good for diatoms was good also for other things in like proportion. Oblique illumination and blue light were praised for the same reason. The comfortless purchaser was left to reflect—having resolved a pleurosigma or an amphipleura—how few of them he ever cared to resolve, and that blue light concealed what he wanted to see. Every one easily admits, however, now that a diatom can bė photographed: and since the publication of Koch's Bakterienkunde in 1889 and 1890 it has been granted that bacteria can be; they can be made to lies so uniformly in one plane. Doubtless it will always remain true that some things can be photographed better than others, and that a good preparation is to be preferred for this purpose to a poor one, that only the best obtainable is to be photographed at all; but we are now in a position to photograph any object better than it is possible to see it by any single focusing of the microscope, and by repeated exposures any object can be photographed as well as it can be seen, so that all at least can be seen in the pictures that can be in the object. Fig. 7 is an egg from the ovary of a cat; the section is so thick that tissue cells lying behind it can be seen through it; and yet all is clear. It goes without saying that all the figures of the accompanying plates are of considerable thickness; one of them, Fig. 16, is an unsectioned blastula of Ascaris; the cavity within is seen through a cell which lies above it, and the light that illuminates it has passed through a cell that lies below, and yet the blastocoele is produced with almost diagramatic clearness.

WHAT THE NEXT STEP IN PHOTOMICROGRAPHY OUGHT TO BE.

The apparatus for the best work in photomicrography is very expensive and always will be. It requires and always will require an expert knowledge to make lantern slides and prints from microscopic preparations that an investigator can not afford to acquire and keep, and time that he could ill afford to spare. Education ought not to lack, it must not, will not lack this means of furthering its ends. We must establish here and there laboratories of photomicroscopy, in connection, preferably, with some of our institutions of learning, at which this work can be done for a considerable number of institutions. By this means negatives would accumulate from year to year until thousands of them might be at the command of all; the cost need not be great for all schools to possess slides of their own from this collection, or slides might be rented at a very small cost; all investigation monograms could thus be illustrated and teaching everywhere could be put in almost immediate touch with the latest that is known, and nothing else so vitalizes the work of the classroom, as every one knows who has tried it. I have tried to get slides from the plates used in works that had been published and copyrighted; I have never been able to do so; there was perhaps no means by which they could be easily made; there should be no other reason; they could only be used for teaching purposes; when one has harvested all the honor and money that can come from his publications I can not see why the good, that it does not impoverish him to part with should not be shared.

A scheme of this kind would furnish opportunity for friendly comparison of work which could not be other than a benefit. A half dozen such laboratories could do the work for the whole country: these could be affiliated and along this one line at least we should be spared the wastefulness of the anarchy of independent effort.

COURSE OF STUDY.

It would immediately come to pass in connection with such laboratories that courses of instruction would spring up. Such courses would be elected without doubt by many students in the various departments of botany and zoology, and as a result the ability to do good work would spread with the demand for it. One year's work in optics with special reference to photomicrography, microscopy and projection, one year in the theory and practice of photography, and two in the theory and practice of photomicrography would fill every requisite, whether of quantity or quality, from the beginning; it would be the work of experience to select finally what is just the best for such a course out of very much that is certainly good.

I have seen none of the literature of photomicrography of value except Neuhaus's "Lehrbuch der Microphotographie." Dr. Neuhaus is a practicing physician of Berlin. He has given us a work of such excellence that one does not need to see another; it contains a bibliography that probably leaves out little that has been written that is worth keeping. It should be translated into English. It was first published in 1890 and a second edition was called for in 1898. It is the first German work that has survived into a second edition.

EXPLANATION OF PLATES.

Except where otherwise stated the following figures have been made with a 2mm. apochromatic immersion objective and a 4 projection eyepiece with a camera extention of 37 inches and a magnification of 1,500. The slides, except where otherwise mentioned, were prepared by Mr. Elwood Mendenhall in the Earlham Biological Laboratory. The ascaris slides were stained by the iron-haematoxylin method. The material was fixed in Fleming's chrom-osmium-acetic fixative. The time of exposure was from 2 to 10 seconds. Zettnow's filter was used in each case, and for the Lilium candidum sections which were stained with saffranin, a Methylene blue filter in addition. No ground glass was used in any instance.

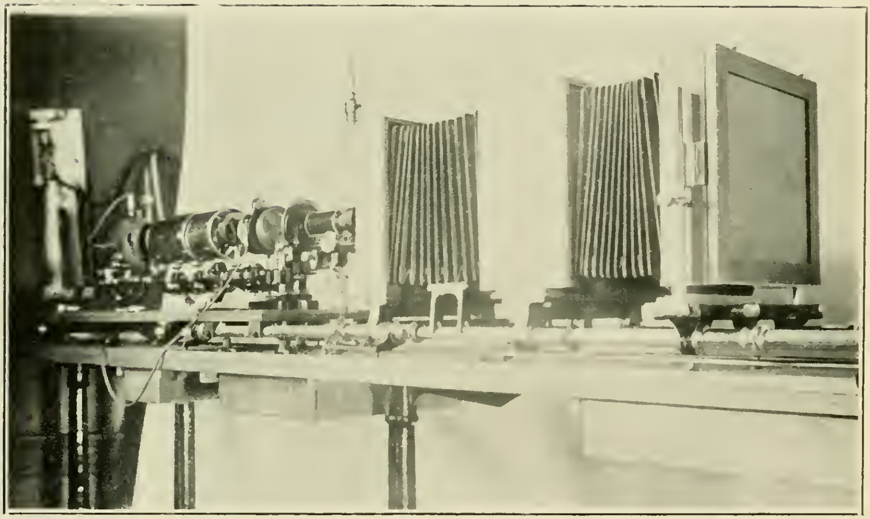
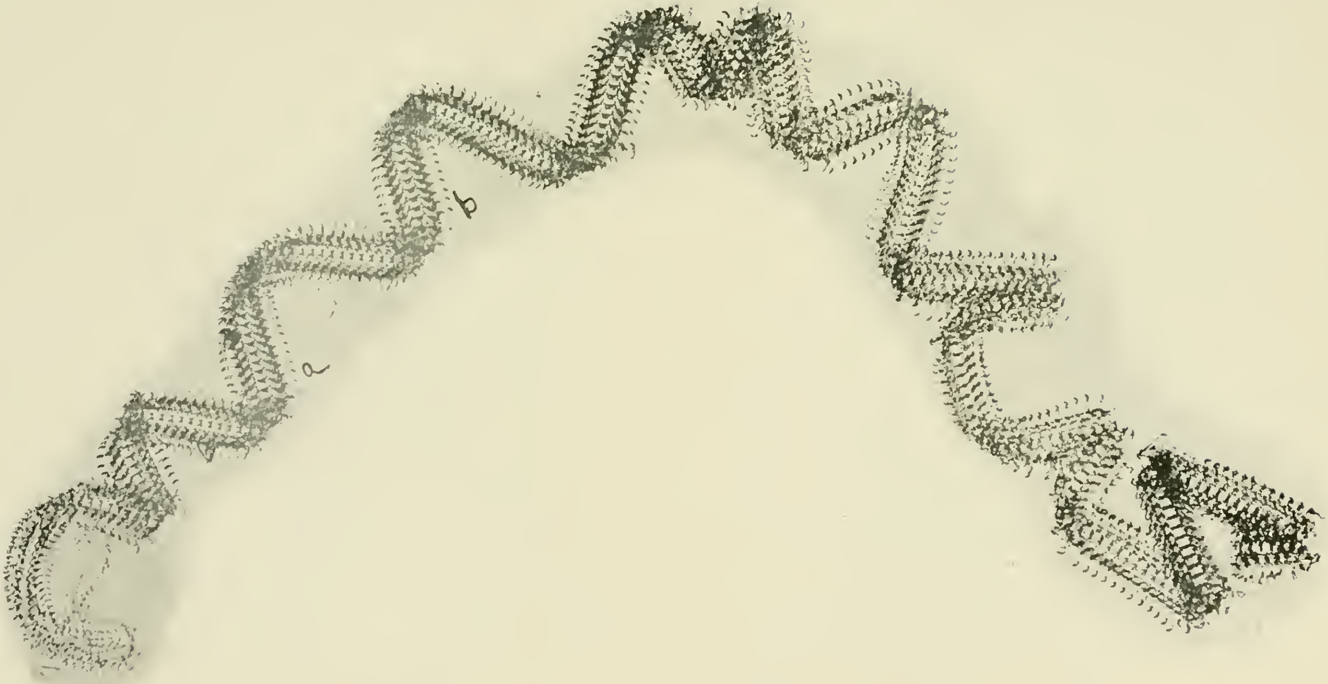


Fig. 1.



TONGUE OF SEA SNAIL.

Fig. 3. 70mm. objective, camera extension of 65 inches If same magnification had been obtained with 16mm. objective, the field would only have shown portion between a and b.

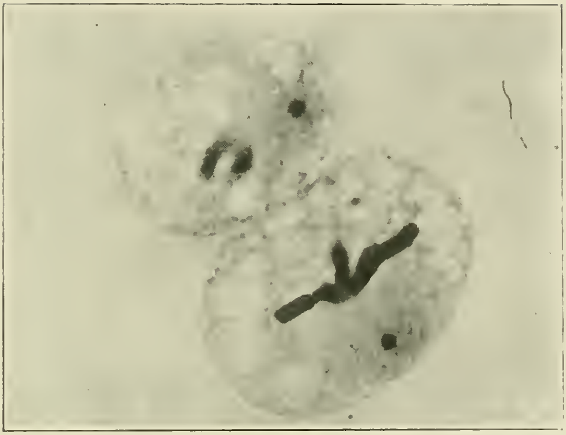


Fig. 5. Ascaris megalocephala, $\frac{1}{12}$ in objective and 4 projection eyepiece; focused for centrosome in larger cell.

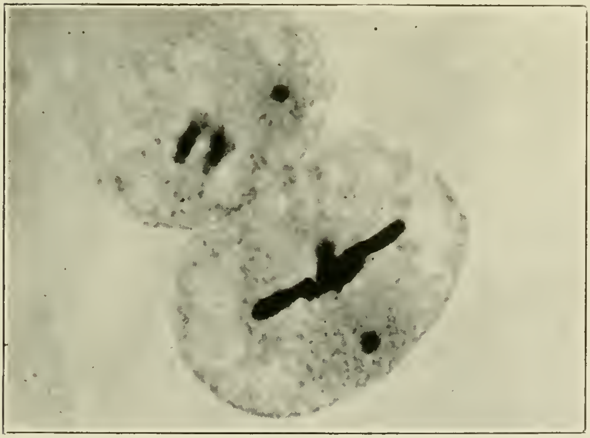


Fig. 6. Same as fig. 5, except it is focused for centrosome in smaller cell.

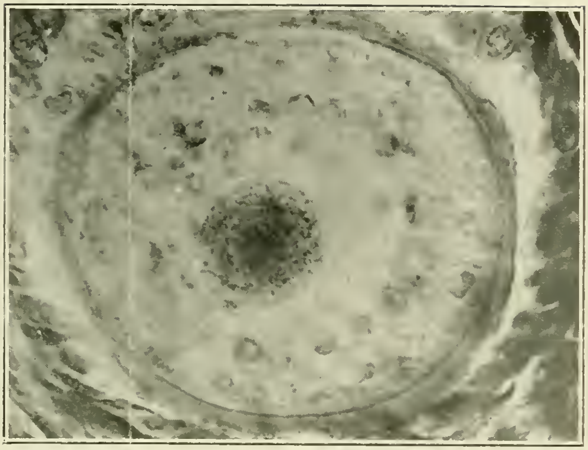


Fig. 7. Egg from the ovary of a cat, multiplied 1,500 times. Slide by Mr. Bertsch.

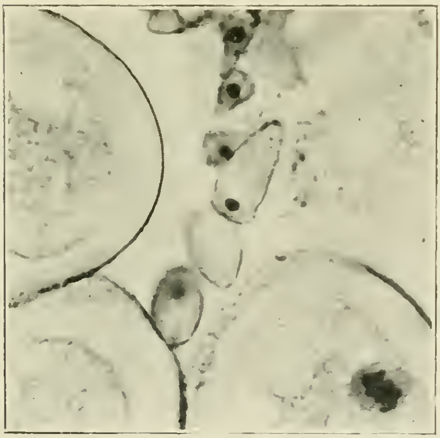


Fig. 8. Sperm cells of ascaris multiplied 825 times. 4mm. objective; 4 eyepiece.

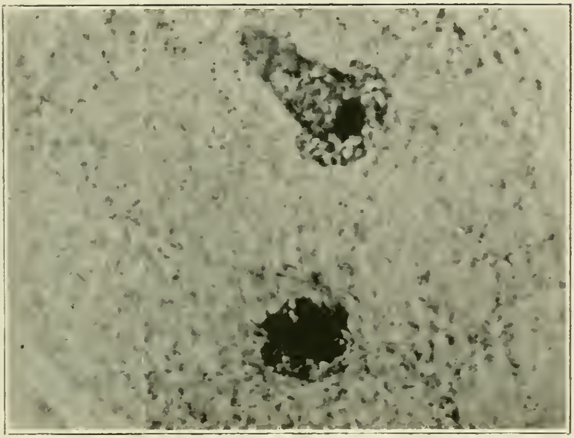


Fig. 9. The sperm cell is entering the egg from above; egg nucleus below multiplied 1,500 times.

Fig. 10. The formation of the first polar body; sperm nucleus below. Slide by Mr. Irwin

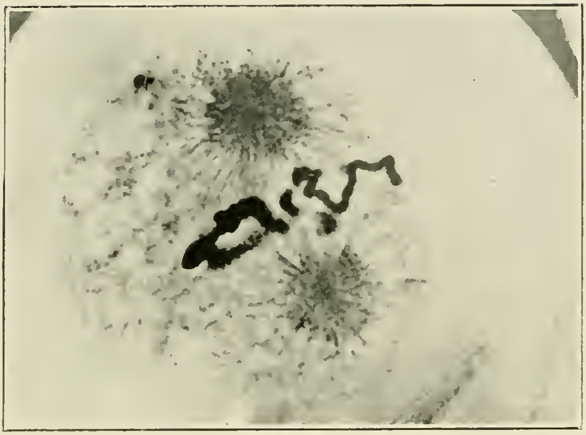


Fig. 11. The mitotic figure is complete.

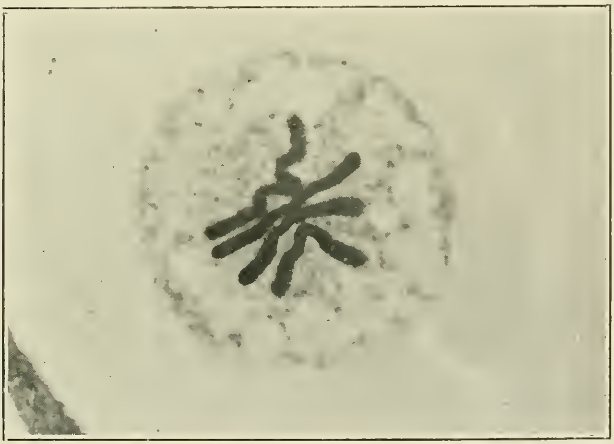


Fig. 12. Chromosomes of the equatorial plate seen from the pole.

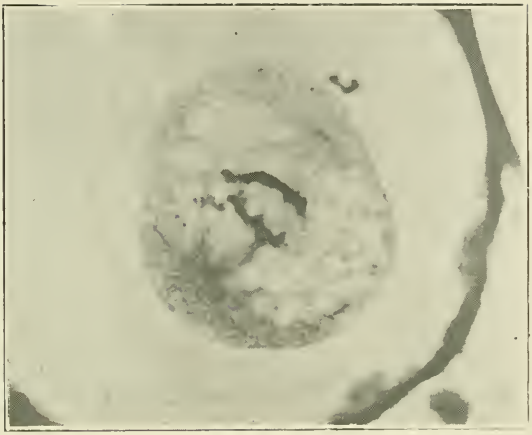


Fig. 13. An early telophase; two centrosomes above; polar bodies outside of egg.

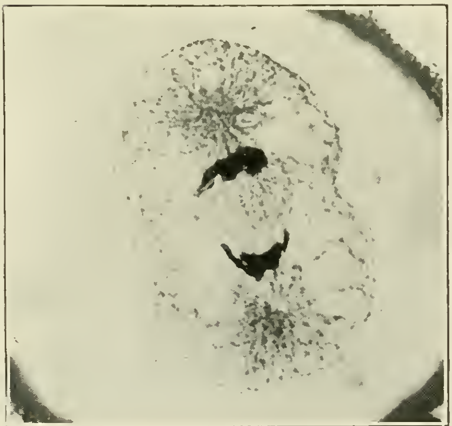


Fig. 14. A somewhat later phase; walls beginning to contract for two-cell stage.

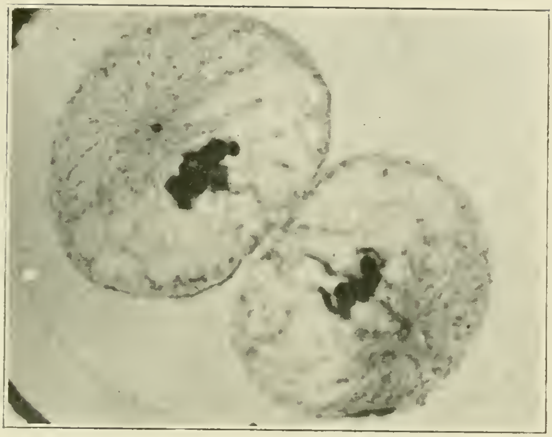


Fig. 15. Two-cell stage.

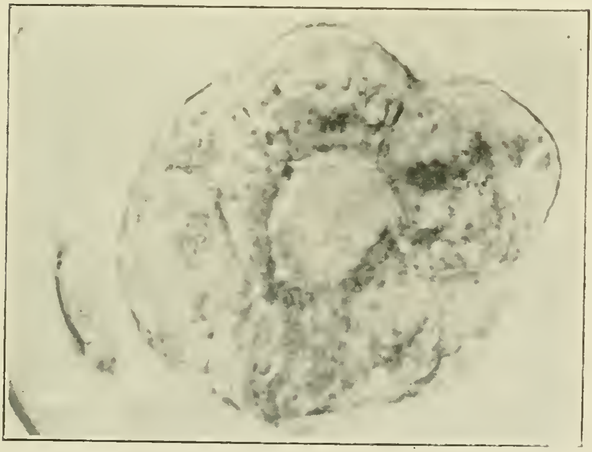


Fig. 16. Blastula of ascaris, multiplied 1,500 times. The specimen is not sectioned; see text.

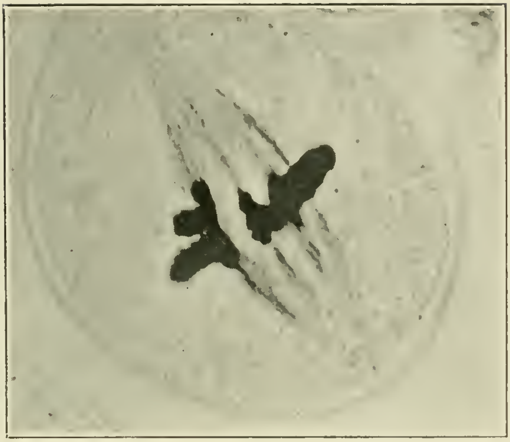


Fig. 17 Pollen mother cell of Lillium candidum; slide by Prof. David M. Mottier, multiplied 1,500 times.

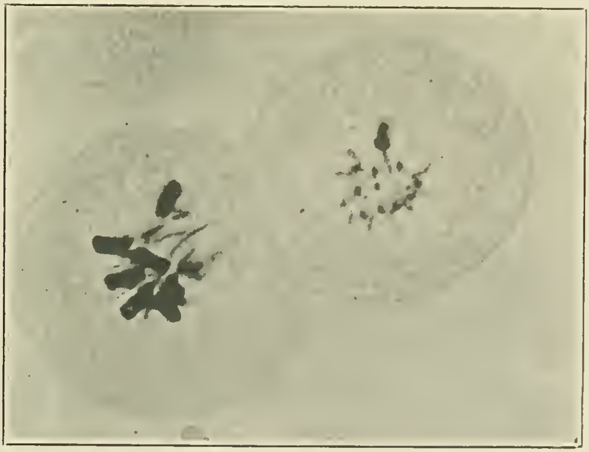


Fig. 18. L. candidum. The right-hand cell is cut at nearly right angles to plane of Fig. 17.

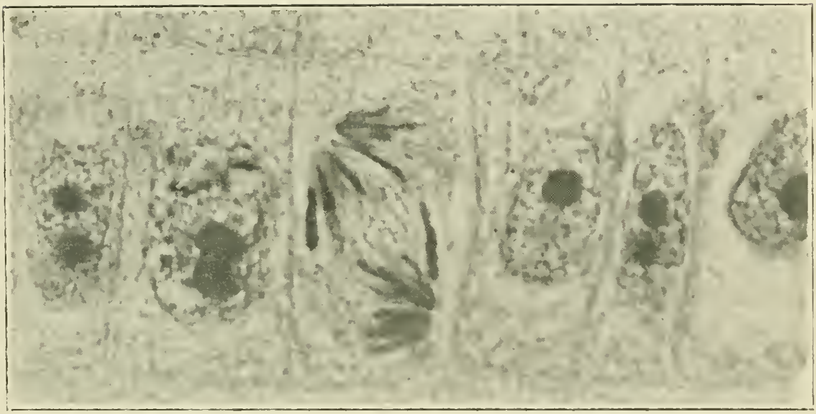


Fig. 19. Onion root; the oblique mitotic figure accommodates itself to the confined cell space.

Fig. 20. Spinal cord of embryo pig, multiplied 50 times; Golgi preparation. Slide by Messrs. Warfel and Marshall.

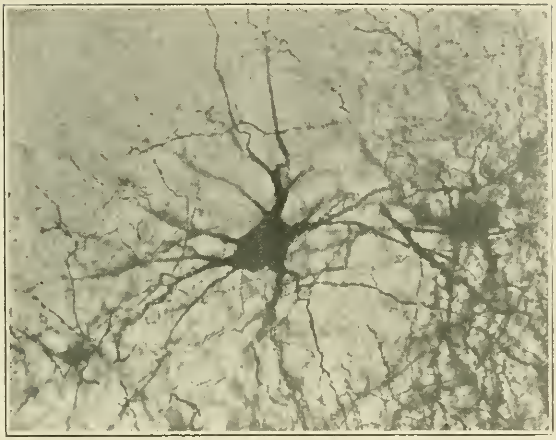


Fig. 21. The upper left-hand cell of fig. 20, multiplied 200 times.

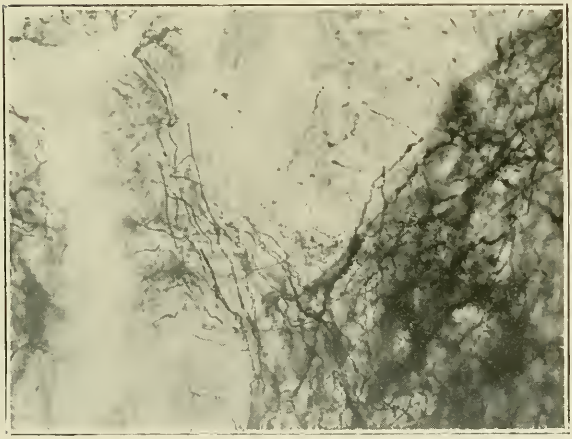


Fig. 22. The Commissure of fig. 20, multiplied 200 times.

The Leonids of 1900.

By John A. Miller.

The number of Leonids observed this year was very much smaller than was anticipated. Doubtless many escaped notice because of the bright moonshine and cloudy weather. Still, bearing these facts in mind, the shower was very disappointing. The *totale* of observations tend to confirm Dr. Johnstone Stoney's prediction that, owing to planetary perturbations, the stream bearing these meteors would not come nearer the earth this year than one and a half million miles.

On the mornings of November 14th and 15th my colleague, Mr. W. A. Cogshall, and myself, aided by our students, observed these meteors in order to obtain data concerning—

(a) The frequency of fall.
(b) The radiant.
(c) Duration of visibility; and
(d) The height at which the meteors appeared and disappeared.

On both mornings the sky was cloudy until three o'clock, and parts of it were overcast even after that time. Hence our observations for frequency are of small value. However, from 3:52 to 4:22 on the morning of the 14th our observers counted thirteen meteors. These came from the neighborhood of Leo, but were probably not all Leonids. At no other time were meteors so frequent as then. It was a source of remark, however, that they seemed to fall in groups two or three. That is, when one appeared one or two others followed at short intervals.

We attempted to obtain a sufficient number of trails of the meteors, photographically, to determine a radiant, but were unsuccessful. Our visual observations for the same purpose were more fruitful. On the morning of the 14th 45 meteor trails were platted; 13 of these were Leonids. On the morning of the 15th 41 were platted; 17 of which were Leonids. The radiant obtained from these paths was at the point whose right ascension is 149° and whose declination is 21°.

A Bergström chronoscope was employed to measure the duration of visibility. This instrument measures time accurately to the thousandth of a second, which is much less than the error introduced by the observer in pressing the telegraphic key which registers the appearance and disappearance of the meteor. The average of the results obtained for the duration of visibility is 0.6 second.

In order to secure the parallax of the meteors observations were made at Bloomington and at Bedford. The co-ordinates of these stations are, for Bloomington, longitude 86° 32′ 11″, latitude 39° 10′; for Bedford, longitude 86° 39′ 10″, latitude 38° 52′. The distance (rectilinear) between the two stations is 33.652 meters, equaling 20.13 miles.

An examination of our charts and recorded times showed that of all the meteors platted only one had been observed simultaneously at both stations.

Using the method of Klinkerfues, we found that the height of the meteor at the time of apparition was 143 miles, and its height at the time of its disappearance was 64 miles.

Mosquitoes and Malaria.

By Robert Hessler.

[Abstract.]

The recently developed theory that mosquitoes are the carriers of malaria from one man to another, which is based on the definitely ascertained cause of malaria, is a question of considerable importance to inhabitants of malarial districts, such as we have, for instance, along the Wabash River.

Speaking of Indiana, especially when compared with former times, it may be said that malaria has lost its terrors. To see what the disease really is requires a visit to such a region as the desolate Roman Campagna, or to the Isthmus of Panama. The ravages of the disease, known about Rome as Pontine fever and at Panama as Chagras fever, is something terrible to contemplate.

Popularly it is generally believed that the drainage of wet areas and of stagnant waters is the cause for the great diminution in the number of cases and of its severity among us.

For a cause, biologists and physicians always want something tangible —a something that can be seen, felt, weighed or measured; a something

that appeals to the senses. Many persons are satisfied with a very simple explanation, and frequently a name suffices. The term "malaria" etymologically means "bad air," and was applied to the disease in olden times when bad air or a "miasm" was supposed to cause it.

Now what is malaria? we may ask. What is its cause? How does it get into the body?

Diseases due to a specific cause, to a living organism, spread about over the face of the earth just as we see animals and plants spread. Many with originally restricted habitats have in the course of time attained a world-wide distribution. Some diseases, natives of warm climates, periodically leave their natural boundaries, as yellow fever or cholera, flourish for a short time and then disappear utterly. If a new disease appears in a country and the conditions for its existence are favorable, then the disease remains and is called endemic. The cold of our winters has a destructive effect on many diseases and a retarding influence on others. Some flourish only during the warm months of the year.

The date when a new disease first appeared in a country, or rather an old disease in a new country, is accurately known in many instances, and the gradual spread after its introduction has been carefully followed in some cases. Leprosy, for instance, now so common in the Sandwich Islands, was brought in by the Chinese in 1840.

Malarial fever had a restricted habitat in former times and has gradually spread and still does spread to places where it had never been seen before. Its appearance and spread in the Island of Mauritius in comparatively recent years was attended with a frightful loss of life. It was brought into the island in 1866 by some sick sailors, and an epidemic followed; in the year 1867, 32,000 out of a population of 310,000 died of malaria. In some of the lowly situated districts more than one-fifth of the population perished from fever alone.

The original home of malaria is unknown. Many of the islands of the sea are still free from it. All other conditions may be favorable, but unless the active cause is introduced the disease never appears in a country where it had never been known to occur.

It is now about twenty years since Laveran, a French military surgeon, then stationed in Algiers, discovered and first described the active cause of malaria. This discovery has been verified again and again and is now universally recognized as the cause. It is a minute form of life belonging to the sporozoa and is most commonly known under the name of Plasmodium malariae. To detect this parasite in the blood is the crucial test for malarial fever in these days of laboratory methods of investigating and diagnosing diseases; once found, the application of the remedy for the disease is clearly indicated—this is quinine or one of the alkaloids of the cinchona group. Quinine is a protoplasmic poison to the malarial parasite.

The Plasmodium malariae lives in and at the expense of the red blood corpuscles of human beings afflicted with the disease. It appears first as a minute speck in the corpuscles, gradually enlarges, and about the time the cell is consumed it undergoes a segmentation, each segment being a new and independent being which at once seeks a new host, a fresh corpuscle. Segmentation keeps up the species in the body of the host.

Under suitable conditions a higher development of the parasite can be seen. It is a process of differentiation into gametes, or males and females, and the resulting offspring are concerned in the transmission of the species, and of the disease, be it noted, into a new host.

The role of the mosquito in carrying the disease from one person to another has been worked out during the past two years. The prevailing view of how this is done may be outlined in this wise: When the Anopheles mosquito bites a human being afflicted with malaria, the parasites in the blood are taken into the insect's stomach and here and in the intestines they undergo a certain cycle of existence, or evolution, lasting about a week or ten days, and sporozoids—corresponding to the eggs of higher animals or to the seeds of plants—are formed, and these get into the salivary gland, and when the mosquito bites agáin they are, along with the saliva, injected into the wound. Once in the human system these sporozoa seek and occupy the red blood corpuscles; gradually they increase in numbers by sporulation, and in the course of a few days, or after one or more weeks, evidence of malaria manifests itself. In this way malaria is transmitted to a new individual.

The life history, or the development of the parasite, can be followed:

First. In the blood of a malaria fever patient by taking a drop of the blood at variable intervals and examining it under a high power of magnification. This will show the sporulating generation.

Second. In blood kept for some time under suitable conditions—warmth and loss of fluid by evaporation—under the microscope.

Third. In the organs, notably the spleen, of persons dying from malaria.

Fourth. In the bodies of mosquitoes after feeding on the blood of a malarial fever patient, the insects being kept at a summer heat.

With the cause definitely recognized, malarial fever may be defined in this wise:

"A specific infectious disease depending upon the presence in the blood of one or more of several species of closely allied parasites (Haemosporidia), which develop within, and at the expense of, the red blood corpuscle of the infected individual, resulting, according to the species and number of the parasites present, in more or less periodic febrile paroxysms or in continued fever."

We may now ask: How does this active cause get into the body? Or, in other words: How do we catch malaria?

When the mosquito theory was first announced it was thought that any and all mosquitoes could transmit the disease. It has since been found that there is only one genus which is now universally suspected.

There are about 250 species of mosquitoes described, and of this number about 30 have been found in the United States. The genus to which the malaria carrying mosquito belongs is that of Anopheles; it may be recognized by its spotted wings and the peculiar position of the body when at rest—the body axis projecting away from the place of support, as a wall. Our common mosquito belongs to the genus Culex and is considered harmless; it has no spots on the wings and the body axis at rest is parallel to the wall. Anopheles is an inhabitant of the country. Culex lives in the city as well as in the country.

Mosquitoes normally live on the juices of plants; the sucking of blood is an acquired habit. The females alone suck blood, the mouth-parts of the males are not adapted for it. They seem to survive our winters; they are often to be seen during warm days in the midwinter months. In the spring the few survivors are ready to repopulate all the country around—and at the same time spread malaria. With us malaria is essentially a disease of warm weather.

There are two chief methods by which the subject can be studied:

First. To search for Anopheles in its usual habitat and then for the malarial fever. Or,

Second. To find the malarial fever and then look for Anopheles.

The blood of man upon which the mosquito has been feeding can readily be studied in thin sections of the insect properly stained. In some of the slides which I will pass around, the distended stomach, filled with blood, can be easily distinguished; under a high magnification any Plasmodium malariae in the corpuscles can be seen.

From the preceding remarks it will be seen that three chief factors are involved in this question:

1. The fever-stricken human being, or, the disease in the body, or, in other words, the reaction brought about by the presence of the active cause.

2. The cause itself, the Plasmodium malariae.

3. The transmitting agent, carrying the active cause from one infected human being to others. This is the Anopheles mosquito.

Now what is to be said on the application of all these discovered facts? Most of us, unless we see a well defined application for newly discovered facts, are not inclined to attach any great importance to such discoveries, and, on the other hand, the more directly we are concerned the greater the value to us. In the field of medicine the value of a discovery is estimated in the light of the relief it gives mankind from disease and affliction.

How best to apply this new knowledge in reducing the ravages of malaria and in banishing it from the face of the earth is a question on which opinions differ. By some it is held that the best method of procedure is to destroy all the mosquitoes, and thus prevent the transmission from one individual to others. It is claimed by advocates of this class that the malarial parasite may not live exclusively in man, but might be inoculated from lower animals. On the other extreme are men who aim to exterminate malaria by exterminating the malaria germ itself, by properly diagnosing all malaria cases and administering sufficient quinine; by isolating all such patients and protecting them from mosquito bites. They blame the mosquito less than the infected blood upon which the insect feeds. It would be impossible, they argue, to get rid of all the mosquitoes in any community, much less of those in the whole world. Their reliance is quinine and screens.

Besides these extreme views there is what may be called a compromise, that is: To reduce the number of breeding places of the mosquito to a minimum, by drainage and drying up all wet places and pools of stagnant water; by isolating the sick and protecting them from the bites and by the administration of quinine. With the breeding places reduced and the sick isolated there will be a constantly diminishing number of malarial fever cases.

A number of experiments have already been made along these lines. Former efforts, as those of the Italian government in planting Eucalyptus trees, have been futile because founded on imperfect data. Of the Eucalyptus it should, however, be said that it does have a slight influence. the leaves containing a volatile oil offensive to the mosquito, and on this account they do play a slight part in lessening the ravages of the disease among those living in a grove of the trees.*

Quite different are the results of experiments made this year. From the Eucalytus theory of a generation ago to the mosquito theory of to-day is a step far in advance, and results based thereon are equally significant.

The Italian railways—with their lonely stations in the plains and valleys—were the first to take advantage of the new theory in adopting prophylactic measures against mosquito infection of malaria by protecting their buildings and those occupied by their workmen by mosquito netting. The tests have been regarded as conclusive. Of 104 railway employes protected from mosquito infection not one contracted the disease. On the other hand, out of 359 persons not thus protected but otherwise living under similar conditions, only seven or eight escaped the fever.

A more elaborate test was made at Paestum, in a fearfully infected region to the southeast of Naples. The houses had wire screens over every opening—doors, windows, chimneys, etc., and persons going in and out after dusk were obliged to wear veils and closely woven, thick gloves. One hundred three persons were thus protected and of this number only three showed symptoms of malarial infection. The difficulty of inducing ignorant persons to fully comply with directions for protecting themselves accounts for the exceptions. No quinine was used by the party. Out of the population of 307 souls living in that region and not protected, all but five contracted malaria—these five being sons of the soil who seem to have been immune to a considerable extent. Where the protected party took no quinine, the exposed persons, on the other hand, during the same period, took six pounds.

---

*The specimens of Eucalyptus here shown are, one from Battipaglia, north of Paestum, in a terribly devastated region of Italy; the other from the Roman Campagna above the Callistus catacombs.

It is now proposed to isolate all fever patients in the malarial districts and to protect the dwellings by screens—a tremendous undertaking with an area of 20,000 square miles and with a population, much of it very ignorant, of 2,500,000.

CHANGES IN INDIANA.

In regard to the changed condition in Indiana—the former prevalence of malaria, especially in the Wabash bottoms, even only two or three decades ago, and its comparative rarity at the present time: It seems to me that the explanation is to be sought chiefly in the fact that proper medication, the taking of sufficient quinine, is resorted to promptly nowadays, resulting in the rapid disappearance of the disease, or disease symptoms, in the afflicted individual, and thus keeping the number of foci from which the disease could be disseminated at a minimum, and at the same time shortening the period of existence of such foci, or, in other words: The fewer individuals there are in any neighborhood the less the liability for the healthy to contract the disease.

In former times quinine was a very costly remedy, used as a last resort and usually in insufficient doses; to-day quinine is very cheap and by many used for any suspicious malarial symptoms.

Then, too, mosquitoes were, no doubt, more abundant in former times than at present, owing to the greater number of wet places where the animals could breed; stagnant water being one of the essentials in the life history of the insect. Drainage is restricting such breeding places more and more, thus indirectly reducing the number of mosquitoes. Now that the proper relationship of malaria to swamps and pools is known, it becomes a comparatively easy matter to still further diminish the progeny of the "skeeters" still among us. The simplest method, except drying up wet places, is to spread a film of oil over all bodies of stagnant water—the larvae as they come to the surface to breathe get the oil in the respiratory system and quickly perish. The necessity of isolating and properly protecting all malarial fever cases is self-evident.

SUMMARY AND CONCLUSIONS.

Malaria is a disease which once had a restricted distribution, but which in the course of time has been distributed over the face of the earth; it is most common in warm climes; it is due to a specific cause, the Plasmodium malariae, a minute organism living in and destroying the red blood corpuscles. The parasites are transmitted from one person to another by the mosquito. A certain cycle of the life history of the malarial parasite takes place within the body of the mosquito and the spores are injected from the salivary glands into and under the skin in biting.

Certain species of mosquitoes are the carriers to and fro of the infect--ing organisms. They may in a general way be recognized by their spotted wings and by their peculiar position when at rest.

The prevalence of malaria can be diminished by guarding against mosquito bites; by isolating malarial fever patients, giving them sufficient quinine and protecting them from being bitten; by reducing the number of breeding places of the mosquitoes by drainage.

Individual prophylaxis is best attained by avoiding the bite of the mosquito.

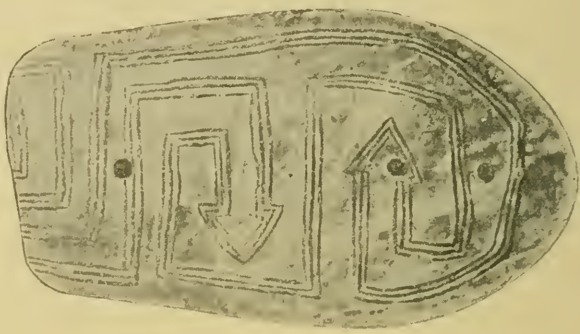
A Shell Gorget Found Near Spiceland, Indiana.

By Joseph Moore.

All I propose to do in this brief paper is to give a history of the object represented by the accompanying photograph, leaving it for others to tell the meaning of the engraved design and also its relation to other specimens of prehistoric art. About half a mile north of Spiceland, Henry County, while some men were loading gravel and sand, they came to some graves from which were taken two or three badly decayed human skeletons, the skull of a groundhog and the gorget which is the subject of this report. One of the human skulls is well preserved and the other sufficiently so to indicate its character. They represent rather a fine type of head.

The photograph herewith presented is very nearly one-half the size of the original, which is in length five and three-fourths inches. The greatest breadth toward the wider end is three and one-eighth inches, and that of the narrower end is two and one-half inches.

It has been wrought by dressing off the borders of a very large specimen of fresh water mussel, a species of Unio. It is evident both from the incompleteness of the original tracing on its concave surface and from the natural form of that species of shell that one-fourth, more or less, of the entire length of the original ornament has been broken off while yet in use, and the broken edge dressed to improve its appearance.



There are four perforations. As to the design, it has been engraved by a steady hand, and the fine grooves afterwards neatly stained with dark paint.

The photograph would probably represent the original somewhat more perfectly had not the finder varnished it, supposing it would otherwise be likely to crumble, as did the larger part of the two skeletons. It was, however, well preserved.

Professor Holmes of the Smithsonian Institute and Professor Warren K. Moorehead both regard it as an interesting find, and one or both of them will probably tell us more about what it is supposed to mean. So far as I have yet been able to learn, inscriptions on shell are more common further south, say in Tennessee and the Gulf States, than in the latitude of central Indiana.

This design is in some respects allied to what may occasionally be found among the ruins of Central America, judging from pictures observed in archeological reports.

I am indebted to David Newby of Spiceland for the specimen and to Professor Collins of Earlham for the photograph.

A Harbor at the South End of Lake Michigan.

By J. L. Campbell.

The northern boundary intended for Indiana by the act of Congress, July 13, 1787, and also the boundary designated in the act introduced December 27, 1815, by Mr. Jennings, the territorial delegate for the admission of Indiana as a State, was an east and west line through the southern extreme of Lake Michigan.

But an amendment to the original bill was adopted removing this boundary line ten miles to the north, and in this form the act was passed April 19, 1816.

This ten-mile line was marked on the early maps of the State, and has been the subject of curious inquiry by many who are ignorant of this item of State history.

By this amendment there was added to the territory of the State nearly one-half of the present counties of Steuben, Lagrange, Elkhart, St. Joseph and Laporte.

By the original line the State would have been cut off entirely from the great northern chain of lakes, and Michigan and Illinois would have cornered at the extreme southern limit of the lake.

The ten-mile strip gives to the State a lake front of forty miles between Michigan and Illinois, and makes Lake, Porter and Laporte counties parts of the border of our great inland sea.

I do not know who deserves the honor of securing the ten-mile strip, but I would be glad to erect two monuments to his memory, one where our shore line touches Illinois and the other to mark the line between this State and Michigan.

From the period of the admission of the State in 1816 until the present our wisest statesmen and best engineers have manifested great interest in the improvement of our lake front.

Michigan City was laid out in 1831, and in 1836 Congress made an appropriation of $20,000 for the beginning of a harbor at that place.

The site is a good one—the growth of the city has been satisfactory, a fair degree of liberality has been shown by the general government for the harbor, and the results prove that the expenditures have been wise.

It merits and should continue to receive the most generous support. But the new conditions around the head of Lake Michigan require improvements and advantages on a much greater scale than the continued support of a single harbor.

The village of 1830 at the mouth of Chicago River has become the second city of importance in the United States.

Its traffic by rail and water has become so great that relief and enlargement are most pressing, and these must be provided along the Indiana lake front.

The shore line along the lake is made up of loam and sand, which, although not the best material for harbor building, are of comparatively easy manipulation.

With other sites for a new harbor I ask attention anew to the mouth of the Calumet River, and particularly to the feasibility of using the strip of low land or lakelet east of the river and extending possibly into Porter County.

Between the sand hills or ridges, which are shown on the government survey, and the nearest railway line there is a strip of marsh land called, on the old maps, Long Lake.

If on examination it should be found practicable to dredge out this lake to the proper depth and connect it with the mouth of the Calumet the desired harbor would be easily constructed.

This site is specially commended on account of the protection afforded by the sand ridges on the north, thereby making it a haven as well as a harbor, and because it would interfere least with the railways along the lake shore.

The commercial advantages to the State are of the greatest importance.

All the railways running southeast and east from Chicago would use this new port for transfers between rail and water—and possibly also between railways west and north of Chicago on account of less expensive terminal facilities—so that the co-operation and support of the great railway interests would be secured.

Here would be the point of minimum cost between the Lake Superior iron ores and the block coal of central Indiana and the greatest stimulus offered to the development of all kinds of manufacturing industries.

The cheapening of transportation for oolitic limestone would be no small factor in favor of this new outlet.

Hammond and other flourishing cities in the northwest part of the State would experience the most direct benefits by the increase of business and manufacturing facilities and consequent increase in population.

The proposition is worth at least a passing thought and is commended to the State and general governments for further consideration.

Some Properties of the Symmedian Point.

By Robert J. Aley.

Monsieur Emile Lemoine, at the Lyons meeting of the French Association for the advancement of the Sciences in 1873, called attention to a particular point within the triangle, which he called the center of antiparallel medians. Since that time a number of mathematicians have studied the point and have discovered many of its properties. The point is such an interesting one that a brief collection of its more striking properties may be of some value. No claim is made to completeness.

DEFINITIONS OF THE POINT.

1. The point of concurrency of the bisectors of all lines antiparallel to the sides of the triangle.

2. The point of concurrency of the lines isogonal conjugate to the medians of the triangle; that is, the point of concurrency of the symmedians of the triangle.

3. The point within the triangle, the sum of the squares of whose distances from the three sides is the least possible.

4. The point within the triangle, whose distances from the sides is directly proportional to the sides.

NAMES OF THE POINT.

1. Center of antiparallel medians, proposed by Monsieur Emile Lemoine.

2. Symmedian point (symédiane, from symétrique de la médiane), proposed by Monsieur Maurice d'Ocagne. The Engish form "symmedian" was suggested by Mr. R. Tucker in 1884.

3. Minimum point, suggested by Dr. E. W. Grebe.
4. Grebe's point, proposed by Dr. A. Emmerich.
5. Lemoine's point, proposed by Professor J. Neuberg.

METHODS OF CONSTRUCTING THE POINT.

1. Draw the medians AM_a, BM_b of the triangle ABC. Then draw AK'_a, BK'_b, making the same angle with the bisectors of angles A and B, respectively, as are made by AM_a and BM_b. The intersection of AK'_a, BK'_b is K, the symmedian point.

2. Draw antiparallels to BC and CA. Join A and B, respectively, to the midpoints of these antiparallels, and the intersection of these joining lines is K, the symmedian point.

3. To the circumcircle of the triangle draw tangents at B, C and A, and let these intersect in X, Y, Z, respectively. Then AX, BY, CZ concur at K, the symmedian point.

SOME PROPERTIES OF THE POINT.

1. K is the point isogonal conjugate to G, the centroid.

2. If K_a, K_b, K_c are the feet of the perpendiculars from K to the three sides respectively, then

$$\left.\begin{aligned} KK_a &= \frac{2\triangle a}{a^2+b^2+c^2}. \\ KK_b &= \frac{2\triangle b}{a^2+b^2+c^2}. \\ KK_c &= \frac{2\triangle c}{a^2+b^2+c^2}. \end{aligned}\right\}$$

Where $\triangle$ is the area of the triangle ABC, and a, b, c are three sides of the same triangle.

3. Area of $\triangle$ BKC $= \frac{\triangle a^2}{a^2+b^2+c^2}$

Area of $\triangle$ CKA $= \frac{\triangle b^2}{a^2+b^2+c^2}$

Area of $\triangle$ AKB $= \frac{\triangle c^2}{a^2+b^2+c^2}$

$\triangle BKC : \triangle CKA : \triangle AKB = a^2 : b^2 : c^2.$

4. Antiparallels to sides of the triangle through K are equal. Such antiparallels cut the sides of the triangle in six points which lie on a circle whose centre is K. This circle is called the *Cosine* Circle.

5. K is the median point of the triangle $K_aK_bK_c$.

6. The line KM_a (M_a is the mid point of BC) passes through the mid point of the altitude AH_a.

7. The sides of the K-pedal triangle $K_aK_bK_c$ are perpendicular to the medians of ABC, respectively.

8. The sides of the G-pedal triangle $G_aG_bG_c$ are perpendicular to the symmedians AK, BK, CK, respectively.

9. $a . GA . KA + b . GB . KB + C . GC . KC = a . b . c.$

10. If the symmedian lines AK, BK, CK meet the circumcircle of ABC in A', B', C', then the triangles ABC and $A'B'C'$ are co-symmedian, that is they have the same symmedian point K.

11. K and M (M is the circumcentre of ABC) are opposite ends of a diameter of Brocard's Circle.

12. Parallels to the sides of ABC through K, determine six points on the sides which lie on the Lemoine Circle.

13. If points A', B', C' be taken on KA, KB, KC so that $KA' : KB' : KC' = KA : KB : KC =$ constant, then antiparallels to the sides through A', B', C', respectively, determine six points on the sides of the triangle which lie on a Tucker Circle.

14. If $A_1 B_1 C_1$ is Brocard's first triangle, then

$A_1 K$ is parallel to BC.

$B_1 K$ is parallel to CA.

$C_1 K$ is parallel to AB.

15. AK, BK, CK produced meet Brocard's circle again in A'', B'', C'' respectively, and these points form Brocard's second triangle $A'' B'' C''$.

16. If KA, KB, KC, meet the sides of ABC in X_1, X_2, Y_1, Y_2 and Z_1, Z_2 respectively, then the sides of the triangle $Z_1 X_1 Y_1$ are parallel to $A\,\Omega$, $B\,\Omega$, $C\,\Omega$ respectively, and the sides of $Y_2 Z_2 X_2$ are parallel to $A\,\Omega'$, $B\,\Omega'$, $C\,\Omega'$ respectively, where Ω and Ω' are the Brocard points of ABC. Ω and K are the Brocard points of $Z_1X_1Y_1$ and Ω' and K are the Brocard points of $Y_2Z_2X_2$.

17. The point of concurrency D of AA_1, BB_1, CC_1 is the point isotomic conjugate to K.

18. The line MK is perpendicular to and bisects the line $\Omega\Omega'$.

19. The Simson line of Tarry's point is perpendicular to MK.

20. $\text{Cot} \angle KBC + \cot \angle KCA + \cot \angle KAB = 3 \cot \omega$ where ω is the Bocard angle.

21. If the symmedian AK cut BC in K'_a and the line MM_a in Q then (AK'_a, KQ) is a harmonic range.

22. If from K'_a perpendiculars p an q are drawn to CA, AB respectively, then

$$\frac{p}{b}=\frac{q}{c}=\frac{2\triangle}{a^2+b^2}$$

23. $AK:KK'_a=b^2+c^2:a^2$

24. $BK'_a:K'_aC=c^2:b^2$

$CK'_b:K'_bA=a^2:c^2$

$AK'_c:K'_cB=b^2:a^2$

$$BK'_a=\frac{ac^2}{b^2+c^2} \text{ etc}$$

25. The tangent to the circumcircle at A, and the symmedian AK are harmonic conjugates with respect to AB and AC.

26. The angles AMK, BMK, CMK are equal respectively to the angles (BC, B_1C_1) (AC, A_1C_1), (AB, A_1B_1), that is the respective angles between the sides of Brocard's first triangle and the corresponding sides of the fundamental triangle.

27. The sides of the $\triangle K_aK_bK_c$ are proportional to the medians of the $\triangle ABC$, and the angles of the $\triangle K_aK_bK_c$ are equal to the angles which the medians make with each other.

28. The sum of the squares of the sides of $K_aK_bK_c$ is less than the sum of the squares of the sides of any other triangle inscribed in ABC.

29. The ratio of the area of ABC to that of its co-symmedian triangle $A'B'C'$ (See No. 10) is $(-a^2+2b^2+2c^2)(2a^2-b^2+2c^2)(2a^2+2b^2-c^2):27a^2b^2c^2$.

Note On McGinnis's Universal Solution.

By Robert J. Aley.

The full title of the book is, "The Universal Solution for numerical and literal equations by which the roots of equations of all degrees can be expressed in terms of their coefficients, by M. A. McGinnis, Kansas City, Missouri, the Mathematical Book Company, 1900."

In his preface the author announces that the book appears at "the request of many able mathematicians, teachers and scholars throughout the United States." He also modestly states that the imaginary is for the first time put upon a true basis, that bi-quadratics are more thoroughly treated than in any prior work and that it is the only work in which general equations beyond the fourth degree are solved. It is also the only book that shows the fallacies in Abel's proof that equations of higher degree than the fourth can not be solved by radicals.

That the book is interesting goes without saying. No one who promises so much can fail to write in an interesting manner. One follows breathlessly to see the kind of a paradox that will be produced.

A number of simple theorems in the theory of numbers and the theory of equations are stated as though they were new.

On page 53, article 164, we read: "The roots of quadratics represent the sides of *right triangles* when Real Quantities; the sides of *isosceles triangles* when *Real Imaginaries;* and when *Pure Imaginaries* may be represented by *lines*." His argument for the latter part of the statement, it is needless to say, is not convincing.

A number of special numerical problems in equations of various degrees are solved. In many of these some very ingenious special methods are exhibited.

One chapter is devoted to the discussion of Wantzel's modification of Abel's proof of the impossibility of an algebraic solution of equations of higher degree than the fourth. The character of the discussion can be best understood by quoting the conclusion. "If we should accept his (Wantzel's) demonstration as true, we would be forced to the conclusion that the general equation of a degree higher than four was destitute of roots. The concluson of Wantzel that the roots can not be indicated in algebraical language is equivalent to saying that there are no roots, since it is absurd to say that finite quantities exist which can not be expressed in any function of other finite quantities, which are themselves symmetrical functions of the first, however complicated."

The author's notion of the imaginary is summed up in a general theorem, as follows: "An Imaginary Quantity is the indicated square root of the difference of the squares (with its sign changed) of the bases of two right triangles having a common perpendicular which is the radius of a circle; two of such triangles lying wholly within the semicircle, and two partly within and partly without the semicircle." What the theorem or the demonstration means would be hard to tell.

Of his so-called universal solution I will consider only that of the sixth degree. He assumes that—

$$x^6 + mx^5 + nx^4 + bx^3 + px^2 + tx + q = 0$$

$$\left\{x^2 + \frac{m}{a}x + y\right\} \left\{x^2 + \frac{m}{b}x + z\right\} \left\{x^2 + \frac{m}{c}x + w\right\} = 0$$

He then puts

$$(1) \quad n - \frac{m^2}{A} = \frac{A_o}{2m} - \frac{m^2}{2A^2} = y + z + x$$

$$(2) \quad p - \left\{\frac{m^2n}{B^2} - \frac{m^4}{B^3}\right\} = \frac{Bt}{m} = yz + yw + zw.$$

$$(3) \quad q = yzw$$

$$(4) \quad oA^3 - 2mnA^2 + 2m^3A - m^3 = 0$$

$$(5) \quad tB^4 - mpB^3 + m^3nB - m^5 = 0.$$

From (4) and (5) find A and B

Then x, y, z are found from 1, 2, 3 by means of a cubic equation.

The author incidentally remarks that the proper combination of the three values of A, and the four values of B are easily determined by a little practice. The author also says that it is evident that by comparing coefficients the values of 1/a, 1/b, 1/c can be obtained. The novice will find some difficulty in doing it. The real point of difficulty, however, is that we have eight unknown quantities, viz., a, b, c, x, y, z, A, B, and nine equations to be satisfied, viz., five by equating coefficients, and four from (1) and (2). So that the boasted solution is after all only a solution when there is some condition placed on the roots.

Graphic Methods in Elementary Mathematics.

By Robert J. Aley.

The Automatic Temperature Regulator.

By Chas. T. Knipp.

(Published in the Physical Review, Vol. XII, No 1, January, 1901.)

The Cayleyan Cubic.

By C. A. Waldo and John A. Newlin.

The Use of the Bicycle Wheel in Illustrating the Principles of the Gyroscope.

By Chas. T. Knipp.

(Published in the Physical Review, Vol. XII, No. 1, January, 1901.

The Cyclic Quadrilateral.

By J. C. Gregg.

PROBLEM.

The opposite sides of a quadrilateral FGHI inscribed in a circle, when produced, meet in P and Q; prove that the square of PQ is equal to the sum of the squares of the tangents from P and Q to the circle.—No. 80, page 470, Phillips and Fisher's Geometry.

SOLUTION.

(See Fig. I.)

On PO and QO as diameters draw circles (centers S and T) and cutting circle O in C, D, E and K. QK and PD are tangent to O. Through the points Q, F and G draw a circle cutting PQ in A. Then $\angle PHG = \angle GFI = \angle QAG$ $\therefore$ $\angle PAG$ is the supplement of $\angle PHG$ and PAGH is cyclic, and

$$PQ.PA = PF.PG = \overline{PD}^2 \text{ and}$$

$$PQ.QA = QH.QG = \overline{QK}^2 \text{ and adding these two equations}$$

$$\overline{PQ}^2 = \overline{PD}^2 + \overline{QK}^2 \text{ — Q. E. D.}$$

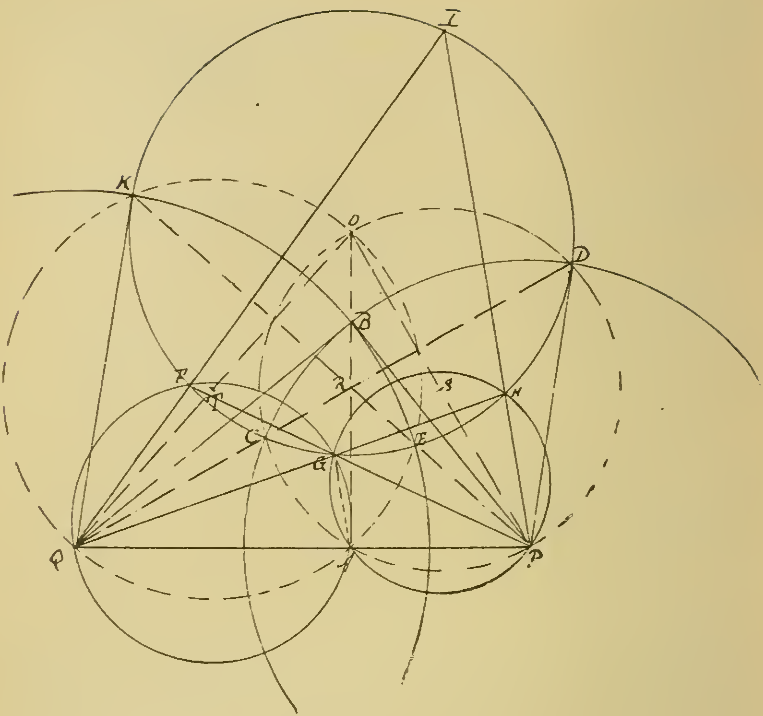


Fig. I.

DISCUSSION.

(1) With P and Q as centers, and PD and QK as radii draw two arcs meeting in B. Then PBQ is a right angle, and PB is tangent to arc EBK, and as the tangents PD and PB to circle O and arc EBK are equal, P must be on the common chord KE produced; and in the same way DCQ is a straight line.

(2) Since PK.PE=PF.PG=PQ.PA, the point A is in the circumference T, and OA is perpendicular to PQ, and A is also in the circumference S.

(3) PQ.PA=PF.PG=PI.PH. ∴ the points A, Q, I, H are concyclic, and in the same way A, P, I, F are also concyclic.

(4) PK and QD are respectively perpendicular to QO and PO, and R is the orthocenter of the triangle POQ, and AO passes through R.

(5) The three arcs DEC, EBK and DBC cut orthogonally, two and two, and the common chord of any two of them passes through the center of the third.

(6) (See Fig. II.)

$\angle GPA + \angle GQA = \angle HIF$ (supplement of $\angle PGQ$).

$\angle GPH = \angle GAH$.

$\angle GQF = \angle GAF$ and adding these three equations

$\angle QPI + \angle PQI = \angle HAF + \angle HIF$, or

$180° - \angle HIF = \angle HAF + \angle HIF$.

$180° - 2\angle HIF = \angle HAF$. But $\angle HOF = 2\angle HIF$.

$\therefore 180° - \angle HOF = \angle HAF$ and H, A, F, O, are concyclic.

(7) We have now shown the following points to be concyclic:

A, G, F, Q,—center M.
A, G, H, P,—center N.
A, O, K, Q,—center T.
A, P, D, O,—center S.
A, P, I, F,—center S′.
A, Q, I, H,—center T′.
A, H, O, F,—center O′.

And we will show that X is the center of a circle through A, G, O, I.

(8) CD, OA and HF are the three common chords of circles O, S and O′, and must meet in a point. Hence HF, the diagonal of FGHI, passes through R.

(9) Since APIF is cyclic $\angle QAF = \angle QIP$; and for the same reason $\angle PAH = \angle QIP$. $\therefore \angle QAF = \angle PAH$ and $\angle OAF = \angle OAH$.

(10) Since the circles S′, O′ and M pass through the points A and F, their centers S′, O′ and M are in the same line perpendicular to AF. For a similar reason N, O′, T′ are in the same line perpendicular to AH, and S′, S, N and T′, T, M are respectively in the same lines perpendicular to PQ or TS. Also T′S′, TS and MN respectively bisect AI, AO, and AG at right angles. Now the angles SO′S′ and SO′N have their sides respectively perpendicular to the sides of the equal angles OAF and OAH. $\therefore \angle SO'S' = \angle SO'N$ and $SN = SS'$, and in the same way $TM = TT'$. Hence the lines T′S′ and MN will meet TS at the same point X, and $XA = XG = XO = XI$ and X is the center of the circle through A, G, O, I.

(11) Now HF, OA, and GI are the three common chords of the circles O, O′ and X and must meet in a point. Hence GI the other

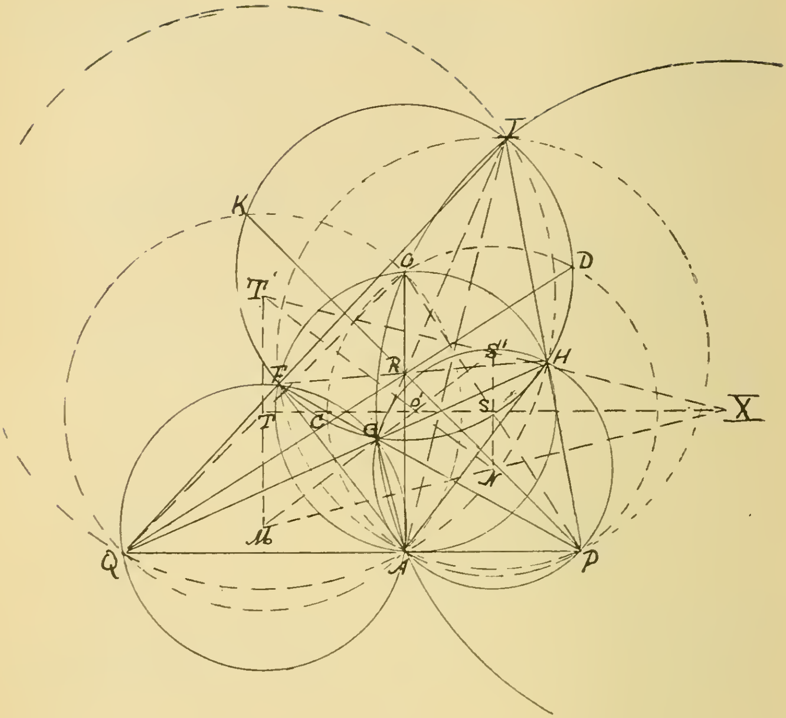


Fig II.

diagonal of FGHI also passes through R, and we have established the following

Theorem.—The diagonals of an inscribed quadrilateral meet in the orthocenter of the triangle whose vertices are the center of the circle, and the points where the opposite sides meet.

(12) (See Fig. 1.) Since QK, QE, PC and PD are tangents to circle O, the following theorem holds: If the diagonals of an inscribed quadrilateral meet in R, and its opposite sides meet in P and Q, and PR and QR be drawn cutting the circle in E, K, C and D, then PD, PC, QK and QE are tangent to the circle.

(13) The diagonals of *any* quadrilateral inscribed in circle O, and whose opposite sides meet in P and Q, will pass through R.

(14) If any point I, in circle O be joined to P and Q and cutting the circle in F and H, PF and QH will meet on the circumference as at G.

Note on the Determination of Vapor Densities.

By Chas. T. Knipp

The object of this note is to describe briefly a method of determining vapor densities which was suggested to the writer last year while making observations on the surface tension of water at high temperatures.

The principle used is that the buoyancy of vapor increases as the density increases. An iron core *mn* (Fig. I), carrying a sphere *S* at its lower end is lifted by the sucking action of a coil in which a current is flowing. The lifting coil and core with sphere attached are contained in a steel vessel of sufficient strength to withstand high pressures. Three insulated circuits are run through the plug closing the vessel. The scheme

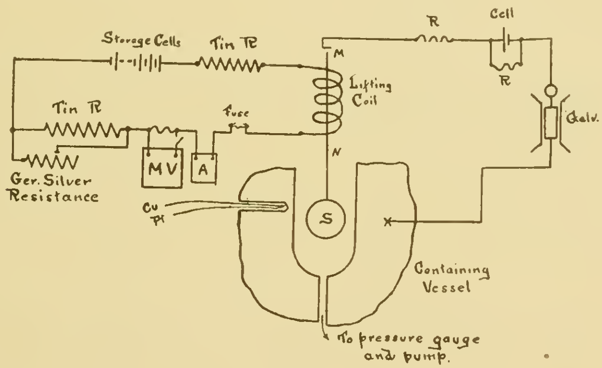
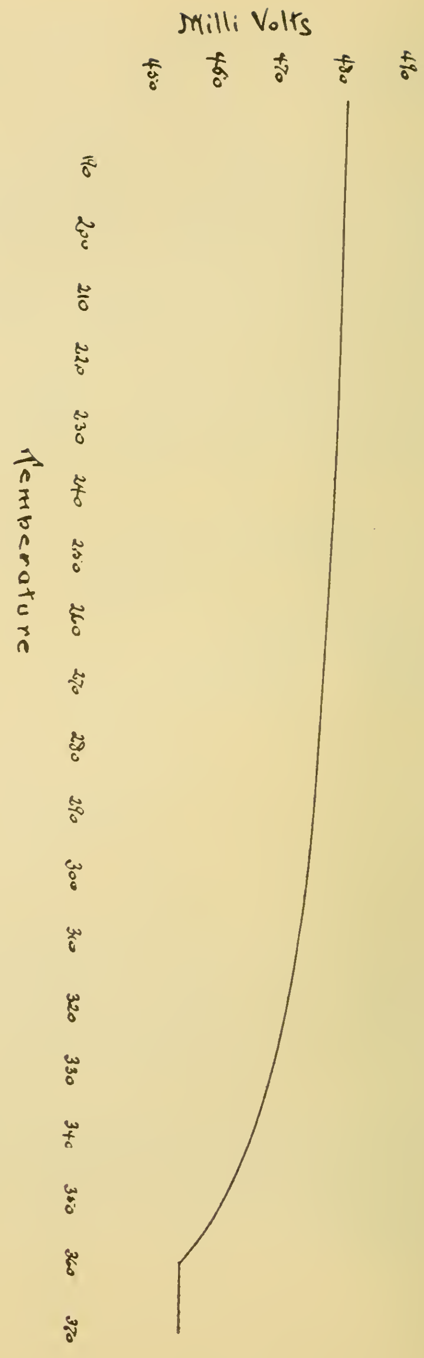


Fig. 1.

of connections is shown in Fig. I. The lifting current is supplied by a number of storage cells, the current being adjusted by tin resistances until the sphere is lifted. At that instant contact is made at *M*, closing the signal circuit, shown to the right in the figure. The temperature is read by means of a Cu-Pt thermo-junction. This is placed in a hole drilled in the containing vessel to within 2mm of the inner cavity. The vessel communicates with a pressure gauge and pump. The current required to lift the sphere is read by means of a milli-volt meter looped around a .03-ohm coil.



Milli Volts
490
480
470
460
450
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
370
Temperature

Fig. 2.

As yet only a few readings have been made, and these were obtained incidentally while conducting the investigation referred to above. A curve was platted (Fig. 2) in which temperatures are abscissas, and the corresponding currents are ordinates. Only the upper portion of the curve is shown in the figure. The density increases very slowly at first, and becomes constant when the critical temperature is passed.

This method furnishes a means of determining the critical temperature and critical pressure, as well as the critical volume of a liquid.

An Improved Wehnelt Interrupter.

[Abstract]

By Arthur L. Foley and R. E. Nyswander.

The chief difficulties encountered in working with the ordinary type of Wehnelt Interrupter are that the glass tube which holds the platinum wire is continually breaking and that the length and size of the projecting platinum wire can be changed only by constructing new tubes.

In the improved interrupter a lead vessel serves as electrode and to contain the electrolyte. The platinum wire is held in a brass tube having its lower end slotted and conical. A collar, sliding on the conical end, serves to press the jaws together and to clamp the platinum wire. The projecting end of the wire may be about 1 cm. long; the remainder of the wire may extend up the inside of the tube.

The lead vessel should be filled half full of the electrolyte and over this should be poured a layer of coal oil 2 or 3 cm. deep. The brass tube is gradually lowered until the platinum point extends to the desired depth in the electrolyte. The remainder of the platinum wire and the brass tube are entirely protected by the oil. The oil serves also to decrease the spray and fumes from the electrolyte. A platinum loop instead of a point is preferable in many cases. The action of the interrupter is made more constant.

Many other electrolytes may be used besides the usual 10 per cent. solution of sulphuric acid and water. As a matter of fact for high or low voltages some other electrolytes are superior. The following tables gives some data concerning a few of many electrolytes that have been used with this form of interrupter:

Solution (in water).	Voltage.	Spark.	Remarks.
1% sulphuric acid	40– 50	Short and thin	Fairly constant.
5% sulphuric acid	25– 40	Short and thin	Fairly constant.
10% sulphuric acid	20– 50	Strong	Fairly constant on high voltage.
20% sulphuric acid	20– 30	Very strong	Unsteady. Will not work on high or low voltage.
5% sulphuric acid } 5% nitric acid }	12– 20	Average	Fairly constant.
5% caustic potash	40– 50	Average	Stops frequently but, starts again without interruption.
10% sodium sulphite	75–115	Very heavy	Quite constant. High frequency. Used on 115 circuit without resistance.
10% sodium hyposulphite	40– 90	Strident	Ceases if short circuit is made on secondary.
10% acetic acid	....	....	Will not work on any voltage.
10% potassium sulphate	70–115	Average	Fairly constant.
10% ammonium nitrate	35– 85	Strong	More constant if secondary short circuited.
10% potassium nitrate	90–115	Very heavy	Not constant when t° increased.
5% nitric acid (glass vessel and platinum sheet electrode)	30– 50	Strong and strident	Steady.

A Method of Measuring the Absolute Dilatation of Mercury.

[Abstract.]

By Arthur L. Foley.

The forms of apparatus used by Dulong and Petit, and Regnault, in determining the absolute dilatation of mercury are open to one or both of the following objections: (1) Some parts of the mercury columns are exposed and so the termperature can not be exactly the same throughout; (2) the heights of the columns must be measured from some assumed point of equilibrium in a horizontal connecting tube. The method proposed in this investigation is entirely free from both these objections.

The two arms of a vertical U tube are jacketed in the usual way, except that the jacketing tubes are of glass to permit the heights of the mercury columns to be taken with a cathetometer, at any level. Into the tube is poured a quantity of mercury sufficient to stand several centimeters high in each arm. When the required temperature has been attained the two heights are carefully measured. More mercury is added and under the same temperature conditions the heights are again measured. The differences in the heights before and after adding the mercury, together with the temperature difference of the two arms, are all the data required. Many independent determinations may be made by adding or removing mercury. As the readings are in every case difference readings any effects that might come from capillary and convection currents in the horizontal tube are eliminated. Two of my students, J. G. Gentry and O. A. Rawlins, have obtained remarkably consistent results by this method, though the coefficient of dilatation obtained by them is slightly less than that obtained by Regnault.

The Geodesic Line of the Space $ds^2 = dx^2 + \sin^2 x dy^2 + dz^2$.

By S. C. Davisson.

The Friction of Railway Brake Shoes Under Various Conditions of Pressure, Speed and Temperature.

By R. A. Smart.

Information concerning the friction of unlubricated rubbing surfaces is, unfortunately, limited in quantity, and it is believed that the data presented herewith, although relating particularly to the friction of brake shoes for railway cars, may be properly offered to the Academy as a contribution to the general subject.

The brake shoe is an important factor in the chain of mechanism popularly known as the air brake. It is not, strictly speaking, a part of the air brake, but is the immediate agent through which the air brake accomplishes the stopping of the train. It is the block of metal which is pressed against the tread of the car-wheel and which creates, in contact with the wheel, the friction which brings the wheel and hence the train to rest. It will at once be seen that the effectiveness of the whole air brake system on our railways is dependent directly upon the efficiency with which the brake shoe does its work. For instance, we can conceive of the brake shoe being made of some substance like glass, so hard that its friction would be practically nothing, in which case the air brake would be powerless to stop the train.

In fact, so important is the brake shoe in the eyes of railway officials that the Master Car Builders' Association has caused to be built an elaborate machine to be used exclusively for the testing of brake shoes. The need of such a machine will be understood when it is stated that the tendency of brake shoe manufacturers is, in order to be able to guarantee long life for their shoes, to make them so hard as to seriously impair their frictional qualities.

The Master Car Builders' Brake shoe testing machine, which has been deposited by them in the engineering laboratory of Purdue University, consists of a heavy revolving weight whose kinetic energy at any speed is equal to that of one-eighth of a loaded 60,000-pound freight car. On the same shaft as this weight and revolving with it is an ordinary car wheel. By a series of weighted levers, the shoe to be tested is pressed against the moving car wheel, thus bringing the wheel and, hence, the revolving weight to rest. When it is remembered that the freight car has eight wheels, each fitted with a brake shoe, it will be seen that the machine reproduces the conditions surrounding one-eighth of a freight car, so far as the forces involved in stopping the car are concerned. The machine provides a complicated recording mechanism by which the performance of the shoe while under test may be determined.

The present tests were undertaken to determine the effect upon the coefficient of friction of variations in three factors, viz.: The normal pressure between the shoe and the wheel, the speed of the wheel at the time the shoe is first applied, and the temperature of the rubbing surfaces. The effect of the first two variables was determined by making stops from various initial speeds and under different braking pressures, and calculating for each test the mean coefficient of friction for the stop. The limits of the variable elements under which the tests were made were as follows: Initial speed, 10 to 65 miles per hour; normal pressure, from about 2,800 pounds to about 10,700 pounds, these limits being the ones found in ordinary road service. In making a stop, the method of procedure is as follows: The weight and car wheel are brought to the desired speed of rotation by an engine. The engine is then disconnected from the revolving weight by a clutch and the brake shoe is brought in contact with the car wheel with the desired braking pressure. As the car wheel and weight are being brought to rest under the action of the brake shoe, the recording mechanism attached to the latter draws an autographic record of certain elements in the performance of the shoe, from which the mean coefficient of friction during the stop may be calculated.

The effect of the third variable mentioned above, namely, the temperature of the rubbing surfaces, was more difficult to determine. The temperature of the shoe only was observed, and this was found by imbedding in each end of the shoe the thermo-electric joint of a Le Chatelier pyrometer. This joint, in connection with a D'Arsonval galvonometer, gave continuous readings of the temperature of the face of the shoe near each end. The tests were made by making continuous runs at constant speed and noting simultaneously the temperature of the shoe and the coefficient of friction. The limits of temperature under which the tests were made were from about 60° F. to about 1500° F.

The results from the tests may be summed up as follows:

1. The coefficient of friction of brake shoes decreases with increase of pressure. The values are approximately as follows:

Soft cast-iron shoe.

Slow speed.

Pressure increasing from 2,700 pounds to 10,700 pounds.

Coefficient of friction decreasing from 37 per cent. to 20 per cent.

Soft cast-iron shoe.

High speed.

Pressure increasing from 2,700 pounds to 10,700 pounds.

Coefficient of friction decreasing from 25 per cent. to 15 per cent.

Hard cast-iron shoe.

Slow speed.

Pressure increasing from 2,700 pounds to 10,700 pounds.

Coefficient of friction decreasing from 33 per cent. to 18 per cent.

Hard cast-iron shoe.

High speed.

Pressure increasing from 2,700 pounds to 10,700 pounds.

Coefficient of friction decreasing from 17 per cent. to 12 per cent.

2. The coefficient of friction of brake shoes decreases with increase of initial speed. The values are approximately as follows:

Soft cast-iron shoe.

Light pressure.

Speed increasing from 10 to 65 miles per hour.

Coefficient of friction decreasing from 37 per cent. to 25 per cent.

Soft cast-iron shoe.

Heavy pressure.

Speed increasing from 10 to 65 miles per hour.

Coefficient of friction decreasing from 27 per cent. to 20 per cent.

Hard cast-iron shoe.

Light pressure.

Speed increasing from 10 to 65 miles per hour.

Coefficient of friction decreasing from 33 per cent. to 20 per cent.

Hard cast-iron shoe.

Heavy pressure.

Speed increasing from 10 to 65 miles per hour.

Coefficient of friction decreasing from 25 per cent. to 12 per cent.

3. The coefficient of friction of cast-iron brake shoes is practically constant with variations in temperature of shoe and wheel within the limits of the experiments.

Diamond Fluorescence.

[Abstract.]

By Arthur L. Foley.

A year ago I presented to the Academy an account of an experiment with a diamond and a photographic dry plate (Proceedings of Academy, 1899, p. 94). Later experiments have confirmed the theory presented. It has been found that a low temperature is favorable to the success of the experiment.

A Theorem in the Theory of Numbers.

By Jacob Westlund.

Let n be any prime number and let

$$S_k = 1^k + 2^k + 3^k + \ldots\ldots\ldots\ldots + (n-1)^k.$$

Then

$S_k \equiv 0$, mod n, when $k \not\equiv 0$, mod $(n-1)$ and $S_k \equiv -1$, mod n, when $k \equiv 0$, mod $(n-1)$.

Proof. Consider the congruence.

$$x^{n-1} - 1 \equiv (x-1)(x-2)\ldots\ldots\ldots\ldots(x-\overline{n-1}), \text{ mod } n.$$

This congruence is evidently satisfied by the $n-1$ incongruent numbers.

$$1, 2, 3, \ldots\ldots\ldots\ldots\ldots\ldots(n-1).$$

But the congruence is of the degree n — 2, since it may be written

$+ a_1 x^{n-2} - a_2 x^{n-3} + a_3 x^{n-4} \ldots\ldots\ldots\ldots - a_{n-1} - 1 \equiv 0$, mod n, where

$a_1 = 1 + 2 + 3 + \ldots\ldots\ldots\ldots + (n-1)$

$a_2 = 1 . 2 + 1 . 3 + \ldots\ldots\ldots\ldots + 2 . 3 + \ldots\ldots\ldots\ldots$

$a_3 = 1 . 2 . 3 + 1 . 2 . 4 + \ldots\ldots\ldots\ldots$

. . . .

$a_{n-1} = 1 . 2 . 3 \ldots\ldots\ldots\ldots (n-1)$.

Hence, since the number of roots of a congruence with prime modulus can not be greater than the modulus, the given congruence must be identical. Hence,

$a_1 \equiv 0$, mod n.

$a_2 \equiv 0$, mod n.

$a_{n-2} \equiv 0$, mod n.

$a_{n-1} \equiv 1$, mod n.

But from the theory of symmetric functions we have the following relations:

$S_1 - a_1 = 0$.

$S_2 - S_1 a_1 + 2a_2 = 0$.

. . . .

$S_{n-2} - S_{n-3} a_1 + \ldots\ldots\ldots\ldots - (n-2) . a_{n-2} = 0$.

$S_{n-1} - S_{n-2} . a_1 + \ldots\ldots\ldots\ldots + (n-1) . a_{n-1} = 0$.

$S_n - S_{n-1} . a_1 + \ldots\ldots\ldots\ldots + S_1 . a_{n-1} = 0$.

. . . .

Hence,

$S_1 \equiv 0$, mod. n.

$S_2 \equiv 0$, mod. n.

. . . .

$S_{n-2} \equiv 0$, mod. n.

$S_{n-1} \equiv$ 1 mod. n

$S_n \equiv 0$, mod. n.

. . . .

$S_{2n-3} \equiv 0$ mod. n.

$S_{2n-2} \equiv -1$ mod. n.

$S_{2n-1} \equiv 0$ mod. n.

. . . .

or

$S_k \equiv 0$, mod n, when $k \not\equiv 0$ mod $(n-1)$ and $S_k \equiv -1$, mod n, when $k \equiv 0$ mod $(n-1)$.

On the Decomposition of Prime Numbers in a Biquadratic Number-Field.

By Jacob Westlund.

Let

$$x^4 + ax^2 + bx + c = 0$$

be an irreducible equation with integral co-efficients, whose discriminant $\triangle$ we suppose to be a prime number. Denote the roots of this equation by $\theta, \theta', \theta'', \theta'''$, and let us consider the number-field $k(\theta)$, generated by θ. Then since the fundamental number of $k(\theta)$ enters as a factor in the discriminant of every algebraic integer in $k(\theta)$, it follows that $\triangle$ is the fundamental number of $k(\theta)$ and

$$1, \theta, \theta^2, \theta^3$$

form an integral basis, i. e., every algebraic integer α in $k(\theta)$ can be written

$$\alpha = a_0 + a_1\theta + a_2\theta^2 + a_3\theta^3$$

where a_0, a_1, a_2, a_3 are rational integers.

The decomposition of any rational prime p into its prime ideal factors is effected by means of the following theorem: If

$$F(x) = x^4 + ax^2 + bx + c$$

be resolved into its prime factors with respect to the modulus p and we have

$$F(x) \equiv \left\{ P_1(x) \right\}^{e_1} \left\{ P_2(x) \right\}^{e_2} \ldots\ldots (\text{mod } p)$$

where $P_1(x), P_2(x)\ldots$ are different prime functions with respect to p, of degrees $f_1, f_2, \ldots$ respectively, then

$$(p) = \left[p, P_1(\theta) \right]^{e_1} \left[p, P_2(\theta) \right]^{e_2} \ldots\ldots$$

where $\left[p, P_1(\theta) \right]$, $\left[p, P_2(\theta) \right]$ ..... are different prime ideals of degrees $f_1, f_2, \ldots$ respectively. (1)

In applying this theorem to the factorization of p we have two cases to consider, 1st when $p = \triangle$ and 2nd when $p \neq \triangle$.

Case I. $p = \triangle$.

Suppose

$$(p) = A_1^{e_1} A_2^{e_2} A_3^{e_3} A_4^{e_4}$$

where $A_1, A_2 \ldots$ are different prime ideals of degrees $f_1, f_2, \ldots$, respectively. Then, since the fundamental number of $k(\theta)$ is divisible by $p^{f_1(e_1-1)+f_2(e_2-1)+\cdots}$ (1), we have

$$f_1(e_1-1) + f_2(e_2-1) + f_3(e_3-1) + f_4(e_4-1) = 1,$$

(1) Hilbert: "Bericht über die Theorie der Algebraischen Zahlkörper," Jahresbericht der Deutschen Mathematiker-Vereinigung (1894-95), pp. 198, 202.

and also

$$f_1^{e_1} + f_2^{e_2} + f_3^{e_3} + f_4^{e_4} = 4.$$

From these two relations we see, remembering that $\triangle$ is divisible by the square of a prime ideal (2), that the required factorization of p is either

$$(p) = A_1^2 . A_2 . A_3$$

where A_1, A_2, A_3 are prime ideals of first degree, or

$$(p) = A_1^2 A_2$$

where A_1 is of first degree and A_2 of second degree.

Hence the factors of F(x) are either

$$F(x) \equiv \left\{ P_1(x) \right\}^2 P_2(x) \, . \, P_3(x) \qquad (\text{mod. } p),$$

where $P_1(x)$, $P_2(x)$, $P_3(x)$ are prime functions of first degree, or

$$F(x) \equiv \left\{ P_1(x) \right\}^2 P_2(x)$$

where $P_1(x)$ is of first degree and $P_2(x)$ of second degree.

In order to find the prime ideal factors of p we have thus to resolve F(x) into its prime factors with respect to the modulus p. To do this we set

$$X^4 + ax^2 + bx + c \equiv (x + l)^2 (x^2 + mx + n) \quad (\text{mod. } p)$$
$$\equiv x^4 + (m + 2l) x^3 + (n + l^2 + 2ml) x^2 + (ml^2 + 2ln) x + nl^2. \quad (\text{mod. } p.)$$

Hence, for determining l, m, n we have the congruences

$$\left.\begin{array}{l} m + 2l \equiv o \\ n + 2ml + l^2 \equiv a \\ ml^2 + 2ln \equiv b \\ nl^2 \equiv c \end{array}\right\} (\text{mod. } p).$$

Eliminating m and n, we get

$$\left.\begin{array}{l} 4l^3 + 2la \equiv b \\ 3l^4 + al_2 \equiv c \end{array}\right\} (\text{mod. } p),$$

which give

$$2al^2 \equiv 3bl - 4c \quad (\text{mod. } p).$$

Having thus obtained the values of l, m, and n, we set

$$X^2 + mx + n \equiv (x + r)(x + s) \quad (\text{mod. } p)$$
$$\equiv X^2 + (r + s) x + rs. \quad (\text{mod. } p).$$

Hence,

$$\left.\begin{array}{l} r + s \equiv m \\ rs \equiv n \end{array}\right\} (\text{mod. } p).$$

or

$$(r - s)^2 \equiv - 4 (a + 2l^2) \quad (\text{mod. } p).$$

(1) Hilbert, p. 201. (2) Hilbert, p. 195.

1. If $\left(\frac{-(a+2l^2)}{p}\right) = -1$, then $x^2 + mx + n$ is irreducible and we have

$$F(x) \equiv (x+1)^2 (x^2 + mx + n) \pmod{p}$$

and hence

$$(p) = (p, \theta + 1)^2 (p, \theta^2 + m\theta + n).$$

2. If $\left(\frac{-(a+2l^2)}{p}\right) = +1$, then let $r - s = k$ be a solution of $(r-s)^2 \equiv -4(a+2l^2) \pmod{p}$ and we get r and s from the congruences

$$\left.\begin{array}{l} r + s \equiv m \\ r - s \equiv k \end{array}\right\} \pmod{p}.$$

We have then

$$F(x) \equiv (x+1)^2 (x+r)(x+s) \pmod{p}$$

and hence

$$(p) = (p, \theta + 1)^2 (p, \theta + r)(p, \theta + s).$$

Case II. $p \pm \triangle$.

In this case we have the two relations

$$f_1(e_1 - 1) + f_2(e_2 - 1) + f_3(e_3 - 1) + f_4(e_4 - 1) = 0.$$

$$f_1 e_1 + f_2 e_2 + f_3 e_3 + f_4 e_4 = 4.$$

Now since $\triangle$ is the only prime which is divisible by the square of a prime ideal, the relations given above show that p can be factored in one of the following ways:

1. $(p) = A_1 . A_2 . A_3 . A_4$ where A_1, A_2, A_3, A_4 are all of 1st degree.
2. $(p) = A_1 . A_2 . A_3$ where A_1 is of 2d degree and A_2, A_3 of 1st degree.
3. $(p) = A_1 . A_2$ where A_1 and A_2 are both of 2d degree.
4. $(p) = A_1 . A_2$ where A_1 is of 1st degree and A_2 of 3d degree.
5. $(p) = A_1$ where A_1 is of 4th degree, in which case (p) is a prime ideal.

Hence F(x) can be factored in one of the following ways:

1. $F(x) \equiv P_1(x) . P_2(x) . P_3(x) . P_4(x) \pmod{p}$.
2. $F(x) \equiv P_1(x) . P_2(x) . P_3(x) \pmod{p}$.
3. $F(x) \equiv P_1(x) . P_2(x) \pmod{p}$.
4. $F(x) \equiv P_1(x) . P_2(x) \pmod{p}$.
5. $F(x) \equiv P_1(x) \pmod{p}$.

where $P_i(x)$ is a prime function of the same degree as the corresponding A.

In order to decompose $F(x)$ into its prime factors with respect to the modulus p we set

$$x^4 + ax^2 + bx + c \equiv (x + l)\ (x^3 - lx^2 + mx + n) \pmod{p}.$$
$$\equiv x^4 + (m - l^2)\, x^2 + (n + lm)\, x + ln \pmod{p}$$

hence,

$$\left.\begin{array}{l} m - l^2 \equiv a \\ n + lm \equiv b \\ ln \equiv c \end{array}\right\} \pmod{p}.$$

from which we get

(1) $l^4 + al^2 - bl \equiv - c. \pmod{p}$.

A) If (1) has one solution only, then the prime factors of $F(x)$ are $(x+l)$ and $(x^3 - lx^2 + mx + n)$ and the required factorization of p is

$$(p) = (p,\ \theta + l)\ (p,\ \theta^3 - l\theta^2 + m\theta + n).$$

B) If (1) has two solutions l and l'. Then $F(x)$ contains two factors of 1st degree and one of 2d degree and we have

$$F(x) \equiv (x + l)\ (x + l')\ (x^2 + sx + t) \pmod{p}.$$

where

$$\left.\begin{array}{l} s \equiv - (l + l') \\ t \equiv a - l^2 - l'^2 - ll' \end{array}\right\} \pmod{p}.$$

and hence,

$$(p) = (p,\ \theta + l)\ (p,\ \theta + l')\ (p,\ \theta^2 + s\theta + t).$$

C) If (1) has three solutions in which case it evidently must have four solutions l, l' l'' l''', then

$$F(x) \equiv (x + l)\ (x + l')\ (x + l'')\ (x + l''') \pmod{p}.$$

and hence,

$$(p) = (p,\ \theta + l)\ (p,\ \theta + l')\ (p,\ \theta + l'')\ (p,\ \theta + l''').$$

D) If (1) has no solution, $F(x)$ has no factors of 1st degree. Then we set

$$F(x) \equiv (x^2 + mx + n)\ (x^2 - mx + n') \pmod{p}.$$
$$\equiv x^4 + (n + n' - m^2)\, x^2 + m\,(n' - n)\, x + nn' \pmod{p}.$$

Hence,

$$(2) \qquad \left.\begin{array}{l} n + n' - m^2 \equiv a \\ m(n' - n) \equiv b \\ nn' \equiv c \end{array}\right\} \pmod{p}.$$

If the system (2) is soluble we have

$$F(x) \equiv x^2 + mx + n)\ (x^2 - mx + n') \pmod{p}.$$

and hence,

$$(p) = (p, \theta^2 + m\theta + n)\ (p, \theta^2 - m\theta + n').$$

If (2) is insoluble, F(**x**) is irreducible and hence (p) is a prime ideal.

As an application we give a table of the prime ideal factors of certain rational primes in the number-field generated by a root θ of the equation

$$x^4 + x + 1 = 0.$$

Here $\triangle = 229$ and we get

$$(229) = (229, \theta - 75)^2\ (229, \theta^2 - 79\theta - 71)$$
$$(2) = (2)$$
$$(3) = (3, \theta + 2)\ (3, \theta^3 + \theta^2 + \theta + 2)$$
$$(5) = (5, \theta + 2)\ (5, \theta^3 + 3\theta^2 + 4\theta + 3)$$
$$(7) = (7)$$
$$(11) = (11, \theta + 4)\ (11, \theta^3 - 4\theta^2 + 16\theta + 3)$$
$$(13) = (13)$$
$$(17) = (17, \theta - 3)\ (17, \theta^3 + 3\theta^2 - 8\theta - 6)$$
$$(19) = (19, \theta - 2)\ (19, \theta^3 + 2\theta^2 + 4\theta + 9)$$
$$(23) = (23, \theta + 4)\ (23, \theta + 5)\ (23, \theta^2 - 9\theta - 8).$$

Dissociation-Potentials of Neutral Solutions of Lead Nitrate with Lead Peroxide Electrodes.

[Abstract.]

By Arthur Kendrick.

To determine if in such solutions and with lead peroxide electrodes electrolytic action takes place at voltages lower than that required for the separation of lead and lead peroxide with platinum electrodes, the method developed by Nernst[1] and Le Blanc[2] was made use of.

Two platinum wires coated with a thick, firm crust of lead peroxide were first used as electrodes. The current-potential curves obtained showed sharp bends at about 0.4 volt. To determine at which electrode the action at this voltage took place an electrode was made of a platinum wire projecting 1mm from a sealed glass tube. This point was coated with the lead peroxide before use each time. The other electrode con-

1. W. Nernst, Bericht. d. deutschen ch. Gesel. 30, p. 1547, 1897.
   L. Glaser, Zeit. für Electrochemie, 4, p. 355, 1898.
   E. Bose, Zeit. für Electrochemie, 5, p. 153, 1899.
2. LeBlanc, Zeit. für ph. Chemie, 12, p. 333, 1892.

sisted of a piece of platinum foil of several square c. m. area, coated with lead peroxide. Thus the two areas were vastly different; and nearly the whole of the polarization occurred at the point electrode, which was used successively as anode and as kathode.

When used as anode the current-potential curves showed the bend at about 0.4 volt. But used as kathode, the several curves were not in as good mutual agreement, and do not clearly indicate a particular voltage at which action at that electrode begins. The general indications are that the lead appears at a voltage considerably less than that required to separate lead on a platinum kathode, and that the peroxide is reduced. The irregularities that may mask the critical voltage seem to be due to local concentration changes around the electrode.

PbO_2 seemed to form at the anode at the voltage 0.4.

Some Observations with Rayleigh's Alternate Current Phasemeter.

By E. S. Johonnott, Jr.

This instrument in the field of alternate current measurements takes a place similar to that of the galvanometer in direct current measurements; with some advantages, and also with some disadvantages. For example, its indications may represent either current or electromotive force, and the angle of lag and true watts in a circuit may be obtained by a simple calculation. However, its indications, as in all other alternate current meters, vary as the square of the current; hence its range of sensibility is limited.

The principal feature of the instrument is the ease with which it gives the angle of lag of the current in a circuit behind the electromotive force impressed at its terminals. Also when once calibrated it gives all the quantities needed to determine the energy absorbed in a conductor.

Similar to the tangent galvanometer it consists of an iron magnet suspended in the field of the current whose value is required.

Fig. I is a horizontal sectional view of the form used by Lord Rayleigh. *M* represents the current coil, and is connected in series with the conductor on which the measurements are desired to be made. *S* represents the E.M.F. coil and is shunted across the terminals of the conductor.

Between the coils, M and S, with its center on their common axis, a piece of soft iron wire is suspended at an angle of 45° to the axis of the coils.

In the instrument with which the following observations were made, the coil M consisted of 72 turns of No. 22 copper wire wound in two sections having 48 and 24 turns respectively. S was similarly wound with No. 28 manganin wire and had a resistance of 668 ohms. Each was made adjustable along their common axis for a distance of 13 centimeters.

The needle was suspended with a fine phosphor-bronze torsion fiber. The deflections were measured with mirror and scale.

If an alternating current is sent through either of the coils, the needle becomes a magnet acted upon by a couple depending upon the instantaneous value of the current. The couple will be in the same direction whatever the direction of the current. In short, it will vary as the sine of twice the angle theta and as the mean of the square of the current values.

Since the couple varies as the sine of twice the angle theta, it will be a maximum for theta = 45°. Here also will be the position for the least sensitiveness to change in the zero.

In order to use the instrument as a phasemeter, readings of the deflection produced by the current in M, and the fall of potential in S are taken independently. Then, usually, two readings of the deflection produced by the currents in both coils simultaneously are taken—one in which both couples act in the same direction, the other when they act in opposite directions. The values of these two latter readings depend upon the angle of lag, and together with the reading for the currents, independently, give sufficient data for its computation.

The calculation may be made in two ways:

(1) Analytically.

(2) Graphically.

In the first method,

$$C_1{}^2 = A^2 + B^2 + 2AB \cos \phi$$

$$C_2{}^2 = A^2 + B^2 - 2AB \cos \phi \text{ when}$$

A^2 is the deflection with M acting independently.

B^2 is the deflection with S acting independently.

C_1^2 and C_2^2 is the deflection with M and S acting simultaneously.

ϕ may be found from either equation.

In the second method, two triangles are laid off with their sides proportional to the square roots of the readings. The angle of lag, ϕ, is given in either case as shown in Fig. II.

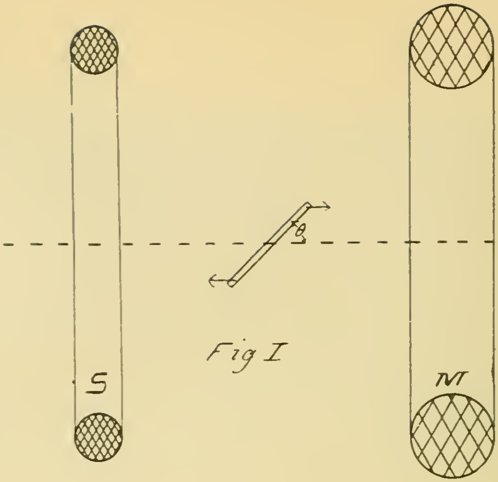


Fig I

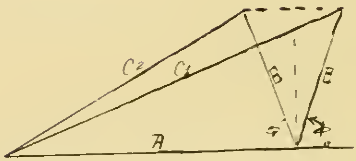


Fig II

$$C_1^2 = A^2 + B^2 + 2AB\cos\phi$$
$$C_2^2 = A^2 + B^2 - 2AB\cos\phi$$

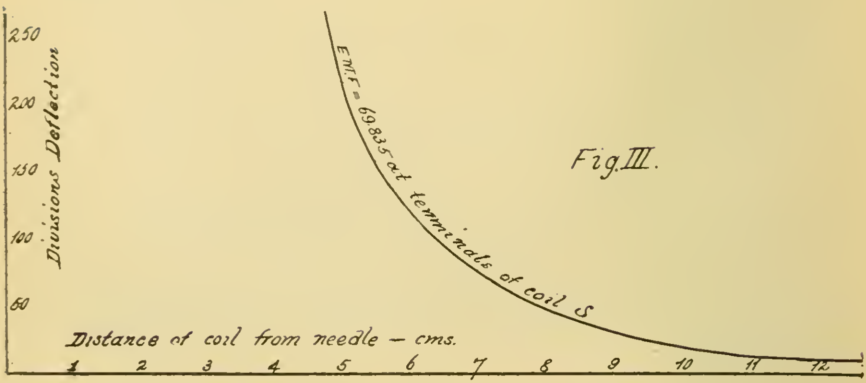


Fig. III.

Considerable range in sensibility for both coils is obtained by adjusting them at different distances from the needle. Some idea of this range may be obtained through inspection of the curve given in Fig. 3.

This was taken with the coil S, having a constant E.M.F. of 69.835 volts at its terminals. The abscissae represent the distances of the coil from the needle; the ordinates, the corresponding value of the deflections on the scale.

Both coils were calibrated at different distances from the needle with the Thomson balances. Fig. 4 represents curves taken with the coil, M, and shows no appreciable departure from the law of the squares.

In order to facilitate taking the readings, compensating coils, M' and S', Fig. 5, were arranged in the circuit for M and S respectively, so that the conditions within the conductor on which the observations were being made remained the same when either M or S was cut out. This obviated removing either coil when the reading due to the current in the other was desired.

In Fig. 5 is shown a diagram of the connections used in making an observation for the angle of lag in a circuit which is here shown to be a coil, X, on a split anchor ring. X and M are connected in series in the secondary of a one-to-one transformer, in order to have no appreciable impedance in the circuit, other than X. The electrical conditions in this circuit were then controlled by the resistance and choking coil in the intermediate circuit. One commutator was arranged in the shunt circuit to reverse the current in S, another to substitute the compensating coil S' for S.

One of the greatest difficulties encountered in measurements of this character is due to unsteadiness in the source. Particularly is this true when all the readings can not be taken simultaneously. This may, however, in a measure, be overcome by arranging an auxiliary voltmeter similar to the E.M.F. coil, S, with its terminals connected across the terminals of the secondary of the city transformer. The phasemeter readings are then taken when the deflection due to their auxiliary coil is constant.

With respect to accuracy the phasemeter as a current meter is perfectly similar to the galvanometer.

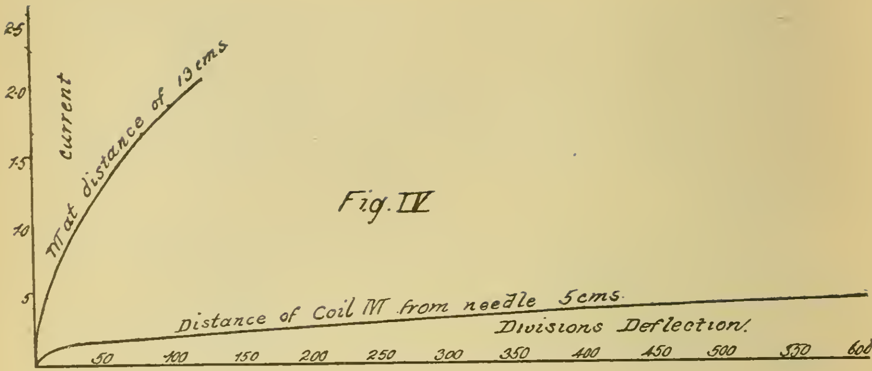

2.5
2.0
1.5
1.0
5
current
M at distance of 13 cms
Distance of Coil M from needle 5 cms.
Divisions Deflection.
50
100
150
200
250
300
350
400
450
500
550
600

Fig. IV

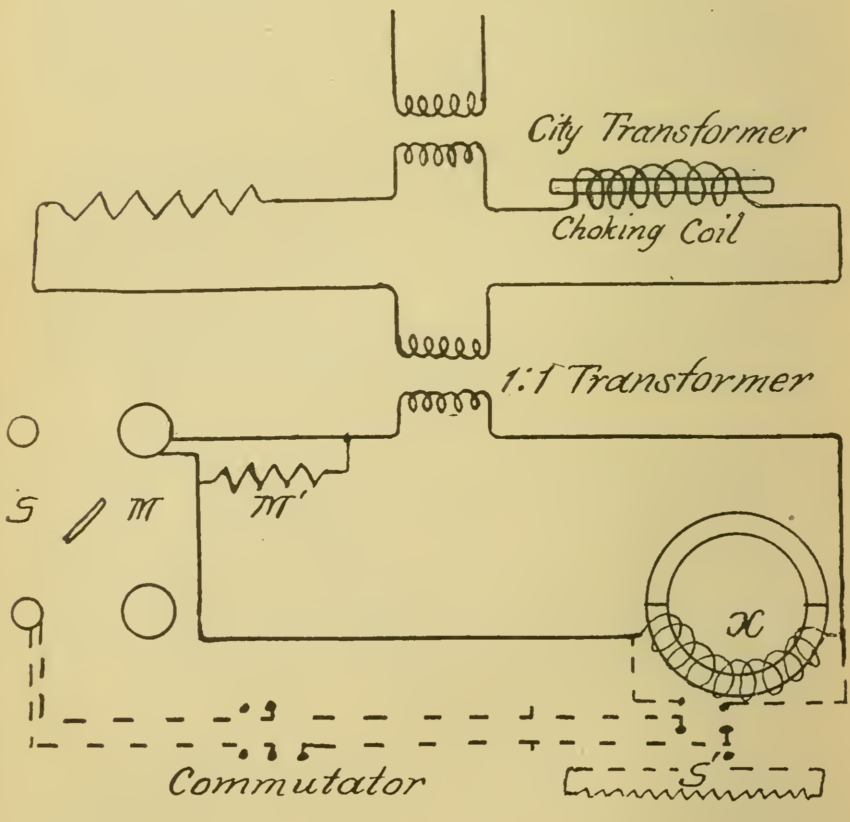

City Transformer
Choking Coil
1:1 Transformer
S
M
M'
X
Commutator
S'

Fig. V.

Some measurements on hysteresis and the effect of iron in the magnetic circuit have been undertaken. It would, however, be too premature to take up their description at this time.

The instrument which has been described was built, largely, by Mr. Edwin Place, formerly connected with the Institute. He made many observations similar to those above recorded.

I should like to take this opportunity to thank Dr. Gray for his many suggestions and for the removal of a number of stumbling blocks.

A Demonstration Apparatus.

By P. N. Evans.

The apparatus is a simple modification of that commonly used to compare, by diffusion, the density of another gas with air. It consists of a porous battery-cell placed horizontally and fitted by a stopper to a glass tube bent downwards at right angles a few inches from the stopper, and then upwards again to its original height. This U-shaped manometer is about two feet long and half filled with a dark-colored liquid; the limbs are close enough together to make a slight difference of level easily seen, against a white background fastened to the tube. To further increase the sensitiveness of the instrument a perforated glass plate or heavy card is secured between two corks on the horizontal part of the tube close to the cell, so that the cylinder or beaker of gas to be examined may be pressed lightly against this, and thus largely prevent loss of the gas before sufficient time has elapsed to show the maximum deviation in the manometer.

While the ordinary apparatus is recommended for demonstration only with gases differing considerably from air in density, this modification has given very satisfactory results with hydrogen sulphide, and even oxygen, with densities of 1.18 and 1.11 respectively, a difference in level of at least an inch being observed in the latter case. A slight effect, clearly visible to the manipulator, though not satisfactory for demonstration purposes, was obtained with nitrogen—density 0.972.

Still greater delicacy may be obtained by slanting the whole apparatus, giving the manometer a decided inclination.

Methylation of Halogen Amides with Diazomethane.*

By Jas. H. Ransom.

Since the classical work of Hofmann on the rearrangement of the halogen amides to derivatives of the isocyanates the mechanism of this reaction has been the subject of numerous investigations. Hoogewerff and van Dorp extended the work of Hofmann and pointed out the probability of a similarity in this reaction and that known as the "Beckmann rearrangement" of the oximes. After some more recent work on the brom-amides by Lengfeld and Stieglitz, the latter, with his pupils, studied the influence of the amide hydrogen atom on the rearrangement. He found that when this hydrogen was replaced by an alkyl radical no rearrangement took place in the sense of the Hofmann reaction, and suggested as the simplest and most reasonable explanation, that at some early stage of the reaction, under the influence of the alkali, the molecule

*This work was undertaken during the past summer, at the University of Chicago, in company with Dr. Julius Stieglitz.

lost hydrobromic acid, leaving monovalent nitrogen, which, by its reactivity, drew to itself the radical originally attached to carbon. As Stieglitz has pointed out, this explanation would account for the Beckmann rearrangement, and for that of the acid azides.

It seemed not without interest, therefore, to determine experimentally the position of the amide hydrogen in the halogen amide molecule. The two possible positions of this atom, R CO—N H/Cl and RC—(OH)=N Cl, correspond to the two classes of alkyl derivatives, chlor alkyl acid amides, R CO N R/Cl, and chlorimido acid esters, whose properties are now known. But the fact that the salts of such a molecule may have a different constitution from that of the free acid would make quite uncertain any conclusions drawn from the results obtained from the usual methods of introducing an alkyl radical.

Von Peckmann has shown that substances of an acid character react readily with diazomethane, forming a methyl derivative of the substance, the methyl entering where the hydrogen was attached. As the reaction is carried out with the free acid in absolute ethereal solution the probability of a rearrangement of the molecule during the process of methylation is reduced to a minimum. Ransom has shown, also, in two cases, that this method of methylation can be used to advantage in deciding delicate questions of constitution.

With these ideas in view, the following work was undertaken: Benzchloramide is best made by adding a solution of chloride of lime to a cold saturated solution of benzamide, which had previously been acidified with acetic acid, and extracting the oil which is formed with ether. On drying the ethereal solution with calcium chloride and evaporating the ether in vacuo without heating, a crystalline residue results which after recrystallizing from benzol was found to be 98.1 per cent. pure. The purity was determined by finding the percentage of active chlorine in the substance, by adding potassium iodide to a dilute alcoholic solution and titrating the free iodine with sodium thiosulphate. An ethereal solution of diazomethane was then prepared and some of the benzchloramide, suspended in a little ether, added to it until the yellow color of the diazomethane had nearly disappeared. Nitrogen was evolved in large quantities. When the action had ceased the ether was evaporated and there was left an oil with a peculiar but not unpleasant ethereal odor. The oil did not solidify even in a freezing mixture. Some of it was dissolved in ligroin and dry hydrogen chloride passed into the solution.

Chlorine was evolved and a white solid separated which was very soluble in water. The aqueous solution after standing some time gave off a distinct odor of benzoic ether ($C_6H_5COOCH_3$). Caustic soda separated from the solid an oil which had the characteristic odor of benzimido ether ($C_6H_5C{\overset{OCH_3}{\underset{=NH}{}}}$). A quantity of the salt was heated in a bath to 118°. A gas (CH_3Cl) was evolved which burned with a green flame, and in the tube there remained a crystalline substance which proved to be benzamide. Some of the methylated chloramide was suspended in water and reduced with hydrogen sulphide. When the oil had become dissolved the solution was poured from the free sulphur and distilled with a concentrated solution of caustic soda, the distillate being collected in hydrochloric acid. This distillate was evaporated to dryness, and the residue extracted with absolute alcohol. Very little dissolved in the alcohol and no trace of methyl amine could be detected, nor of aniline by using either the delicate Jacquemine test or the isocyanide reaction. The properties of this substance therefore and its reactions correspond in every detail with what would be expected from the constitution,

$$C_6H_5C{\overset{-OCH_3}{\underset{=NCl.}{}}}$$

Besides, benzchloramide is a fairly strong acid, as its alcoholic solution can be titrated against standard caustic alkalis, using either phenolphthalein or litmus as indicator. This acidity is not due to hydrolysis, thus forming free hydrochloric acid, since it gives with silver nitrate, even on standing, only a trace of silver chloride. A solution of the substance therefore contains hydrogen ions, a thing not to be expected on the supposition of an amide hydrogen. We may conclude therefore that benzchloramide contains an hydroxyl group.

Attempts were made to extend the investigation to other amides, viz., m—nitrobenzamide and anisic acid amide. The chloramide of the former however was found to be so unstable even at 0° that work on it was discontinued for the time. Anisic acid chloramide is also unstable, but at —5° enough of it was obtained to try the action of diazomethane upon it. The bleaching powder method was the one used to make the chloramide, but it always contained some of the dichloride, which was then converted into the monochloride by dissolving in caustic soda and reprecipitating it with acetic acid. As the least excess of acid decomposes it completely, the yields are very poor. A small amount of the substance, about 90 per cent. pure, was methylated as described above.

An oil was obtained which, when dry hydrogen chloride was passed into its solution, evolved chlorine, and deposited an oily solid salt. At 115°-120° it lost methyl chloride and there remained a crystalline substance which, however, was not the amide and contained chlorine. This was saponified with caustic soda, but the acid formed melted at 205°-210° and still contained chlorine. It is evident that at some stage the benzene ring became chlorinated. But the fact that methyl chloride was evolved on heating indicates that the methyl was united to oxygen.

A little preliminary work was done with the brom-amides, they being more easily prepared pure than the corresponding chlor derivatives. While the results were not conclusive, they indicated that either methylation occurred on the nitrogen atom or that a rearrangement of the amide to the amine had taken place. For a distinct isonitril odor was observed when the saponified product was boiled with chloroform and caustic potash. Besides when m-nitro benzbromamide was methylated a substance was obtained with quite different properties from those in the former cases. It contained a large amount of bromine, though almost inactive. A small amount of the substance gave a distinct test for formaldehyde (resorcin and sulphuric acid). This might indicate that a molecule of the brom amide had added itself to the methine (CH_2) group, thus:

$$\mathrm{R\ Co\ N}^{\mathrm{H}}_{\mathrm{Br}} + \mathrm{CH_2} \longrightarrow \mathrm{R\ Co\ NH - CH_2\ Br.}$$

This on saponification would give a derivative of formaldehyde and would contain inactive bromine.

The work will be extended in this and other directions as soon as opportunity offers.

Note on the Apparent Deterioration of Formalin.

By Thomas Large.

Attention of chemists and naturalists is called to the following facts: A stock of formalin, purchased from a prominent firm, for 40 per cent. formaldehyde, was kept at the Biological Station of Illinois for three years, where it was subjected to winter temperatures. When temperature was low a precipitate of white paraform (?) appeared, and was redissolved with higher temperatures. In the past summer some difficulty was experienced with it in preserving larger fishes in warm weather. A sample of the formalin was submitted to Dr. Palmer, Professor of Chemistry in the University of Illinois, for examination. The following is his report on it: "We find that it contains 38½ per cent. of formic aldehyde. This is practically the quantity that is supposed to be contained in commercial formalin, i. e., 40 per cent. formic aldehyde. I find that nearly one-half of the formic aldehyde is polymerized, i. e., about 18½ per cent. is in the form of the polymer tri-oxymethylene. I am not sufficiently familiar with the use of the formalin as a preservative to be able to state whether this polymerization will interfere with the use of the formalin as a preservative, but would suggest that possibly the formalin has proved unserviceable because nearly half of the constituent which is expected to do the work is in the form of the polymer, and probably unserviceable."

Notes on the Examination of Vegetable Powders.

By John S. Wright.

[Abstract.]

Brief accounts were given of the methods employed in preparing vegetable powders for microscopical studies, especially through the use of clearing and other microchemical reagents. References were made to the work previously done along this line and to the literature of the subject. Histological characters of vegetable powders were discussed, particular attention being paid to the value of the microscope as a means of identifying and detecting adulterations in granulated and powdered drugs and spices.

The Staining of Vegetable Powders.

By John S. Wright.

[Abstract.]

The use of differential stains to aid in the study of the histological elements of vegetable powders is in many instances important. If in

the study of a powder it may be stained differentially to correspond with the staining which can be employed upon various sections made of the original crude material, it becomes much easier to refer the minute granules and fragmentary elements to the tissues from which they originated.

There are two ways by which we may produce differentially stained powders for microscopical examination. The first and simplest is to make thick (½-¼mm) transverse sections of the tissues to be studied. These may then be stained in the usual manner, after which they are triturated in a mortar to a No. 60, 80 or 100 powder, as the case requires. Such powders are differentially stained in a satisfactory manner, but the fragments and cell masses often show truncated ends, due to sectioning, which are not found in powders produced wholly by grinding.

While the above process is an aid to the proper understanding of powders it is not of direct service in the great number of cases in which the microscopist is required to determine the identity and purity of powders. In such instances any staining method to be of service must enable the operator to differentially stain the powders directly. This may be accomplished by placing about ¼ or ½ gm. of the powder in a glass tube (50 to 60mm long and 10 to 15mm in diameter), one end of which has been closed by tying over it a piece of closely woven white silk cloth. Resting on this cloth bottom the powder may be treated with the various bleaching fluids, washed, double stained, dehydraded and cleared for mounting by allowing the tube to stand in watch glasses into which the stains and reagents have been poured. In this way a number of powders each in a separate tube may be treated at the same time. Owing to the great capillarity of fine powder it may often be necessary to promote the drainage and washings by blowing on the free end of the tube with the mouth; in this way it is possible to make rapid transfers from one reagent to another.

Cryptogamic Collections Made During the Year.

By M. B. Thomas.

During the past year some very interesting collections of cryptogams have been made in the local flora of Montgomery County.

These have been studied with special care and added to our already very complete list of the plants of the local flora. Very careful notes have been secured as to the distribution, variations and other important questions connected with the plants as collected.

During the early part of the year, in connection with the work in forestry, a collection was made of the fungi injurious to timber in our locality. The number of species was not as large as could reasonably be expected, and it seems that most of the devastation by fungi in our native forests is produced, in the main, by a very imited number of species.

Some additions have been made to our list of algae and a few to the collection of mosses. The latter list now includes 39 species.

Our most important contribution to the State flora is in the slime moulds.

During the past summer two students, Messrs. H. H. Whetzel and A. A. Taylor, devoted much time to this group. The result is an addition of 31 species to our list presented to you two years ago by Mr. Olive. This now gives us a total of 77 myxomycetes in Montgomery County. In addition to this we now have on hand some material not yet worked over, and doubtless several species in this are not included in our list. This is all the more interesting when we consider that our county is not particularly adapted to these forms of plant life and that the number reported is nearly two-fifths of the whole number found thus far in the United States.

The additions to the list are as follows. The classification used is the one presented by Lister in his Mycetozoa.

Order *Ceratomyxaceae.*

Ceratomyxa mucida Schroet.

Order *Physaraceae.*

Plysarum polymorphum var. *obrusseum* Rost.

Physarum calidris Lister.

Physarum newtoni Macbride.

Physarum compactum Lister.

Physarum globuliferum Pers. (Bull).

Physarum galbeum Wingate.

Chondrioderma spumarioides Rost.

Order *Didymiaceae.*

Didymium dubium Rost.

Didymium farinaceum Schrader.

Order *Stemonitaceae.*

Stemonitis tenerrima B. and C., Morg.

Stemonitis smithii Macbride.

Stemonitis webberi Rex.

Stemonitis confluens Cook and Ellis.

Comatrichia obtusata Preuss.

Comatrichia persoonii Rost.

Comatrichia laxa Rost.

Lamproderma arcyrionema Rost.

Order *Reticulariaceae.*

Enteridium rozeanum (Rost) Wingate.

Order *Heterodermaceae.*

Lindblandia tubulina Fries.

Order *Lycogalaceae.*

Lycogala exiguum Morg.

Lycogala flavo-fuscum Rost.

Order *Arcyriaceae.*

Arcyria incarnata Pers.

Arcyria oerstedtii Rost.

Arcyria digitata (Schw) Rost.

Arcyria ferruginea Sauter.

Arcyria cinerea (Bull) Pers.

Order *Trichiaceae.*

Hemitrichia intorta Lister.

Hemitrichia karstenii (Rost) Lister.

Trichia rubiformis Pers.

Experiments with Smut.

By M. B. Thomas.

On two previous occasions I have reported to the Academy some special progress made with experiments with formalin as a fungicidal agent.

The first report included the results of a series of experiments upon the effects of formalin in different strengths of solution, with varying periods of time, on the germinating power of a number of cereals.

The second report was the result of a practical field experiment based on the facts discovered by the earlier investigations. The conditions of this field experiment were not as trying or severe as might be desired, and although the results were highly gratifying, yet they did not seem as conclusive as we could wish. Accordingly, the past summer, another field experiment, on a somewhat larger scale, was tried in a part of the State where the smut of oats has been very destructive.

The trial was conducted on the farm of Chas. Baker, Noble County.

The last week in April three acres of oats were sown in three plats, the seed being treated respectively 40, 60 and 90 minutes in a solution of one part of commercial formalin to 200 parts of water. The seed was scattered broadcast without drying. Alongside of these areas was sown a field of untreated seeds. All of the seed used was from a previous crop of smutty oats that was very much infested.

No difference was noted in the time of germination of the several lots, but the treated seeds produced plants that were more uniform and better developed than those from the untreated ones.

At the time of cutting the difference between the two fields was very striking. Fully 15 per cent. of the heads of the untreated seeds were smutty, while not one stalk of the plants from the treated seeds showed any signs of smut. The whole experiment was conducted by the owner of the place from directions and material furnished by the department and the results were examined by one of our students. Of the three separate lots of treated seeds the ones soaked for 60 minutes seemed to be the best, and that time is recommended as safe and efficient for treatment. Comment on this experiment is unnecessary, and it is hoped that these facts may increase the use of this fungicide to the improvement of our production of oats.

The Flora of Lake Maxinkuckee.

By J. T. Scovell.

Lake Maxinkuckee is situated in Marshall County, Indiana. It occupies parts of sections 15, 16, 21, 22, 27, 28 and 34 of Township 32 north of Range 1 east of the second principal meridian. The lake is a little more than two and one-half miles long from north to south and about one and one-half miles wide, having an area of nearly 1,900 acres. The surface of the lake is about 735 feet above tide. It is 150 feet above Lake Michigan, but 130 feet below the summit of the divide between Lake Michigan and the Wabash River. The lake is 15 feet above the Tippecanoe River five miles south, and about 75 feet above English Lake, 20 miles west. These elevations show that the lake is on a slope that descends gently toward the south and west. The lake is near the southwestern angle of the Saginaw moraine. The country about the lake is quite varied. There are hills and valleys, broad undulating plateaus, wet marshes and boggy swamps. The soils are sand, gravel, boulder, clay and swamp muck. There are more hills and clay and boulders on the east, more sand and gravel, more marshes and swamps on the west. On the east the surface rises somewhat abruptly to a general level of 75 or 80 feet above the lake, some hills reaching an elevation of about 140 feet. On the west there is a narrow divide 25 to 30 feet above the lake, then low land and swamp. The confused mingling of sand, gravel, clay and boulders, the irregular hills and the numerous kettle holes indicate that the surface features about the lake are of glacial origin. Just east of the center of the lake there are 15 or 20 acres of water that is from 85 to 90 feet deep. This deepest water is part of some 300 acres of deep water that forms the central portion of the lake. Fully one-half the area of the lake is shallow, the water being ten feet or less in depth.

Wells drilled from 75 to 150 feet through sand, gravel and clay, without reaching bed rock, indicate that the lake bed is wholly composed of morainic materials. In fact it seems to occupy a cluster of kettle holes, one long and deep, surrounded by several of lesser size and depth. The region drained into the lake is quite limited, being scarcely more than three times its area. "The Inlet" enters the lake from the southeast, Aubeenaubee Creek from the east, and Culver Inlet, with one branch from the north and one from the east, enters the northeastern part of the lake. These four streams, each rising within two miles of the lake, each largely fed by springs, are the principal inlets. Several very small streams, the outlets of springs, bogs, flowing wells and little swamps, contribute something to the waters of the lake. "The Outlet" is a sluggish stream which flows from the west side of the lake southerly into the Tippecanoe River. About 80 rods from the lake the outlet expands into a pond or lake, having an area of about 60 acres. This body of water is shallow, at no place more than 12 feet deep. The greater part of its bed is muddy, and two-thirds of its outline is marshy. The ordinary variation in the level of the lake during the year is less than two feet. Such variation does not materially change the area of the lake or appreciably modify the various forms of life that inhabit its waters.

Perhaps one-eighth of the outline of the lake is low ground, marshy, swampy or boggy. But in general the muck or black mud is shallow, seldom more than two or three feet in depth, and it rests on a bed of hard sand or gravel. From the shore out to a depth of six or eight feet the lake bed is of hard sand or gravel, even along the low ground. At the mouths of the southeast and northeast inlets there are considerable areas of shallow mud over the sand, and at the mouths of the lesser inlets there is always a little soil. But for long distances along the steep banks of clay or gravel there is no fine soil, just sand or gravel. On the north, west and south this bed of sand and gravel supports an abundant growth of Chara, which is generally of small size and thickly crusted with calcic carbonate. This bed is also the home of immense numbers of bivalve mollusks. The chara and shells of dead mollusks yield considerable quantities of calcic carbonate. At first one would expect to find this material making deposits over the bed of this shallow water. But this calcic carbonate and other fine material is swept away and deposited in deeper water, where it helps to form the extensive marl beds of the lake. During the summer there are more winds from the east than from any other quarter, but during the year there are more westerly winds, and in general the westerly winds are stronger. There are also many northerly winds and many southerly winds, so that during the year there are numerous winds from each quarter. These winds pile up the water along the shores toward which they blow. This causes more or less of an undercurrent toward the deep water which carries with it all the fine material of the shallower water. As the westerly winds are more numerous and stronger these undercurrents are stronger on the east, carrying the fine material into deeper water, the marl beds commencing in eight to ten feet of water instead of in six to eight feet of water as on the other sides of the lake. The marl forms a rich soil which shades off into darker material under deeper water. During the winter ice forms to a thickness of from 15 to 25 inches. As the ice expands it crushes against the banks with great force. Where the shores are low the ice often pushes great quantities of sand and other materials up into ridges, sometimes two or three feet high. These ridges or ice beaches are generally washed away by the high water common in spring, but sometimes they remain, making a distinct and somewhat peculiar plant region. Along the steep banks, the boulders that have fallen to the beach during the summer are crowded against the bank by the ice, making in some places quite extensive stone walls. With such a variety of soils as occur in and about Lake Maxinkuckee, a varied flora may be expected. In the waters of the lake there are great quantities of microscopic life, called *plankton.* Of the microscopic plants, protococcus, rivularia, oscillaria, diatoms, desmids and others are common everywhere in the open lake, but were most abundant among the higher vegetation along the shores. Occasionally rivularia would occur in such quantities as to be conspicuous to the naked eye. Spirogyra, vaucheria, oedogonium, hydrodiction, stigeoclonium, nostoc, cladophera, zygnema, chetophora, and others often occurred in masses in the shallow water. Chara and nitella were very abundant.

Nitella sp? A tall, slender plant, was abundant between 18 and 22 feet, ranging from 12 to 25 feet. In water from 20 to 25 feet deep we seldom found anything beside nitella.

Nitella sp? A small, delicate plant found in shallow water, common in the marshes and in the lake out to a depth of two feet.

Chara sp? A slender, rank-growing plant quite free from lime. Was abundant between 10 and 14 feet, ranging from eight to 24 feet. In some localities this chara was the only plant found between 10 and 14 feet.

Chara sp? A stout plant, seldom more than eight inches high, was thickly coated with lime. It was most abundant at a depth of from eight to 10 feet, often forming a thick mat of vegetation to the exclusion of other plants.

Chara sp? Much smaller than the above mentioned, quite abundant in shallow water, often the only vegetation. It was usually thickly coated with lime.

There are doubtless other species of chara and nitella about the lake, but the ones mentoned are the most abundant.

Potamogeton natans L. This plant was more common in the southwestern portion of the lake, growing in water from four to six feet deep.

P. amplifolius Tuckerm. This plant was abundant in water from five to eight feet deep, but ranged from two to 24 feet. On the Sugar Loaf bar, it was abundant and rank from nine to 24 feet.

P. lonchites Tuckerm. This pond-weed was common everywhere in shallow water. A cluster of rank potamogetons growing in eight to ten feet of water on Weed Patch bar I called lonchitis, but do not feel quite sure that I was correct.

P. heterophyllus Schreb. This plant was quite common out to a depth of four feet.

P. lucens L. This plant, sometimes called perch weed,was widely distributed, growing most commonly in water from six to eight feet deep.

P. praelongus Wulf. Not very common, growing in water from eight to 12 feet deep.

P. perfoliatus L. Not common, but quite abundant in a few localities in the south part of the lake. More common in water from eight to 12 feet deep.

P. zosteraefolius Schum. Quite common. More abundant between 10 and 16 feet, but ranging from two to 26 feet.

P. friesii Ruprecht. Widely distributed, more abundant between 12 and 16 feet, but ranging from eight to 25 feet.

P. pusillus L. More common in the southeastern portion of the lake in deep water, ranging from 10 to 24 feet.

P. pectinatus L. Forming thick masses, excluding other vegetation in water 10 to 16 feet deep, also in shallow water one to three feet deep. It often stands at the head of a steep slope.

P. robbinsii Oakes. Very common in the shallow waters of the Little Lake, but in the large lake more common in water from 10 to 18 feet deep, ranging from two feet to 24 feet.

Naias flexilis (Willd) Rost and Schmidt. Very abundant, ranging from one to 24 feet. Most common in the northeastern part of the lake.

Naias flexilis robusta Morong. This plant, while not common, was found in several localities

Sagittaria graminea Michx. In the shallow water of the Little Lake.

Philotria canadensis (Michx.) Britton. Very abundant in a few localities in shallow water, as near the head of the outlet. It is widely distributed in deep water, ranging from one to 22 feet.

Vallesneria spiralis L. Called Eel-grass. Said to be the wild celery of Chesapeake Bay. The plants bearing pistillate flowers grow in shallow water. I saw none deeper than two or three feet. The male plant was most abundant in water from eight to 18 feet deep. We found it as deep as 24 feet. The pistillate flower is carried to the surface of the water by a long thread-like scape. After fertilization the scape forms a spiral of several coils, drawing the ovary several inches under water, where the seeds ripen. The staminate flower has a short peduncle. When the pollen is mature, the flower separates from the plant and rises to the surface. The pollen, escaping from the anther, floats away to the pistillate flowers. The buds or stolons formed in the fall, on the male plant, are highly prized by mud hens and ducks as food. They will dive 10 or 15 feet for it. The shores are often thickly covered with the leaves they break off while getting these dainty bits of food.

Eleocharis interstincta (Vahl.) R. and S. In shallow water in both lakes, often forming large patches.

E. mutata (L.) R. and S. Abundant in shallow water near the mouth of the southeast inlet.

E. palustris (L.) R. and S. Found along the southern shore of Lake Maxinkuckee.

Scirpus americanus Pers. Common in the shallow water of both lakes.

S. lacustris L. Common in the western and southern portions of the lake out to a depth of seven or eight feet. Specimens from 10 feet to 13 feet long often occur.

Spirodela polyrhiza (L.) Schleid. Common in quiet waters about the lake shores.

Lemna trisulca L. Common in the outlet and in the southeastern inlet.

L. minor L. Often found with *Spirodela*.

Wolffia columbiana Karst. In the southeastern inlet and in the outlet.

Eriocaulon septangulare With. In Lake Maxinkuckee, but not common.

Brasenia purpurea (Michx.) Casp. Very abundant in the outlet, only occasionally found in the lake.

Nymphaea advena Soland. Common.

Castalia odorata (Dryand) Woods and Wood. Abundant in the outlet and in the Little Lake. Only occasionally found in the larger lake.

Ceratophyllum demersum L. Common everywhere to a depth of 24 feet.

Abundant in shallow water and quite plentiful between 14 and 20 feet.

Batrachium trichophyllum (Chaix.) Bossch. Abundant in the southeastern part of the Little Lake.

Roripa nasturtium (L.) Rusby. Abundant in the northeastern inlet and in other places.

Myriophyllum spicatum L. Abundant in the Little Lake and in the outlet. In water from two to eight feet deep.

Myriophyllum verticillatum L. Found in both lakes. Not deeper than 14 feet.

Utricularia purpurea Walt. In the outlet.

U. vulgaris L. In the outlet and Little Lake.

U. intermedia Hayne. In the outlet and Little Lake.

U. minor L. In the Little Lake and outlet.

U. gibba L. In the outlet.

U. biflora Lam. In the Little Lake.

Bidens beckii Torr. Found in both lakes. Not very abundant, but ranging from two to 20 feet in depth.

Peltandra virginica (L.) Kunth. Found in shallow water of both lakes, often in the mud along shore.

Pontederia cordata L. Common in shallow water of both lakes, often above water line along shore. Both of these plants, after fertilization, bend over, thrusting the ovary into the water or mud, where the seeds ripen.

On the marshes below the level of high water we found—

Dryopteris thelypteris (L.) A. Gray.

Equisetum fluviatile L.

Typha latifolia L.

Alisma plantago-aquatica L.

Sagittaria latifolia Willd.

Dulichium arundinaceum (L.) Britton.

Eleocharis ovata (Roth) R. and S.

Scirpus smithii A. Gray.

Acorus calamus L.

Xyris flexuosa Muhl.

Juncus effusus L.

Salix discolor Muhl.

Polygonum sagittatum L.

Decodon verticillatus (L.) Ell.

Mimulus ringens L.

Lobelia syphilitica L.

Cephalanthus occidentalis L.

Nyssa sylvatica Marsh.

Polygala cruciata L.

Spiraea tomentosa L. And more than sixty others, largely sedges and grasses.

In addition, along the beach, between low and high water, we found—

Panicum crus-galli L.

Muhlenbergia sylvatica Torr.

Cyperus diandrus Torr.

Polygonium pennsylvanicum L.

Impatiens biflora Walt.

Teucrium canadense L.

Lycopus virginiana L.

Mentha piperita L.

Mentha canadensis L.

Xanthium canadense Mill

Eclipta alba (L.) Hassk.

Bidens connata Muhl. And more than fifty others. In all making over two hundred plants in and about Lake Maxinkuckee growing below high water mark.

I desire to call attention specially to the following facts: First, that the bed of the lake is comparatively barren under water from two feet to six or eight feet deep; second, that there is an abundance of rank vegetation under water from eight feet to 20 feet deep; third, that we found no vegetation below a depth of 26 feet in Lake Maxinkuckee.

Generic Nomenclature of Cedar Apples.

By J. C. Arthur.

In a communication made to this society at a former meeting (December, 1898) the writer gave some account of recent studies in the nomenclature of plant rusts, especially as applied to species occurring in the State of Indiana.* At that

*Arthur, J. C.—Indiana plant rusts, listed in accordance with latest nomenclature. *Proc. Ind. Acad. Sci. for 1898:* 174-186.

time no extended study of the generic nomenclature of this group of fungi had been attempted, and the conclusions of Dr. Kuntze (*Rev. Gen. Pl. III*) were accepted as the most satisfactory at hand. Since then the ground has been gone over to some extent, and some questions worth public discussion have arisen. Among the most interesting of these is the correct appellation of the cedar apples.

Two species of cedar apples occur in Indiana; both forming swellings, or pseudo-apples, on the branchlets of red cedar in one stage of growth, and so-called rust spots on the leaves of various apples and thorns in the alternate stage. These were placed under the genus *Puccinia*, following the authority of Dr. Kuntze, one being *Puccinia globosa* (Farl.) Kuntze (*Gymnosporangium globosum* Farl. and *Rœstelia lacerata* Fr.), and the other being *Puccinia Juniperi-Virginianæ* (Schw.) Arth. (*Gymnosporangium macropus* Lk. and *Rœstelia pyrata* Thax.).

The development of the concept, now embodied in the genus containing the cedar apples and apple rusts, is an interesting one. Many of the earlier systematists placed the cedar apples among the algæ, and even after becoming fully recognized as fungi, it was long before their close relation to the other *Uredineæ* was firmly established. The apple rusts have been confounded with the cluster-cups of other genera, even quite recently, although it has now been nearly forty years since their connection with the cedar stage was first established. However, it is not with the development of the concept of the genus that this paper has to deal, but with the unfolding of its nomenclature.

Reviving the ancient usage of the generic name *Puccinia* in order to have it replace the familiar name *Gymnosporangium* was done in the interest of a stable nomenclature. The result shows, however, that a stable nomenclature is not to be obtained at a single dash, even when the principles are recognized and accepted that are to govern the procedure. Dr. Kuntze (*Rev. Gen. Pl.*, Vol. 3, p. 507) gives Haller, 1742 (*Enum.*, Vol. 1, p. 17), the credit of founding the genus *Puccinia*, but Magnus (*Bot. Centr.*, Vol. 77, p. 4) has clearly shown that Haller's type material could not have belonged to the *Uredineæ*. The next subsequent author mentioned by Kuntze is Adanson, 1763. In accordance with the Rochester Code, Haller is excluded from consideration on account of antedating 1753, the initial date for priority, but Adanson might be accepted. This author presents an abbreviated diagnosis derived wholly from Micheli's classical work *Nova Plantarum* of 1729. It runs as follows: "*Puccinia Mich. t.* 92. *Tige élevée cilind, simple ou rameuse. Coriace. Toutela plante est formée de piramides ou filets en massues, couchés comme autant de rayons les uns sur les autres*" (*Familles des Plante*, Vol. 2, p. 8). Turning to Micheli, we find that he describes and figures two species under his genus, one evidently belonging to the *Uredineæ* and the other not. According to Magnus this lack of singleness invalidates the name for replacing that of the De Candollean genus *Gymnosporangium.* It does not do so, however, in the writer's opinion, but it makes it necessary to decide which of the two species included is to be accepted as the type of the genus.

The idea of definite and unchangeable types is of comparatively recent growth. The type of a species is the individual plant to which the name is first given, and the type specimen is therefore an important adjunct in fixing the name and character of the species. In like manner the type of a genus should be the species mentioned under it, if there is but one given, but if more than one be given, and the author has neglected to designate the one to be accepted, it would seem to require for the sake of uniformity and stability that the first species named under the genus be assumed to be the type. This method in whole or in part has been ably advocated by Underwood, Cook, Jordan, Coville, Ward, Greene and others. Up to the present time it has been put into rigid practice to a limited extent only, the revision of American ferns by Prof. Underwood being the most conspicuous example, but it seems to the writer that the general acceptance of the rule will go far toward furnishing a stable basis for taxonomic nomenclature. To one who has watched the course of the present movement for a nomenclature that stands squarely upon priority, guided by uniform procedure rather than by individual judgment, the rule of types here set forth must seem a necessity that will inevitably be adopted sooner or later. It is for the sake of lending a hand in bringing about so desirable an end that the study of the cedar apple nomenclature is here presented.

If the rule of taking the first species mentioned under a genus as its type is applied, there can be no question that Adanson's genus *Puccinia* is to be accepted as a name antedating *Gymnosporangium*, and we may waive the discussion of the exact determination of the type, brought forward by Magnus. But this does not settle the matter.

In Linnæus' *Species Plantarum* of 1753, which is accepted as the beginning of valid nomenclature, only two species occur, belonging to the *Uredineæ;* one is *Lycoperdon epiphyllum*, now called *Puccinia epiphylla* (L.) Wettst., and the other is *Tremella juniperina*, known to be unquestionably *Gymnosporangium juniperinum* (L.) Wint. Linnaeus' genus *Tremella* contains seven species, the one just mentioned being the first, while the six which follow do not belong to the *Uredineæ*. The first species is characterized as follows (p. 1157):

> "Tremella sessilis membranacea auriformis fulva. *Fl. suec.* 1017.
> Byssus gelatinosa fugax, junipero innascens. *Fl. lapp.* 531.
> Habitat in Juniperetis primo vere."

Hill, a clump of red-bud trees. At another, on the border line between the upland and lowland forest, the ground is thickly covered with ground ivy, *Nepeta glechoma*.

Here in the low-ground forest we have, especially in the first forest mentioned (that near the laboratories), a dense undergrowth of hazel-nut, prickly ash, hop tree and many other shrubs, so that the wood was somewhat difficult to pass through. The forest floor is also thickly covered with a quite dense growth of vines and tall weeds of numerous species, among which may be mentioned virgin's bower (*Clematis virginiana*), grape, hop, spotted touch-me-not, false nettle, American bell flower, great blue lobelia and cardinal flower, rice cut-grass, and many other such plants.

The low-ground forest in the vicinity of the laboratories was much modified during the summer of 1900, as a good deal of the underbrush was removed. In all cases it goes entirely down to the fringe of willows which grows at the edge of the lake.

The second low-ground forest, at the southern or west of southern side of the lake, not far from the region of Clear Creek mouth, consists of nearly the same sort of trees as the other, but the ground is rather more marshy, black and level, and the vegetation of the forest floor is of a somewhat different sort. There are more soft maples and large willows here, and lizard's tail is a characteristic plant. A small part of the shore is sandy here, and there is, between the lake shore and the low ground, back from the lake, a high, narrow ice ridge, four or five feet wide and breast high, and quite steep on each side. There are tolerable good ice ridges in other places, as south of Chicago Hill pier a little way, shown in Figure 2 (Fig. 2 shows lake plain on the left with willows on the ice ridge on the right), and over by Yarnelle's point, but these are not nearly so well marked.

The greater part of the country between the lake and the hills is a flat, level, meadow-like tract, forming the *Lake plain*. The soil of this plain is generally of a black or brown muck, with plenty of marl in places. Ditches dug through it reveal an abundance of gasteropod shells, many of them yet entire but very fragile, and many of them broken. These attest the former existence of the lake over the lake plain.

Traditions of old settlers refer to a time when the lake shore came up, in places at least, to the foot of the hills. One such tradition refers to the lake reaching the base of the hill known as Hamilton Mound, and the date assigned is about 1836. It is not reported whether this was simply the result of a temporary flood or a constant condition. The area of the surface is subject to quite marked variation at present, possibly more so than before the removal of much of the surrounding forest. The Government Survey shore line of 1834 lies at places considerably outside present maps of the lake. Mr. Large expresses his opinion that it perhaps marked the limit of the swampy ground.

In appearance and vegetation the various parts of the lake plain differ considerably from each other. In some places the soil is a reddish or brownish muck, in other places it is a blackish soil. In some parts it is a

Fig. 2.

sedgy, ferny meadow, in others it is covered with a dense growth of bushes, as clumps of willow, *Cephalanthus* and *Cornus*. There seem to be indications, however, that it was once nearly alike in vegetation, and that the sedgy, ferny meadow has been cleared off by artificial means. One indication of this is that we have wholly different regions on different sides of fences, one side of the fence being bushy, and the other covered with sedges, grasses and ferns only. In one place where there was such a level meadow, a few dead willow sprouts were noticed. Examination revealed that they were charred about the roots and had probably been killed by

? I. On Amelanchier alnifolia. (*Ræst. Harknessiana* E. and E.)

III. On Junip. occidentalis. (*Gym. speciosum* Peck.)

—— T. GLOBOSA (*Farl.*) *n. n.* (1880. *Pod. fuscum globosum* Farl. Gym. of U. S. : 18.) North America.

I. On Malus, Cratægus, Sorbus and Cydonia. (*Ræst. lacerata* Am. Auct.)

III. On Junip. Virginiana. (*Gym. globosum* Farl.)

—— T. BERMUDIANA (*Farl.*) *n. n.* (1887. *Æcid. Bermudianum* Farl. Bot. Gaz. **12** : 206.) North America.

I. On Junip. Virginiana. (*Æcid. Bermudianum* Farl.)

III. On Junip. Virginiana. (*Gym. Bermudianum* Earle.)

—— T. CUNNINGHAMIANA (*Barcl.*) *n. n.* (1889. *Gym. Cunninghamianum* Barcl. Mem. Med. Off. India 5 : —.) India.

I. On Pyrus, Cotoneaster (*Æcid. Cunninghamianum* Barcl.)

III. On Cupressus. (*Gym. Cunninghamianum* Barcl.)

—— T. NIDUS–AVIS (*Thax.*) *n. n.* (1891. *Gym. Nidus-avis* Thax. Bull. Conn. Sta. No. 107 : 6.) North America.

I. On Amelanchier. (*Ræst. Nidus-avis* Thax.)

III. On Junip. Virginiana. (*Gym. Nidus-avis* Thax.)

—— T. KOREAENSIS (*Henn.*) *n. n.* (*Ræst. koreaensis* Henn. Monsunia 1 : —.)

I. On Pyrus, Malus and Cydonia. (*Ræst. koreaensis* Henn.)

III. On Junip. Chinensis. (*Gym. Japonica* Syd.)

Additions to the Flora of Indiana.

By Stanley Coulter.

Since the publication of the "Catalogue of the Flowering Plants and of the Ferns and their Allies Indigenous to Indiana" numerous reports of additions have come to my hands. These reports have been examined with great care, in many cases the specimens themselves being submitted with the report. As a result quite a number of species are to be added to the flora of the State. It is gratifying to note, however, that the majority of these additions are to be found in the grasses and sedges, groups that have been largely neglected by collectors. Another considerable number includes extra-regional plants the occurrence of which within our bounds is to considered as exceptional, and which, while members of the flora are only local or occasional. A third class includes escapes from cultivation, the inclusion or exclusion of which is largely a matter of individual judgment. The number of species added is much smaller than I had reason to expect in view of the fact that the original catalogue was based almost wholly upon accessible herbarium specimens, it being felt that in the absence of such verifying material the enumeration would lose much of its value. This rule led to the temporary exclusion of some of the forms which are now definitely reported and verified by accessible material.

SPECIES TO BE ADDED TO CATALOGUE.

Dryopteris spinulosa (Retz.) Kuntze. (Aspidium spinulosum Sw.)

Reported from Wells County by C. C. Deam, and from Wabash County by J. N. Jenkins. In fruit June 11.

Panicum sphærocarpon Ell. Round-fruited Panicum.

Porter County (E. J. Hill).

Panicum flexile (Gattinger) Scribn. Wiry Panicum.

Lake County (E. J. Hill).

Panicum verrucosum Muhl. Warty Panicum.

Porter County (E. J. Hill).

Bromus tectorum L. Downy Brome Grass.

Lake County (E. J. Hill). This seems to be the western limit of this form, which in favorable localities becomes a troublesome weed.

Agropyron repens glaucum (Desf.) Scribn. (A. glaucum R. and S.)

Lake County (E. J. Hill).

Cyperus Houghtoni Torr.

Lake and Porter Counties (E. J. Hill).

Eleocharis Robbinsii. Oakes.

Porter County (E. J. Hill).

Psilocarya nitens (Vahl) Wood. Short-beaked Bald-rush.

Porter County (E. J. Hill).

Psilocarya scirpoides Torr. Long-beaked Bald-rush.

Porter County (E. J. Hill). Britton and Brown give the range of this plant "In wet soil, Eastern Massachusetts and Rhode Island." The above citation extends the range of the plant far to the west. I have not seen the plant, but admit it because of the well known discriminative accuracy of Mr. Hill.

Fuirena squarrosa Michx.

Porter County (E. J. Hill).

Rhynchospora corniculata macrostachya (Torr.) Britton. (R. macrostachya Torr.)

Porter County (E. J. Hill).

Scleria reticularis Michx.

Porter County (E. J. Hill).

Scleria Torreyana Walp.

Porter County (E. J. Hill).

Scleria pauciflora Muhl.

Porter County (E. J. Hill).

Carex oligosperma Michx. Few-seeded Sedge.

Lake County (E. J. Hill). A species somewhat northern in its mass distribution, seeming to have its southern limit in the station just cited.

Carex limosa L. Mud Sedge.

Wells County (C. C. Deam). "Found on low borders of a small lake in Jackson Township. Scarce."

Carex glaucodea Tuckerm.

Lake County (E. J. Hill).

Carex decomposita Muhl. Large-panicled Sedge.

Wells County (C. C. Deam). "Growing in bunches of moss in bogs made dry by draining."

Xyris Caroliniana Walt. Carolina Yellow-eyed Grass.

Porter County (E. J. Hill). A species found in its mass distribution near the Atlantic coast.

Juncus bufonius L. Toad Rush.

Wabash County (J. N. Jenkins), Kosciusko County (C. C. Deam). "Low, sandy shore of Goose Lake, Kosciusko County."

Juncus articulatus L. Jointed Rush.

Lake County (E. J. Hill). A species decidedly northern in its distribution. Admitted upon the authority of Mr. Hill.

Juncus diffusissimus Buckley.

Crawford County (C. C. Deam). "Valleys about Wyandotte Cave." Britton and Brown give the range of this species, "Southeastern Kansas to Mississippi and Texas." The conditions surrounding Wyandotte Cave are such as to preclude the possibility of the form being introduced along highways or railways. The station given stands as the recorded eastern limit of the species. The determination was made by Mr. M. L. Fernald of the Gray Herbarium, Harvard University.

Stenanthium robustum S. Wats.

Wabash County (J. N. Jenkins). In some of the material examined the pedicels were elongated in fruit, but the form without question is to be referred as indicated above.

Quercus nigra L. Water Oak.

Crawford County, near Wyandotte Cave (C. C. Deam). By error this species was not included in the catalogue. It is fairly well distributed throughout the State, growing near streams and swamps, though sometimes found in upland regions.

Asarum reflexum Bicknell.

Lake County (E. J. Hill). This species was described in Bulletin Torrey Club, Vol. 24, p. 533, pl. 317, 1897. It is distinguished from *A. Canadense* by its smaller flowers, calyx tube white within, *lobes of the calyx limb early reflexed*, purplish-brown, 4″–5″ long, about as long as tube, *triangular*, with a straight obtuse tip 1″–2″ long. (Britton and Brown, Vol. 3, 513.

Mr. Hill reports that all the Asarums he has examined, growing about Chicago, prove to be of this species. None of the sheets in the Purdue herbarium, however, can be so referred. The Asarums should be carefully examined by collectors in order that the distribution of this form within our area may be determined.

Cycloloma atriplicifolium (Spreng) Coulter. (C. platyphyllum Moquin.)

Kosciusko County (C. C. Deam). "In sand pit near Eagle Lake."

Atriplex hastata L. (A. patulum hastatum Gray.)

Wells County (C. C. Deam). "Waste places and cultivated fields."

Allionia hirsuta Pursh. Hairy Umbrella-wort. (Oxybaphus hirsutus Sweet.)

Wabash County (J. N. Jenkins). This form has an assigned range to the west and northwest. Abundant material, however, places the reference beyond question.

Brassica campestris L.

Wells County (C. C. Deam). "Waste places."

Cardamine Pennsylvanica Muhl.

Wells County (C. C. Deam). "Five miles north of Bluffton, May 25, 1899."

Cleome serrulata Pursh. Pink Cleome. (C. integrifolia T. & G.)

Wells County (C. C. Deam). "On prairies south of Bluffton." The species has, perhaps. its eastern limit in Indiana, the assigned range being Illinois and westward.

Fragaria Americana (Porter) Britton. American Wood Strawberry.
Wells County (C. C. Deam). "In woods June 13, 1897."

Agrimonia hirsuta (Muhl) Bicknell.
Wells County (C. C. Deam).

Crataegus cordata (Mill) Ait. Washington Thorn.
Gibson County (J. Schneck, M. D.). An eastern, chiefly mountain form in Gibson County "on the higher hills."

Crataegus macracantha Lodd. Long-spined Thorn. (C. coccinea macracantha Dudley.)
"Along open bottoms in southwestern counties." (J. Schneck, M. D.)
"Banks of Wabash river, Wells County." (C. C. Deam.)

Prunus nigra Ait. Canada Plum, Horse Plum.
"In Woods," Wells County (C. C. Deam). The range of this species is well to the north of Indiana, but the abundance of material shows the above reference to be correct. In flower April 17, 1898.

Trifolium incarnatum L. Crimson, Carnation or Italian Clover.
Wells County (C. C. Deam). Somewhat widely escaped from cultivation within the last few years, but apparently not long persistent.

Oxalis cymosa Small. Tall, Yellow Wood-sorrel.
"Hill near Wyandotte cave, Crawford County, July 11, 1899." (C. C. Deam.)

Lechea tenuifolia Michx. Narrow-leaved Pin-weed.
Crawford County (C. C. Deam). "On hill near Wyandotte cave, July 11, 1899."

Vincetoxicum Shortii (A. Gray) Britton. (Gonolobus Shortii A. Gray.)
Crawford County (C. C. Deam). "On hill near Wyandotte cave, July 12, 1899."

Salvia lanceolata Willd. Lance-leaved Sage.
Gibson County (J. Schneck, M. D.). "On a sandy knoll in low river bottoms." An extreme western form having as its assigned range, "on plains, Nebraska and Colorado to Texas, Arizona and Mexico." The specimens submitted undoubtedly belong to this species, being easily separated from related forms by leaf characters and lobing of the connective. This eastern extension of range is extremely difficult of explanation, especially when the character of the station is taken into account.

Lonicera glaucescens Rydb.
Wells County (C. C. Deam). On bank of creek in Jackson Township, May 28, 1899.

Leontodon autumnale L. Fall Dandelion. Lion's Tooth.

Wells County (C. C. Deam). In yards at Bluffton, introduced in grass.

Helianthus petiolaris Nutt. Prairie Sunflower.

Lake County (E. J. Hill). A western prairie form occasionally found in dry, waste places eastward. Probably introduced into Indiana along east and west railway lines leading into Chicago.

Senecio Balsamitæ Muhl. (S. aureus Balsamitæ T. and G.)

Wabash County (J. N. Jenkins). The range of variation in *S. aureus*, so widely distributed throughout the State, is the only ground for questioning the above citation. The material submitted seems to bear out the description of the species *Balsamitæ*. It is therefore included in the list.

Centaurea Jacea L. Brown or Rayed Knapweed.

Lake County (E. J. Hill.) A form fugitive from Europe, usually found in waste places north, or in ballast about seaports.

Wolffiella Floridana (J. D. Smith). Thompson.

Marshall County, near Culvers (H. Walter Clarke). The abundant material furnished by Mr. Clarke leaves no room for questioning the accuracy of the reference. The range of the species by this citation is sharply extended northward, its assigned limits heretofore being "Georgia and Florida to Missouri, Arkansas and Texas.'"

Wolffia papulifera Thompson. Pointed Duckweed.

Gibson County (J. Schneck, M. D.). "Two miles east of Mt. Carmel, Ill., in Indiana. This is another decided extension of range, in this case eastward, the recorded range of the species being, "Kennett and Columbia, Mo." (Britton and Brown, Vol. 3, p. 510.)

SPECIES ESCAPED FROM CULTIVATION.

Pinus resinosa Ait. Canadian Pine. Red Pine.

Wabash County (J. N. Jenkins). A northern form which will probably not maintain itself in our area.

Populus balsamifera candicans (Ait.) A. Gray. Balm of Gilead.

Gibson County (J. Schneck, M. D.). Specimens of this form were in the Purdue herbarium at the time of collating the catalogue, but it was not included, being considered as an escape, and there being no record of its persistence.

Broussonetia papyrifera (L.) Vent. Paper Mulberry.

Gibson County (J. Schneck, M. D.). An evident escape from cultivation. The inclusion of the species should depend upon the persisteuce of the form in the wild state.

Malus Malus (L.) Britton. Apple.

"Along Wabash and White Rivers" (J. Schneck, M. D.). This form was excluded because regarded as an escape. The history of its persistence for many years in several different parts of the State has come into my hands since the publication of the catalogue. It should in all probability be included in the State flora.

Paulownia tomentosa (Thunb.) Baill. (P. imperialis S. and Z.)

Gibson County (J. Schneck, M. D.).

Tragopogon porrifolius L. Oyster Plant. Salsify.

Wells County (C. C. Deam).

Koelreuteria paniculata Laxm.

Gibson County (J. Schneck, M. D.).

These plants have undoubtedly escaped from cultivation in the locations cited. Whether or not they should be included in the State flora is a matter of personal judgment. Evidently fugitive plants which appear but for a single season in a single station can scarcely be regarded as entitled to place. That a plant escaped from cultivation should be listed as a member of the State flora in my judgment should require evidence, first, that it had maintained itself for at least three years; second, that in these years it was more than holding its own, in other words was making gains, however slight, in its new situation. For these reasons, in my opinion, the above plants, with perhaps the exception of the apple, should not be included in the flora. The list, however, is given for the benefit of those whose judgment would add them to the Catalogue list.

A few critical notes may perhaps find a proper discussion in this paper.

Quercus pagodæfolia Elliott.

Reported by Dr. Schneck as belonging to the flora of the southwestern counties. The question turns upon the point as to whether the form is to be regarded as a distinct species or merely as a variety. This form originally appeared as *Q. falcata* Michx., var. *pagodæfolia* Elliott, being separated from the type by "larger leaves, 11–13 nearly opposite and spreading lobes." Sargent includes it under *Q. falcata* Michx., and Britton and Brown under *Q. digitata* (Marsh) Sudw. In neither of these cases is it given even varietal rank. The form in our area is so well marked that it certainly seems entitled to varietal, if not, indeed, to specific rank. In my judgment, the form should be written *Q. digitata pagodæfolia* Ell., and given a place in the flora.

Quercus Phellos L. Willow Oak.

This form has been recorded as found in Gibson, Posey and Knox Counties. Concerning the occurrence of this species in this region, Dr. Ridgway says: "This species I give with some doubt, not being quite positive that it occurs. I have seen, however, along the road between Mount Carmel and Olney several trees which, at the time of inspection, I unhesitatingly decided to be *Q. Phellos*, but not having seen it since, while Dr. Schneck has not recorded it, I place the interrogation mark before it."[1] Since the publication of the Catalogue Dr. Schneck writes me that "a very narrow-leaved form of *Q. imbricaria* has probably been mistaken for *Q. Phellos*." If this be true, there exists no definite record of the occurrence of *Q. Phellos* in Indiana. Collectors in the southwestern counties should examine carefully as to the correctness of this view.

Celtis pumila (Muhl.) Pursh.

"Rocky banks of Blue River" (J. Schneck, M. D.). This shrub-like Hackberry, undoubtedly occurs in our area. It is included by Britton and Brown (Vol. 1, p. 526) under *C. occidentalis* L., which is described as a "shrub or a tree." Sargent also includes under *C. occidentalis*, of which he says: "A polymorphous species; the low shrub form of hillsides and sand dunes is the *C. pumila* of Pursh." The reasons for not maintaining *pumila* in at least varietal rank are not clearly apparent. The form, however, is in the Catalogue, by inclusion in *C. occidentalis*.

Some Mid-Summer Plants of South-Eastern Tennessee.

By Stanley Coulter.

The center from which the collections here reported were made was Mt. Nebo in the Chilhowee Mountains. It is about ten miles to the east of Maryville, which gives the nearest railway communication. From the summit of the mountain the eye reaches westward over a beautiful plain, to the Cumberland Mountains, while twenty miles to the east there arise the peaks of the Great Smoky Mountains. The region lying between the Chilhowee and Great Smoky Mountains is practically virgin, only relatively small areas having been taken for agricultural purposes. The

[1]Ridgway, Robert.—Notes on the Native Trees of the Lower Wabash and White River Valleys, in Illinois and Indiana. *Proc. U. S. Natl. Mus.*, 1882, p. 83.

time of the visit was the month of August, and while the object of the trip was not botanical, a few plants were collected and preserved as well as was possible under the conditions.

At the base of the Chilhowees runs Little River, its banks thickly clothed with timber, the most prominent form both as to size and number being the sycamore. More interesting was the fact that the mistletoe, which with us is found chiefly upon the elm, the honey locust and the oak, had there its favorite resting place upon the sycamore. Upon the western slopes of the Chilhowees, the chestnut was the characteristic forest tree, reaching very often a trunk diameter of from five to seven feet. In the coves and upon the western slopes of the Great Smokies, pines made up the forests, and we drove through miles of these forests which had as yet been free from the lumberman's axe. Near the summits of the Great Smokies the trees were for the most part stunted beeches, not more than fifteen to twenty feet high or with a trunk diameter exceeding eight inches. Among the pines there grew in abundance a bright yellow orchid which I was unable to collect, but took to be either *Habenaria cristata* or *lacera*. Upon the summit of Thunder Head in the wet places the Indian pipe grew in great masses, covering acres with its graceful, snow-white blossoms. In the lower levels and encroaching everywhere upon the cultivated areas the most attractive plant was the passion flower (*Passiflora incarnata*), known locally as maypop. It was one of the most annoying weeds of the region. The masses of rhodondendrons and azaleas, though past the glory of their bloom, added another feature, strange to northern eyes. These plants practically covered the lower stretches of the mountain, and when in full bloom must have made a most brilliant landscape. No attempt was made to secure a complete collection of the plants of the region, only those being collected which promised to "preserve easily," or were of interest for some special reason.

Thanks are due to Mr. H. B. Dorner, a graduate student in botany at Purdue University, for a critical study of the collection.

Juniperus Virginiana L. Red Cedar.

Common over Chilhowee and Great Smoky Mountains.

Panicum capillare L. Witch Grass. Tumble weed.

Abundant and annoying in cultivated areas.

Commelina nudiflora L. Creeping Day-flower. (C. communis L.)

In moist places at base of mountains.

Stenanthium gramineum (Ker) Morong. (S. angustifolium Gray.)
Found chiefly well up the mountain sides.

Aletris farinosa L. Star grass. Colic-root.
In situations similar to the preceding.

Pogonia trianthophora (Sw.) B. S. P. Nodning Pogonia. (P. pendula Lindl.)
From base of mountain up to 2,500 feet.

Gyrostachys gracilis (Bigel.) Kuntze. Slender Ladies' Tresses. (Spiranthes gracilis Bigel.)
Usually well up the side of the mountain.

Tipularia unifolia (Muhl.) B. S. P. Crane-fly Orchis. (T. discolor Nutt.)
Not unfrequent on western slope of Mt. Nebo.

Carpinus Caroliniana Walt. Water Beech. Blue Beech. (C. Americana Michx.)
Along streams throughout mountains.

Polygonum Persicaria L. Lady's Thumb.
On Pine Top, Blount County, Tenn.

Silene stellata (L.) Ait. Starry Campion.
Abundant in woods throughout the mountains.

Anychia Canadensis (L.) B. S. P. Slender Forked Chickweed.

Clematis Virginiana L. Virgin's Bower.
Abundant along Little River, near Mt. Nebo.

Cassia nictitans L. Wild Sensitive Plant.
Extremely abundant. In places covering acres to the practical exclusion of other plants.

Cassia Tora L. Low Senna. (C. obtusifolia L.)
On banks of Little River, near Mt. Nebo.

Cassia Marylandica L. American Senna.
Found only about the Mountain House on Mt. Nebo, at an altitude of about 2,500 feet.

Stylosanthes biflora (L.) B. S. P. Pencil Flower. (S. elatior Sw.)

Meibomia nudiflora (L.) Kuntze. (Desmodium nudiflorum D. C.)

Lespedeza repens (L.) Bart. Creeping Bush-clover. (L. repens T. and G.)

Lespedeza frutescens (L.) Britton. (L. violacea sessiliflora Chapm.)

Lespedeza hirta (L.) Ell. Hairy Bush Clover. (L. hirta L.)

Lespedeza striata (Thunb) H. and A. Japan Clover.

Bradburya Virginiana (L.) Kuntze. Spurred Butterfly Pea. (Centrosema Virginiana Benth.)
Very abundant in the drier soils.

Rhynchosia erecta (Walt) D. C. (R. tomentosa erecta T. and G.)

Oxalis filipes Small. Slender Yellow Wood-sorrel.
On Mt. Nebo, on western slope, August, 1892.

Oxalis stricta L. Upright Yellow Wood-sorrel.
Abundant in moist soils along banks of Little River.

Polygala Curtissii A. Gray.

Polygala alba Nutt. White Milk-wort.
Very abundant in open places on Mt. Nebo.

Phyllanthus Carolinensis Walt.

Acalypha gracilens Gray. Three-seeded Mercury.
Abundant in thickets.

Euphorbia nutans Lag. Upright Spotted Spurge. (E. hypericifolia Gray.)

Euphorbia corollata L. Flowering Spurge.
Common throughout mountains.

Impatiens biflora Walt. Spotted Touch-me-not. (I. fulva Nutt.)
Near Little River, Blount County, Tenn.

Rhamnus Caroliniana Walt. Carolina Buckthorn.
Along banks of Little River, Blount County, Tenn.

Sida spinosa L.
Common throughout mountains and about cultivated fields.

Ascyrum hypericoides L. St. Andrew's Cross. (A. Crux-Andreæ L.)

Hypericum adpressum Bart. Creeping St. John's-wort.

Hypericum virgatum Lam. (H. angulosum Michx.)

Hypericum mutilum L. Dwarf St. John's-wort.

Sarothra gentianoides L. Orange-grass. Pine-weed. (Hypericum Sarothra Michx.)

Ludwigia alternifolia L. Rattle-box.

Angelica villosa (Walt) B. S. P. (Archangelica hirsuta T. and G.)

Cornus florida L. Flowering Dogwood.
On Pine-top mountain at 2,700 feet altitude.

Rhododendron maximum L. Great Laurel. Rose Bay.
Common in Great Smoky and Chilhowee mountains, along streams, forming dense thickets or "*slicks*" near the base.

Xolisma ligustrina (L.) Britton. (Andromeda ligustrina Muhl.)

Oxydendrum arboreum (L.) D. C. Sour-wood. Sorrel-tree.

Vaccinium virgatum Ait. Southern Black Huckleberry.

Mohrodendron Carolinum (L.) Britton. Silver-bell Tree. (Halesia tetraptera L.)

Ipomœa pandurata (L.) Meyer. Wild Potato Vine.
Abundant on Mt. Nebo.

Ipomœa pandurata hastata Chapm (?).

More abundant than the type especially in the lowlands bordering upon Little river.

Cuscuta arvensis Beyrich. Field Dodder.

On Pennyroyal, at foot of Mt. Nebo.

Hedeoma pulegioides (L.) Pers. Pennyroyal.

Solanum Carolinense L. Horse-nettle.

Banks of Little River, and in adjoining cultivated fields. Locally known as "Tread-softs."

Dasystoma laevigata Raf. (Gerardia quercifolia integrifolia, Benth.)

Ruellia ciliosa Pursh. (Dipteracanthus ciliosus Nees.)

Houstonia cœrulea L. Bluets. Innocence. (Oldenlandia cœrulea Gray.)

Houstonia purpurea L. (Oldenlandia purpurea Gray.)

Diodia teres Walt. Rough Button-weed.

Lobelia amœna glandulifera A. Gray. Southern Lobelia.

Abundant on Mt. Nebo.

Lobelia inflata L. Indian Tobacco.

Very common throughout the mountains.

Lacinaria squarrosa (L.) Hill. Blazing Star. Colic-root. (Liatris squarrosa Willd.)

On each side of Pine Top, Chilhowee mountains.

Graphalium obtusifolium L. Sweet Balsam. (*G. polycephalum* Michx.)

Near base of Mt. Nebo.

Silphium terebinthinaceum Jacq. Prairie Dock. (S. compositum Michx.)?

On Pine Top, Chilhowee Mountains in considerable abundance.

Achillea millefolium L. Yarrow.

Abundant throughout the mountains.

The nomenclature of the article is that of Britton and Brown's Illustrated Flora of the Northern States and Canada, the names in parenthesis being those used by Chapman in his Flora of the Southern United States, edition of 1872.

While Dr. Gattinger has done excellent work in the collation of the flora of Tennessee, there remains in the southeastern counties, especially in the deeper coves, large areas that as yet are practically botanically unknown. The remoteness of these regions from ordinary lines of travel, and the unprogressive character of the inhabitants, have joined to keep this area in a nearly virginal state. No collecting tour could be more profitable botanically than one through the coves and mountain ravines between the Great Smoky and Chilhowee Mountains.

A Study of the Constituents of Corn Smut.*

By William Stuart.

In connection with some studies upon corn smut, which were published in the twelfth annual report of the Indiana Experiment Station,[1] the question as to whether corn smut actually contained some principle injurious to farm animals was given some attention. This portion of the work, which was performed by the writer under the supervision of Dr. Arthur, was not completed in time for publication with the other studies mentioned. This work consisted in making extracts of the corn smut, and determining, by means of standard alkaloidal reagents, whether it contained an alkaloid or not. It also included a study of the physiological action of the extract upon horses, when administered to them either hypodermically or per orum. For the latter portion of the work the writer is greatly indebted to Dr. R. A. Craig, of the Veterinary Department, who administered the doses and observed its effects.

In the preparation of the extract valuable assistance was received from Mr. J. W. Sturmer, of the Purdue School of Pharmacy.

TESTS FOR ALKALOIDAL SALTS.

The methods employed in testing for alkaloidal salts were to make an alcoholic extract of the smut spores and such detritus as would pass through a fine sieve. A hundred grams of the smut spores were weighed out and, after thoroughly moistening them in an open dish with a 33⅓ per cent. solution of alcohol, they were again passed through a sieve to break up all lumps, then transferred to a percolator previously fitted up for the purpose. Sufficient alcohol, of the same strength as that previously mentioned, was added to cover the spores. Maceration of the spores was continued for twenty-four hours before any of the liquid was allowed to pass over into the receiving flask, the latter being so adjusted as to prevent it. At the end of this period the receiving flask was lowered so as to permit of about two drops passing over into the flask per minute. The percolation was continued until the percolate was colorless, sufficient

* Abstract of an article published in the Thirteenth Ann. Rep. of the Ind. Exp. Sta., pp. 26–32, Jan., 1901.

(1) Arthur and Stuart, Twelfth Ann. Report Ind. Exp. Sta., p. 84–135, Jan ,1900.

alcohol being added from time to time to keep the surface of the spores covered with the liquid. The first 50 cc. of the percolate was set aside and the balance collected and evaporated down to 50 cc. on a steam bath. This was added to the first amount saved making 100 cc. of the extract. Each cc. of the extract representing one gram of the spores.

In testing the extract for alkaloids a certain amount of it was taken and evaporated to dryness on a steam bath. The residue was treated with a five per cent. solution of sulphuric acid, and filtered. The filtrate was then subjected to tests with the following reagents:

1. Potassium mercuric iodide (Mayer's solution).
2. Phosphotungstic acid.
3. Iodine in potassium iodide solution.
4. Picric acid.

A small portion of the filtrate was poured out into each of four watch-glass crystals and then a drop or two of the reagents added. The reactions obtained by this method were as follows:

Reagent 1. A slight milky turbidity was produced.

Reagent 2. A decided milky turbidity was obtained.

Reagent 3. No visible reaction.

Reagent 4. No visible reaction.

A number of tests with the same and with fresh lots of extract prepared in the same manner gave similar results.

TESTS FOR TOTAL ALKALOIDS.

In testing for total alkaloids a modified "Prollius Fluid"[2] was used. Two methods were employed. The first was to treat two grams of the smut for four hours with 50 cc. of "Prollius Fluid" in a well stoppered conical flask. The contents of the flask were vigorously shaken at intervals during that period. After macerating four hours the supernatant solution was drawn off and filtered. The filtrate was evaporated to dryness on a steam bath and the residue treated with a five per cent. solution of sulphuric acid. The acid solution was filtered and the filtrate tested as mentioned for the alcoholic extract. The reactions obtained were in each instance similar to those given for alkaloidal salts.

The second method employed consisting in macerating ten grams of the smut spores in 100 cc. of "Prollius Fluid" for twenty-four hours. The

---

[2] Modified Prollius Fluid: Ether, 250 c. c.; Chloroform, 100 c. c.; Alcohol, 25 c. c.; 28% Ammonia, 10 c. c.

flask containing the spores being agitated at frequent intervals during that period. The supernatant liquid was drawn off and filtered, and 50 cc. of it transferred to a separatory funnel and subjected to the "shaking out" process as outlined in Sturmer and Vanderkleed's "Course in Quantitative Analysis: 61-64, 1898, under 'Process 1.—General for Total Alkaloid.'" The results obtained from this method by the reagents were quite similar, although more marked, to those of the preceding ones.

Reagent 1. A slight turbidity was obtained which, on standing for some time, deposited a dark brownish substance on the bottom of the glass.

Reagent 2. A marked cloudiness was obtained which, on standing for some time deposited a whitish crystalline precipitate on the bottom of the glass.

Reagent 3. No visible reaction or any deposit after standing.

Reagent 4. No visible reaction, but on standing a slight deposit was noticed on the glass.

TESTS FOR ALKALOIDS IN COMMERCIAL EXTRACTS OF ERGOT AND CORN SMUT.

The uniformity of the results obtained from the reagents employed, the first two giving positive and the last two negative reactions in each instance, led to an examination of the commercial extracts of both ergot and corn smut.

Ergot of rye test.—The commercial fluid extract of ergot was obtained from a leading wholesale druggist in the city, whose supply was obtained from the well-known firm of Park Davis & Co., of Detroit, Michigan. The fluid extract was evaporated to dryness over a steam bath, the residue treated with dilute sulphuric acid and filtered. Tests of the filtrate were made, and the reactions obtained were as follows:

Reagent 1. A yellowish brown, curdy-like precipitate was obtained.

Reagent 2. A cloudy white precipitate was obtained which on standing changed to a purplish brown, curdy-like substance.

Reagent 3. A reddish brown precipitate was obtained.

Reagent 4. No visible reaction obtained.

Corn smut ergot test.—The material used was obtained from the same local druggist, who in turn received his supply from the well-known firm of Merrill & Co., Cincinnati, Ohio. The fluid extract was treated in the same way as in the preceding test and the reactions obtained were somewhat similar.

Reagent 1. A precipitate was formed, but it was not so marked as in the ergot of rye.

Reagent 2. Reaction much the same as that in rye ergot.

Reagent 3. Reaction not quite so marked as in the rye ergot.

Reagent 4. No reaction was obtained.

A brief summary of the work shows that a substance was obtained in all the extracts made which gave positive reactions with the first two reagents used and negative ones with the last two.

Commercial extracts of rye ergot and of corn smut gave similar reactions to those obtained from the corn smut extract prepared in the laboratory, in the case of reagents one and two, and in addition gave marked results with reagent three.

PHYSIOLOGICAL EFFECT OF AN ALCOHOLIC EXTRACT OF CORN SMUT UPON HORSES.

The study of the physiological effect of an alcoholic extract upon horses was carried on in conjunction with that of the alkaloidal tests in the laboratory, the alcoholic extract used being prepared by the writer in the same manner as that described in the preceding pages. The experimental work upon the horses was performed by Dr. R. A. Craig, of the Veterinary Department of Purdue University.

The appended notes upon the amounts and effects of the doses administered were taken by him and have been kindly placed at my disposal.

Horse No. 1.—A gelding, poor in flesh, but healthy, was given 15 cc. of the extract subcutaneously. The dose seemed to have no effect. The next day 30 cc. were given in the same way. In twenty-five minutes he stopped eating. The pulse and breathing were quickened and the peristaltic movements of the intestines were increased. Forty-five minutes after the drug was given faeces were passed. No further effects were noted.

Horse No. 2.—A gelding in good condition was given 25 cc. subcutaneously. In twenty minutes he became restless, stopped eating, and the pulse and breathing were quickened. A moist evacuation of faeces occurred in twenty-five minutes. An hour after giving the injection its effects had passed off. Two days afterwards 45 cc. were given. The horse soon became restless, the intestinal murmurings were loud and an evacuation of faeces soon followed. When made to turn in the stall his movements were slow and unsteady. One hour after giving the injection his pulse was sixty and his respirations forty-three per minute. He refused to eat and remained dull till noon the following day. After an interval of a few days the horse was given 130 cc. per orum. In forty minutes he stopped eating, his pulse and breathing were quickened, but outside of this no other effects of the drug were noted.

A brief summary of the results show that an injection of 25 to 30 cc. of the drug caused restlessness and increased peristaltic movements of the intestines. This was followed shortly by evacuation of the contents of the rectum. At the same time the pulse and respiration were quickened. The effects of the dose passed off in an hour.

The injection of 45 cc. produced, in addition to the above symptoms, a dullness and an unsteady gait when made to move. The effects of the dose were much more lasting. The horse remained dull and refused to eat for twenty-four hours.

A 15 cc. subcutaneous injection and a 130 cc. per orum dose produced but little effect.

While the results of both the chemical and physiological tests of the corn smut are at variance with those obtained by some other investigators,[3] they are in accordance with results of a number of chemists,[4] and to some extent in their physiological action to that obtained by Dr. Mitchell,[5] whose experiments were performed upon the frog. The concordance of the results obtained from both the chemical and physiological tests would indicate the presence in minute quantity of some narcotic in corn smut. What this narcotic is, and why, when corn smut is consumed in large quantities by farm animals, it does not produce more harmful results, are questions which are yet to be determined.

---

[3] Kedzie, Bull. Mich. Exp. Sta., No. 137 : 45, 1896.
Mayo, Bull. Kans. Exp. Sta., No. 58 : 69, 1896.

[4] Dulong, Journ. de Pharm. 14 : 556, 1828.
Cressler, Amer. Journ. Pharm. for 1861 : 306.
Parsons, Rep. Dept. Agric. for 1880 : 136–138, 1881.
Hahn, Amer. Journ. Pharm. 53 : 496, 1881.
Rademaker and Fischer, Med. Herald for 1887 : 775.

[5] Mitchell, Jas.—The Physiological Action of Ustilago maidis on the Nervous System, Inaug. Thesis, Univ. Pa., 1883. Therap. Gaz., Detroit, 10 : 223–227, 1886.

A Bacterial Disease of Tomatoes.*

[Abstract.]

By William Stuart.

During the winter of 1898-99, while engaged in an experimental study in the growing of tomatoes by the aid of chemical fertilizers, considerable annoyance was occasioned by the appearance of a disease which attacked the fruit and rendered it unmarketable.[1] Usually the fruit showed no sign

Fig. 1. Tomatoes affected with bacterial disease.

of injury until two-thirds grown, and sometimes not until fully developed. The first visible appearance of the disease in infected fruits was in a slight watery discoloration of the tissue beneath the epidermis. As the disease

[*Published in full in the Thirteenth Ann. Rep. of the Ind. Exp. Sta., pp. 33-36, Jan., 1901.]

[1]A disease similar in its character was reported by Beach, in Bulletin 125 of the New York State Agr. Exp. Sta., Geneva, pp. 305-306, July, 1897.

progressed, the affected portion assumed a darker color, followed by a gradual depression of the infected tissue, resembling in many cases that caused by the black rot Macrosporium solani (see Fig. I), but without any fruiting hyphae growing on the surface of the epidermis. It rarely wholly destroyed the fruit, but as a rule seemed to hasten its maturity. Generally the disease attacked the apical portion of the fruit; in a few instances, however, the central or basal portions would show the characteristic watery discoloration.

a b

Fig. 2. Original condition of the fruit prior to infection.

a b

Fig. 3. Changed condition of fruit "b" due to infection.

A microscopical examination of diseased portions of the fruit gave no evidence of the presence of any parasitic fungus. The presence of a motile bacillus seemed, however, to be fairly constant in all tissue examined.

Isolation of the germ.—In the isolation of the germ two different methods were employed. In one sections of the diseased tissue were removed from the fruit with a flamed knife and transferred to bouillon tubes, from which loop plate cultures were made in agar. In the other method direct inoculation of the tubes were made from the inner portions of diseased tissue by means of a sterilized platinum wire.

The cultures obtained from both of these methods were apparently similar, both contained a minute motile bacillus, having the same appearance as that noted in the microscopical examination. The germ thus obtained was assumed at the time to be the same as that seen in the diseased fruit, but its after behavior did not in all respects bear this out.

Growth of the germ upon agar.—The growth of the germ upon slightly acid slant agar was quite characteristic; it produced a vigorous growth, with irregular outline all along the track of the needle. The color of the colonies upon agar was creamy white on the margins, becoming yellowish towards the center, and having a marked viscid surface.

Inoculation experiments.—On February 15 two tomatoes which had every appearance of being perfectly healthy were removed from plants in an adjoining room. One of these was inoculated with a pure culture of the germ, by puncturing the epidermis with a sterilized needle, and with a sterilized platinum wire transferring the germs from the tube to the interior of the fruit. The other fruit was infected by merely smearing the germs over the surface of the pistillate portion of the fruit. After inoculation both fruits were placed under a bell jar. At the end of the second day the first fruit showed signs of infection; a portion of the cells adjacent to the opening made for the introduction of the germ were fast turning a dark color. In a week the greater portion of the tomato was diseased and was giving off an offensive odor. By March 1, or fourteen days after the time of infection, it was completely decomposed, while the one on which infection material had been smeared showed no signs of disease.

On March 2 two more healthy tomatoes were removed from the vines, and after photographing them they were inoculated in the same way as those in the previous experiment. The progress of the disease in this experiment was not quite so rapid as in that of the first, some twenty days elapsing before the whole fruit was affected. Like the first the fruit into which the germs were introduced was totally destroyed, while the other remained perfectly sound. The fruits were again photographed on March 22. Fig. II represents them previous to inoculation, while in Fig. III the changed condition of the diseased fruit is shown.

In order to determine whether the same effects would be obtained by inoculating the fruit on the vine, a cluster of fruit containing four half to two-thirds grown tomatoes was selected for experimentation. Two of the tomatoes were inoculated by introducing the germs into the tissues of the fruit with a sterilized needle. In order to note the effect of the injury from needle puncture the third fruit in the cluster was punctured with a sterilized needle. while the fourth was reserved for control. All inoculations were made on the north side of the fruit in order to avoid any action of the sun upon the wounds. Three days later the tissues surrounding the infected portions of the first two fruits had begun to grow darker. From this time on the progress of the disease was quite rapid No ill effects could be noted on the fruit punctured with the sterilized needle, both of the latter fruits remaining perfectly healthy.

In comparing the action of the disease produced in the artificially inoculated fruit with that of one naturally infected, it will be noted that with the exception of the first appearance of the disease their action was entirely different. In the natural infected fruit there was no offensive odor. the disease rarely affected the whole fruit. and never caused a sloughing of the cell tissues, as did the artificial infections. The wide difference in the action of the germ in the natural and artificially infected fruits may indicate that they were not the same. although looking so much alike, or it may be explained by supposing that in the naturally infected fruits the epidermis, not being broken, excludes all putrefactive bacteria. The putrefactive bacteria having access through the wound caused by artificial inoculation. feed upon the tissues destroyed by the inoculated germ. and thus the two acting in conjunction make the destruction of the fruit much more rapid and complete. The uniformity of the results obtained seems to favor the latter assumption.

SUMMARY.

A decay of green fruits on tomato plants grown in the greenhouse seemed from microscopical examination to be of bacterial origin.

The fruit showed patches that looked watery, became depressed, and after a time turned blackish. Usually the disease started at the apical portion of the fruit. No evidences of a fungus were present. Attempts to separate a specific germ were apparently successful.

Introducing the supposed germ into the fruit by puncturing the epidermis in every instance produced a disease.

The disease caused by the germ from the cultures did not coincide very closely with that from natural infection, and there is still doubt if the two be the same.

No preventive measures can be suggested with the limited knowledge of the disease yet available.

Device for Supporting a Pasteur Flask.

By Katherine E. Golden.

Notes on the Microscopic Structure of Woods.

By Katherine E. Golden.

Movement of Protoplasm in the Hyphæ of a Mould.

By Katherine E. Golden.

Description of Certain Bacteria Obtained from Nodules of Various Leguminous Plants.

By Severance Burrage.

(A preliminary study on the constancy of the distribution of bacterial species in definite species of leguminous plants.)

It has been quite thoroughly proven that several different species of bacteria may be found in the nodules of various leguminous plants. The following questions, however, have not, it seems to me, been definitely settled with regard to them:

Does the same species of bacteria always occur in the same species of legume?

Does the same species of bacteria always occur throughout all the nodules on the same plant of any species of legume?

Does the same species of bacteria always occur in the nodules of all the plants in a field planted with one species of legume?

Does the same species of bacteria occur constantly in the same species of legume year after year?

The following descriptions are merely the beginning of an attempt to investigate and answer these questons.

For much of the culture work, I am indebted to Mr. T. R. Perry, one of the students in Purdue University last year.

SPECIES 1.

Separated twenty times from the nodules of Trifolium pratense.

MORPHOLOGY.

Bacilli with rounded ends, occurring sometimes singly, but generally in pairs. These bacilli measured from .75 to 1 mu in width, and 2 mu in length. Examination of Zoogloea masses on agar shows a distinct capsule formation sometimes measuring 3 mu in width and 4 mu in length.

BIOLOGICAL CHARACTERS.

An aerobic, liquefying, motile, chromogenic bacillus, growing well at room temperature, but slightly better at 37½ C°.

On gelatin plates the colonies are large and white, liquefying the gelatin in a very short time.

A funnel shaped liquefaction occurs in gelatin stab cultures in about 15 days, and a distinct greenish fluorescence is given to the liquid portion, while a white precipitate sinks to the bottom of the "funnel." After all the gelatin is liquefied, a distinct green mycoderm is formed on the surface.

On the agar streak there is a thin, spreading light-green growth which imparts a distinct fluorescence to the agar. On older cultures, this growth thickens and forms a luxuriant zoogloea mass all over the agar. It is from such conditions that the capsule stage may be obtained. Upon potato a slimy, yellowish, dirty-brown growth takes place along the line of inoculation, which growth becomes darker with age.

Milk is quickly coagulated, and the whey takes on a greenish fluorescence. This milk, however, remains neutral.

In solutions containing nitrates, all nitrates are changed to nitrites in from five to seven days.

Glucose solutions are not fermented.

SPECIES 2.

Separated several times from the nodules of Vicia sativa.

MORPHOLOGY.

In crushed nodules the "bacteroid" appearance is quite common, while on the various artificial culture media these are rarely seen. Upon these media, they appear as bacilli with rounded ends, often united in pairs. They measure .8 mu in width and 1.5 mu in length.

BIOLOGICAL CHARACTERS.

This form is a faculative anaerobe, motile, non-liquefying, non-chromogenic. Grows well at the room temperature, and better at the body temperature. In gelatin stab cultures a line of very small colonies is formed along the line of puncture.

On agar plates the colonies appear in thirty-six hours, the surface colonies having a whitish appearance, while the deeper ones have a yellowish tinge.

The agar streak gives rise to a slimy, viscous, whitish growth, having no tendency to spread over the agar.

On potato, a rather restricted whitish growth takes place very slowly, and this growth is very slimy.

In solutions containing nitrates, after twenty days, a considerable portion have been reduced to nitrites, but not all, as there was positive test for nitrates as well as for nitrites.

Glucose solutions are not fermented.

Milk is not coagulated, yet is rendered strongly acid.

SPECIES 3.

Separated in several instances from nodules of Phaseolus nasus.

MORPHOLOGY.

Bacilli with rounded ends, usually united in pairs.

Measurement, 1.5 mu in width, 3 mu in length.

BIOLOGICAL CHARACTERS.

An aerobic, liquefying, motile nonchromogenic bacillus, which grows very slowly at the room temperature, but quickly at the body temperature. In gelatin stab cultures the liquefaction occurs in a straight line across the tube. The whole mass of gelatin becoming liquefied in 15 days.

On gelatin plates the colonies reach one-sixteenth of an inch in diameter, circular in outline.

On agar plates, the colonies are also about one-sixteenth of an inch in diameter, but are somewhat irregular in outline, and very finely granular.

On the agar streak, there is a luxuriant dirty-white, slimy growth, giving a very slight fluorescence.

On potato, there is at first a flesh-colored growth, later becoming a dirty white, and on the very old cultures, a brown.

Glucose solutions are not fermented.

Nitrate solutions give a fair test for nitrites after 24 days.

Milk is in no respect changed by this species.

SPECIES 4.

Found in several nodules on Trifolium hybridum.

MORPHOLOGY.

Bacilli occurring usually in pairs, rarely singly.

In the nodules, these bacilli measure 1.5 mu in width, and 4 mu in length. When taken from culture media they measure 1.75 mu in width and 5 mu in length.

BIOLOGICAL CHARACTERS.

This form is a facultative anaerobe, non-liquefying, non-chromogenic bacillus, quite actively motile. Grows better at the body temperature than at the room temperature.

In gelatine stab cultures there is a scattered growth of individual colonies along the line of inoculation, without liquefaction of the gelatin. An irregular button-like growth takes place on the surface of the gelatin. In bouillon rendered slightly acid, no growth whatever took place, while in neutral bouillon an abundant growth occurred.

On agar streak a non-spreading flesh-colored growth appears, and on potato a light lead colored growth follows the line of inoculation which becomes slimy after four days.

Glucose solutions are not fermented.

Nitrate solutions are wholly reduced to nitrites.

Milk is unchanged.

SPECIES 5.

Found in nodules on several plants of Trifolium reflexum.

MORPHOLOGY.

Bacilli usually arranged in pairs, rarely singly. They measure .5 mu in width, and 1.5 mu. in length.

BIOLOGICAL CHARACTERS.

This species is a non-liquefying, non-chromogenic, motile, facultative anaerobic bacillus, which grows very well at the room temperature, but not so well at the body temperature.

On gelatin stab cultures a few scattered colonies appear along the line of inoculation, and a button-like growth on the surface. The gelatin is not liquefied in two weeks.

On agar streak, a whitish growth follows the line of inoculation.

On potato the growth is a yellowish, lead-colored one, following the line of inoculation.

Glucose solutions are not fermented.

Nitrate solutions are completely reduced to nitrites in three days.

Milk is coagulated, but remains neutral.

Other species are now being worked upon, which have been separated from many other leguminous plants, including crimson clover, locust, small white clover, whippoorwill cow pea, black cow pea, and alfalfa.

A Few Mycological Notes for July and August, 1900, Wells and Whitley Counties.

By E. B. Williamson.

An interest in the doings which go on in fields and woods is natural to everyone, bearing, as all of us do, in our own brains, cells which still retain the impress given them as they developed and multiplied to gradually make man, by the cunning of his intellect, master of his environment. Interest is attracted most easily to those everyday, more conspicuous and beautiful objects, and those which have never been dangerous to man during the period of his later evolution. So at the present time we have popular illustrated works on birds, butterflies and flowering plants, and when the Garden shall have faded into a more correct perspective, we may expect some such popular treatises on the humble though usually beautiful, creatures which go with heads in the dust. But I leave it to the student of psychogony to discover why the fastidious human so often turns with loathing from a mushroom. It would seem that these plants, by their graceful adaptive forms and varied colors, could easily conquer the feelings which seem to frequently exist only because of the falsely suggestive name of "toadstools" commonly given to all species of the Agaricaceae. However, an interest in these larger fungi is felt by many, and one purpose of this brief note is to call attention to two recently published works which make possible at least a general knowledge of the forms to be found in the United States.

The first of these books is "Moulds, Mildews and Mushrooms," by Dr. Underwood, published by Henry Holt & Company. Keys enable the student to trace specimens to their genera, and notes on distribution, habitat, etc., conspicuous species, and a full bibliography are given. The second book is "A Thousand Fungi," by Charles McIlvaine, published by the Bowen-Merrill Company. Many fine plates from photographs and water color studies illustrate a large number of species, especially the commoner and more conspicuous forms. This work is decidedly less scientific that the first, and the many notes are usually intended especially for the mycophagist.

To the best of my knowledge those who gather fungi for food purposes in Wells County, and doubtless also in other portions of the State, confine themselves exclusively to the morel. This species is not rare in the spring. It belongs to another group than the one to which other mushrooms, as they are known, belong. Near Bluffton a species of *Geoglossum*, a genus belonging to the same order as *Morchella*, was not rare in low woods in August. It was not found in sufficient quantities to cook, but eaten raw had a nutty flavor, woody texture.

In low woods on and about rotting logs in Wells and Whitley counties during August *Clavarias* were common. *C. cristata* seemed to be the common species. Underwood says none of them are deleterious, and McIlvane recommends some of them especially for soups. In past years species of *Hydnum* have been observed commonly in the two counties mentioned above, but this year, possibly because of the little time spent in the woods compared with some former years, none were seen.

On August 17 an oak stump growing in a thick woods near Bluffton was found literally covered with *Polyporus sulfureus*. No other mass of color could have clothed the stump to render it more conspicuous in the dark woods. The fungus was young and tender, and a number of persons ate of it sliced and stewed. The flavor possibly suggested veal. I have seen this species growing more in the open on logs where it was almost completely pulverized by insect larvae.

Of the Boletaceae three genera were observed in Wells County—*Fistulina*, *Boletus* and *Boletinus*. None of these were tested for their edible qualities. *Fistulina hepatica* was found only once, on August 25. *Boletinus porosus* grew in shaded woods among old leaves. The short stipe and mottle yellow-ochre and burnt umber pileus of this species render even large specimens six or seven inches in diameter inconspicuous. One species of *Boletus* was common in both Whitley and Wells counties, but was not specifically identified. Height, two inches; diameter of pileus, one and one-half inches; pileus above, chocolate brown, reddish or reddish yellow; flesh, white or very pale yellow, when broken becoming bluish, then very dark yellow; tubes yellow; stipe solid, reddish yellow, not annulated.

Pleurotus ostreatus to the mycophagist is one of the most valuable fungi in northern Indiana. About Bluffton it was found especially on the northern exposures of elm logs which still held their bark, though it has a wide range of habitat. To some its flavor is as good as any mushroom, and the quantities that can often be gathered after a rain from one log recommend it. It often becomes soggy during a rainy spell, but if it is not too much infested with larvae this does not interfere with its edibility. Fried in butter this species is as good as cooked any other way. It is attacked by more enemies than any other woods species of fungus I have noticed. At least two or three species of mollusca, two diptera, possibly a dozen coleoptera and two hymenopetera infest it. A friend reports grasshoppers feeding on it. Centipedes are often found among the gills, being there doubtless in search of insect prey.

Amanita phalloides was found once in a cleared spot in a thin woods near Shriner Lake, Whitley County. This was the only one of the few deadly mushrooms seen during the season. A species which is perhaps dangerous is *Lepiota morgani*. It reaches the maximum of size for an Agaricaceae. One specimen collected at Bluffton was ten inches high, and the pileus was eleven inches in diameter. Another specimen broken off at the ground weighed eleven ounces. I saw the species growing at only two stations and at one of these it formed an incomplete giant fairy ring as has been described. At Bluffton eight persons ate freely of this species, and none suffered any inconvenience. It is generally accepted that genuine cases of mushroom poisoning have never resulted from eating decomposing nonpoisonous species. But is it possible that the ripening of the spores might develop some minor poison? The specimens of *L. morgani* eaten at Bluffton were in every case young and the gills were not colored by the spores. Several small species of *Lepiota* were common in the woods during August, but none of these were specifically determined. One of them had the pileus usually under an inch in diameter, white, the umbone dark wood brown. As it aged the margin of the disc became a delicate and beautiful blue.

Another dangerous species is *Clitocybe illudens*. This was found twice near Shriner Lake, growing on stumps, once in an open field, the second time in the woods. None were cooked. Dr. Underwood says it is unwholesome; Mr. McIlvaine says it is poisonous to some, and its odor is certainly not attractive. It possesses fully the phosphorescent property attributed to it by authors. *Clitocybe monadelpha* was found twice near Bluffton, each cluster growing on the ground in low, thick woods. Another species was very common about logs in woods. It was gray or light brown in color, thin, woody, and wine-glass shaped. The odor if long continued was sickening. On two occasions, when I had a quantity of it in the room where I was working, it all but nauseated me, though I am not easily offended through my olfactory organ.

Collybia radicata was common in Wells County, and it and two larger species of the same genus, all growing in woodland, were frequently eaten. They have nothing in particular to recommend them. *Russula emetica* was taken in Wells County and *Russula roseipes* in Whitley County. The latter species was eaten raw. It had a nutty flavor much like *Marasmius*. A species of *Cantharellus* was found at Bluffton, August 25, but was not identified.

After rains *Marasmius oreades* appears abundantly on the lawn about my home near Bluffton. The fairy rings were seldom well marked. We could not say that the flavor of this species was superior to that of some larger mushrooms which are usually more easily collected. However, the large number of *Marasmius* which may sometimes occur within a small area make it possible to gather a quantity of caps without much labor. *Panus strigosus* was found near Bluffton, August 19. A single individual grew from a decayed spot in a living tree. It was a beautiful specimen and suggested *Pleurotus ostreatus*. *Pluteus cervinus* was common both in Wells and Whitley counties, growing on very old logs, and once in a mass of rotting sawdust, in the woods. The pileus varies greatly in coloration. The species was often eaten, but unless fried crisp it has a rather unpleasant flavor. A species of *Galera*, apparently *flava*, was not rare in the woods about Bluffton, growing in clusters on decaying logs. It was cooked and the caps retained must of their bright yellow or orange color. It might be used as "trimming" for a dish of larger species.

Agaricus campestris was taken in pastures, but I did not find it in quantities as it is often found. A single specimen taken in the woods near Bluffton seemed to be *A. silvaticus*. In the same pastures and in thin woodland, often on manure, *Psathyrella* was common. All the specimens seen seemed to belong to one species, undetermined

Belonging to another order are the puffballs, the larger species of which are among the most valuable and delicate fungi. Representatives of three genera were observed this season about Bluffton. *Geaster* was found a number of times in thin woodland. *Calvatia* was found a few times. The best way to cook it is like egg plant. In former years *Calvatia* has often been observed in great abundance, occurring at the edges of woods or in thin woodland. Specimens not less than eighteen inches in diameter have been seen, and individuals eight or ten inches in diameter were not rare. A species of *Lycoperdon*, which suggested a sea-urchin with the spines removed, was common in pastures. Its diameter seldom exceeded two inches; it seemed to ripen rapidly, and it was usually infested with larvae, so none were cooked.

The Kankakee Salamander.

By T. H. Ball.

The Eel Question and the Development of the Conger Eel.

(Abstract.)

By C. H. Eigenmann.

The eel question, or "when, how and where does the eel reproduce," which is as old as history, was in part solved by Grassi, who in 1897 found that one of the numerous species of Leptocephali found near Messina is the larva of the eel. The eel is said to seek the deeper water, where it deposits its eggs and then dies. During the past summer the eggs of the Conger eel were taken by the U. S. Fish Commission vessel Grampus on the surface of the Gulf Stream. This is the first notice of an eel egg outside of the Mediterranean. A full account of these eggs will appear in the Bulletin of the U. S. Fish Commission.

The Mounting of the Remains of Megalonyx Jeffersoni from Henderson, Kentucky.

By C. H. Eigenmann.

During the fire of the Museum of the Indiana University in 1882 the bones of the Megalonyx belonging to the University were away to be figured. In this way this specimen was saved from the destruction that overtook most of the other specimens in the collections. The trustees have recently decided to have the specimen mounted. The bones have been mounted in their relative positions without reconstruction of the lost parts. It came originally from Henderson, Kentucky.

Contribution Toward the Life History of the Squeteague.

(Abstract.)

By C. H. Eigenmann.

The Squeteague is one of the important food fishes of Narragansett and Buzzard's Bay. During the past summer I studied the habits of the young of this fish. The details will be published in the Bulletin of the U. S. Fish Commission.

A New Oceanic Fish.

[Abstract.]

By C. H. Eigenmann.

A new species of Centrolophine fishes was taken during last summer under a medusa in the Gulf Stream off Newport, R. I. It will be described in detail in the Bulletin of the U. S. Fish Commission.

A New Species of Cave Salamander from the Caves of the Ozarks in Missouri.

[Abstract.]

By C. H. Eigenmann.

While collecting in the caves of Missouri I found a species of Spelerpes rather abundant. It was taken in Wilson's Cave, Rockhouse Cave, Fisher's Cave and also near Marble Cave. It proved to be a new species which is the fourth salamander known to inhabit the caves of North America. It is a twilight species rather than a strictly cave species, being found within a short distance from the entrance of the cave in all instances.

An Addition to the Fishes Occurring in Indiana.

By L. J. Rettger.

Some Observations of the Daily Habits of the Toad (Bufo Lentiginosus).*

By J. Rollin Slonaker.

Wishing to observe the daily habits of the toad and to see if it would hibernate if kept in a warm room during the winter months, a medium-sized female toad (Bufo lentiginosus) was secured October 8th. Not having a suitable place ready for her, she was placed temporarily in a running water aquarium. Here she could climb upon some bricks and be out of the water, but it was evidently too damp, for she showed signs of uneasiness.

On the 16th she was noticed to shed and swallow her skin. This I find is not an uncommon occurrence. October 19th she weighed 59.6 g., and was transferred to a dry earth aquarium. Here she made a hollow in the soft dirt under some leaves and seemed perfectly at home.

*These observations were made at Clark University during the year 1897-8.

It was interesting to see the way she made a hollow, or buried herself. She always used the same method, pushing the dirt to each side with her hind legs and shoving herself backward with her fore legs.

She was accurate in predicting changes in temperature, appearing very hungry, and after eating, burying herself completely before a decided fall in temperature. Before rising temperature she seemed less concerned about getting her food and would not cover herself completely, usually leaving her head out as though waiting for insects.

Plenty of grasshoppers and flies were kept in the aquarium, and she ate freely each day till November 1st, when a cold wave arrived and the room cooled off during the night. This time she buried herself completely. Neither did she again appear nor show signs of life till November 29th, when she slowly emerged. This may be spoken of as a short period of hibernation.

She was in and out almost every day after this, and on December 7th she ate three flies and 2.8 g. beefsteak. In regard to their eating, toads show the same peculiarity that frogs do, in that they will not attempt to take anything that is not in motion. In order to get the toad to eat meat I threaded a small piece on a string and twirled it before her. Her attention would first be attracted by the moving object, and after gazing at it for a few seconds she would quickly run out her tongue and take it. The whole process is almost instantaneous, and one can see but a flash of light red and hear the shutting of her mouth.

After eating this amount she refused to take any more, and buried herself, as I supposed, for another hibernation. But the next day she was out again and ate a fly. On the day following she ate 12 flies and 3 g. of meat. I continued feeding her every few days and, when hungry, she would eat frozen or stale meat and thrust her tongue at any near moving object. With the exception of cold "snaps," when she would remain covered up two or three days at a time, she showed no further signs of hibernation throughout the winter.

On February 14th she weighed 88.9 g. This shows that though there was a tendency to hibernate at first, it did not manifest itself again, for an animal loses weight during hibernation. February 20th she weighed 97 g., showing a gain of 8.5 g. in six days. This rapid increase in weight was probably due to the nutritive diet of beef and to the rapid secretion of eggs.

March 2d she remained several hours in the water, and I have no doubt that she would have deposited her eggs if she had had a mate. At this time her weight was 104.7 g. Her appetite always appeared good, and though I had only meat to give her for two months, she usually took some whenever it was offered her. She always knew when she had enough meat, in fact was never very eager to take it. But with flies she was gluttonous, became excited and eager, and always had room for one more, as shown by the following day's record.

I confined a large number of flies in the aquarium with her. When she heard and saw the flies buzzing about she became very much excited and nervous, and immediately began hopping about and catching them. When thus excited, the long toes of the hind feet always had a peculiar twitching, while the remainder of her body would be comparatively motionless. It was interesting to see how rarely she missed her aim and how rapidly she ate them. At first she averaged about four per minute. Being curious to know how many she would eat, I watched and counted. When she had eaten 40 her rate began to slacken, though she was still anxious and would approach nearer when a fly was beyond her reach. At 50 she showed less energy in the chase. When 60 had disappeared she simply waited till they came within reach of her tongue, while about every third or fourth fly swallowed she would squirm and twist as though making room for one more. When she had eaten 76 I was called away. When I returned about an hour later the remaining 15 or 20 flies had disappeared. Some of these, however, may have been eaten by two or three small frogs that were confined in the same aquarium. One would think she would not want anything more soon, but the next day she was ready for more, and averaged about 40 flies each day.

The greatest weight she reached was 111.5 g. on a diet of meat and flies. It was also interesting to note that if, when she had eaten all the meat that she wanted and had begun to back into the ground, a fly with clipped wing was put before her she would quickly take it, or, if it should run out of her reach, would eagerly give chase.

One day I placed a medium-sized garter snake in the aquarium to see the effect. The toad was out and happened to be close to the side of the aquarium. As the snake crawled slowly toward her seeking a means of escape, her sides began to swell out while she slowly turned her broad back toward the snake. This made her resemble a clod of dirt more than a toad. Evidently she knew that flight was useless and, as a place of concealment was not at hand at that late moment, her safety lay in protective coloration and in resembling a toad as little as possible.

April 20th I placed a male of the same species in the aquarium, thinking she would lay her eggs, but she would have absolutely nothing to do with him. As there seemed to be no likelihood of further development I changed them to a small park which I had prepared in a sunny part of the yard. It was mainly composed of sod, but in one corner was an area of soft earth, while in the center was a large pan of water. Here they mated at once and spent the greater part of two days hopping about, resting part of the time in the water. May 12th they buried themselves completely in the soft dirt to await the passing of a cold wave. When the cold wave had passed they emerged and the mating ceased without the deposition of eggs.

Among the things the toad was observed to eat during her captivity were ants, flies, grasshoppers, bees, wasps and many other insects which found their way within her reach. The eating of bees and wasps was followed by no ill effects except a momentary twisting or wincing. By far the greater part of her food consisted of flies and ants. These are household pests, and since the toad will average 40 or more each day it is needless to say that it is a very useful animal and one that should be protected.

The Methods and Extent of the Illinois Ichthyological Survey.

By Thomas Large.

At the present time the Natural History Survey of the Illinois State Laboratory of Natural History is working on an extensive report on the Fishes of Illinois. This is a continuation of the work begun in 1878 and carried on with many interruptions since that time by Prof. S. A. Forbes and his collaborators. It is the purpose to have every fish known to occur within the State accurately described, with complete statement of all that is known concerning food, habits and breeding, and to have the geographical distribution indicated on maps. In addition to this it is the purpose to illustrate each species with colored plates reproduced from water-color drawings of living fish. The number of species occurring is in the neighborhood of two hundred.

At present several lines of work are in progress: At the Biological Station on the Illinois River, located in the past two summers at Meredosia, aquaria were fitted in the floating laboratory and a gasoline engine and pump on the shore made to furnish clear water in which colors of living fish were studied for color descriptions and were painted by the laboratory artists. The field work for the geographical distribution has been pushed forward by means of wagon and launch expeditions and by volunteer collectors. The launch has not been used sufficiently for extended excursions to make the experience of value to others. With the wagon two men were in the field for six weeks in the fall of 1899, making collections in the Big Vermillion and Kaskaskia rivers and their tributaries. In 1900, with the advantage of the experience of the previous year, an expedition was fitted out to make collections in eastern Illinois, with Golconda on the Ohio River as the objective point, and returning to Urbana, the starting place, through the western and central portion of the State. The equipment consisted of an ordinary covered grocer's delivery wagon and two horses, a 9x9 miner's pyramid tent, woolen blankets, a blue-flame oil stove, an aluminum cooking outfit, a supply of groceries and canned meats, five large milk cans for shipping collections home, "hand-cans" for killing specimens as soon as taken, a ten-foot minnow seine hung to fish three feet, a thirty-foot minnow seine hung to fish five feet, and a forty-yard minnow seine hung to fish six feet. The Baird nets are not serviceable in the muddy streams of Illinois, as the bag collects too much mud. The party, consisting of two men who had had experience in such work, made no attempt to secure accommodations from farmers more than horse feed and water, experience of the previous year proving it to be very expensive in time and temper. Occasionally stops were made at hotels. The entire distance covered was about six hundred miles, in six weeks' time. The cost of subsistence in field, including some repairs, was about ten dollars per week.

In preserving fish the laboratory uses 10 per cent. formalin solution for killing, in which the fish is put as soon as taken from the water. In this the fish die with fins expanded. After remaining a few hours in this solution they are wrapped in cheese-cloth and transferred to a weaker solution (about 1 per cent. to 5 per cent.), for shipment. After being brought into the laboratory they are bottled in a solution consisting of 70 parts

95 per cent. alcohol, four parts glycerine, one part of formalin, and twenty parts of water. In this solution preservation is secured without the brittleness resulting from high per cent. alcohol.

The method of this institution in caring for collections may prove valuable to those interested in museum methods. Each catch is kept separate and given an accessions number referring to all data concerning it, which is entered in an accessions catalogue. The species are then separated and bottled, with tags (similar to those attached) on the outside and inside of the bottles.

Ac. No. Sp. No. Jor. & Ev. No.	**Ac. No.** **Sp. No.** **Jor. & Ev. No.**

Those on the inside are made of ledger paper and written with lead-pencil; those for the outside are written with India ink. The tags bear accessions number, a number referring to the species list of the laboratory, and a number referring to the species number in Jordan & Evermann's "Fishes of North and Middle America." All bottles containing a particular species are racked together in series according to accessions number and placed in shelves. The racks used are wooden trays of two sizes, the larger 4½x15 inches and meant to be wide enough to hold a two-quart fruit jar. The smaller are for vials and small bottles, and are 2x13 inches. This arrangement is exceedingly convenient for ready reference to any particular fish desired.

The plan of securing collections from volunteers in localities from which materials were needed for study of geographical distribution, was put in operation in April, 1900. It commends itself because of excellent results secured and the comparatively light cost. Letters inviting co-operation were sent to high school teachers and others, in localities that had not already been covered by field work. To those responding were sent two pairs of hip boots, a twenty-five foot minnow seine, a five-gallon milk can and a quantity of formalin, with directions for catching, labeling and preserving. In return for the service each collector receives a named set of the fishes from his locality. As a result of the volunteer work of the spring and summer a large triangular area lying between the Illinois and Mississippi rivers as far north as a line from Peoria to Rock Island was quite thoroughly worked, besides several other localities. Some collectors made collections representing entire counties.

Additions to the Indiana List of Dragonflies with a Few Notes.

By E. B. Williamson.

ADDITIONS.

1. *Calopteryx aequabilis* Say. Whiting, Lake County, June 9, 1900, along a ditch which drains into Calumet River, one male; and Wolf Lake, Lake County, July 21, 1900, two males. Clarence C. Bassett.

2. *Lestes eurinus* Say. Elkhart, June 8, 1900, one female. R. J. Weith.

3. *Enallagma calverti* Morse. Lake Maxinkuckee, May 27, 1900, two males, one female. Howard North.

4. *Nasiaeschna* (*Aeschna*) *pentacantha* Rambur. Banks of St. Joe River, Elkhart, June 10, 1900, two females. R. J. Weith.

5. *Aeschna multicolor* Hagen. City limits, Elkhart, September 5 and October 12, 1899, three females, one identified by Dr. Calvert. R. J. Weith.

6. *Sympetrum albifrons* Charpentier. Bluffton, Indiana, September 9, 1900. E. B. Williamson.

7. *Libellula exusta* Say. Woods near Simonton Lake, May 15 and 20, 1900. R. J. Weith.

The State list now numbers 91 species of Odonates. Four of the above additions are due to Mr. Weith, who has also added several species, known from other points in the State, to his local list. Collections are being made at Lake Maxinkuckee, Winona Lake, Evansville, and perhaps at other points, so further additions to the list may be expected, and our knowledge of seasonal and geographical range within the State is certain to be augmented. Descriptions of two of the species mentioned above are unfortunately not found in "The Dragonflies of Indiana." They are given in the notes which follow.

NOTES AND CORRECTIONS.

1. *Enallagma calverti* Morse is of the color type of *En. doubledayi* Selys. The male may be recognized by having the superior abdominal appendages much shorter than the inferiors, in profile appearing like a short cylinder with a rounded apex which is usually distinctly notched below the middle. Mr. Morse's original description of the male of this species follows: "Abd. 23–25mm., hind wing 17–19.5mm. Prothorax greenish black, the following pale (bluish): sides; a transverse line on anterior lobe; the hind margin and a cuneiform spot on each side of

posterior lobe. Thorax with a rather narrow mid-dorsal stripe (sometimes divided by a mere line of blue, most distinct anteriorly), and a very narrow humeral stripe, wider in front, especially at the suture, and a spot on second lateral suture, black. A wide ante-humeral stripe, equal to or wider than the mid-dorsal black stripe, blue. Abdomen blue, the following black: A spot on base of 1; a transverse lunule (convex side forward, doubly concave behind) near apex and a narrow marginal band on 2; an apical spot connected with marginal band on 3 and 4; apical third of 5, two-thirds of 6, five-sixths of 7, and all of 10.

"Superior appendages short, one-fourth to one-third as long as 10, blunt, with the apex directed downward and slightly notched in profile; the upper limb thick and rolled inward, the lower limb thin, rolled inward and upward, appearing like a small, rounded, inwardly projecting shelf on the lower edge of the apex of the appendage. In profile the upper apical angle is very obtusely rounded, the lower slightly notched. Inferior appendages longer, two-thirds as long as 10, rather slender, tapering, slightly curved upward, directed upward and backward, the lower margin convex throughout." Nevada, Wyoming and other western States, and Massachusetts. This is an interesting addition to the list of *Enallagmas* known to occur in Indiana, bringing the number to thirteen, and leaving two regional species, *doubledayi* and *aspersum*, yet to be discovered.

2. *Ischnura kellicotti* Williamson sometimes has the blue ante-humeral stripe of the thorax interrupted as it is normally in *Nehallennia posita* and rarely in *Ischnura verticalis* and *Enallagma germinatum*. Individuals were taken which had the stripe continuous on one side and interrupted on the other. The species was very abundant at Shriner, Round and Cedar Lakes, July and August, 1900, found only about the white water-lily beds. Orange females were numerous.

3. Dr. Calvert has recently called attention to the fact that *Gomphus externus* as identified by Kellicott and as described in "The Dragonflies of Indiana," is in reality *Gomphus crassus*. What is said of *Gomphus externus* on pages 289 and 290 of "The Dragonflies of Indiana," excepting geographical range, belongs to *Gomphus crassus*. *Gomphus crassus* is known from Kentucky, Ohio, Indiana and Illinois. *Gomphus externus* has been taken in Illinois and westward in Nebraska, New Mexico and Texas. It must be dropped from the Indiana list, though it may be found in the State in the future. It may be separated from *fraternus* and *crassus* by the following points: In *externus* the two lateral thoracic stripes are complete, not shortened or interrupted. *Externus* has the dorsum of 9 and 10 with a yellow band as usual in *crassus*. The appendages of the male of *externus*, as figured in the "Monographie des Gomphines," plate XXI, fig. 2, as seen in profile, somewhat resemble fig. 20, plate VI, "Dragonflies of Indiana," excepting

that they are more acute and the lower edge is less angular. The vulvar lamina in *externus*, as in *fraternus*, is not constricted at the middle as it is in *crassus*. In *externus* the lamina is bifid for almost half its length; in *fraternus* it is bifid for scarcely more than a fourth of its length. *Fraternus* and *externus* are about the same in size.

On page 285, "Dragonflies of Indiana," the references should be to plate VI, and not plate VII, as there printed. Line 17 from the bottom, same page, for *Abdomen about 40 in length.* EXTERNUS, read *Abdomen about 38 in length.* FRATERNUS.

4. In "Occasional Memoirs of the Chicago Entomological Society," Vol. I, No. 1, March, 1900, pp. 17 and 18, Mr. James Tough has described and figured the appendages of the male of a very interesting species of *Gomphus* under the name of *Gomphus cornutus*. The author's description is quoted.

"Length, ♂, 55–57mm.; abdomen, 40–42mm.; hind wing, 32–33mm.

"Yellowish green, with black and brown markings. Face and occiput yellowish green, eyes posteriorly black above, yellowish below, occiput distinctly convex, notched in center and fringed with black hairs, vertex and antennae black. Prothorax black, with a geminate spot in center and a patch on each side, yellowish. Thorax yellowish green, except a narrow band, indistinct or absent anteriorly, on each side of mid-dorsal carina, also except humeral and antihumeral bands, and margins of first and second lateral sutures, all of which are brown. Legs black, front femora yellowish green below. Wings hyaline with viens black, pterostigma yellowish, and costa yellowish green. Abdomen of uniform thickness, black, a dorsal stripe or spot on segments 1–8, small and basal on 8, and a small quadrangular spot on 10, yellowish; dorsum of 9 entirely black.

"Superior appendages dull yellowish; seen from above, internal branches produced inward and backward until they meet, acute and spinose at tip; external branches short, rather broad, and tipped with a blunt spine. Inferior appendage, seen from above, slightly longer than superiors, spreading, the distance from tip to tip of outer extremities being more than twice the width of the tenth abdominal segment at base. From side view the internal branches of superiors are seen to bear a conical tooth about midway between base and apex; the inferior curving upward gradually and each branch bearing a curved spine at tip.

"Described from two male specimens, taken at Glen Ellyn, Du Page County, Illinois, one June 14, 1897, the other May 30, 1898."

Mr. Tough writes me that he thinks he has since taken the female of this species. The occiput is high, rounded, and in front is a triangular pyramid, its base bounded by the line between the vertex and occiput, and by lines drawn from the extremities of this line to the middle point of the posterior edge of the occiput. This species will very probably be found to inhabit Indiana.

5. *Gomphus pallidus* Rambur. St. Joe River, June 8, 1900, one female. R. J. Weith.

6. *Gomphus spicatus* Hagen. Elkhart, May 20, 1900. R. J. Weith. In plate VI, "Dragonflies of Indiana," figs. 18 and 19 will *not* serve to distinguish the males of *Gomphus spicatus* and *G. descriptus*. Seen from above the superior appendages of *spicatus* have a distinct median external tooth; *descriptus* has the appendages angulated beyond the middle, but there is no tooth.

7. *Gomphus sp.* Page 294, "Dragonflies of Indiana," is a new species soon to be described by Mr. Hine.

8. With a knowledge of the nymph of *Tachopteryx thoreyi* another arrangement of the genera of the Gomphinae than that employed in the "Dragonflies of Indiana" becomes desirable. The arrangement of genera of the Gomphinae as worked out by Selys in his "Synopsis des Gomphines" and culminating with his final "Note sur la classification" in the fourth addition to the Synopsis, may be employed here for the genera taken in Indiana. The genera would then stand in this order: *Ophiogomphus*, *Dromogomphus*, *Gomphus*, *Progomphus*, *Hagenius*, *Tachopteryx*, *Cordulegaster*.

9. The genus *Nasiaeschna* has recently been established by Selys (Természetrajzi füzetek, XXIII, 1900, p. 93) for the species *Aeschna pentacantha* Rambur. In the key to genera in "The Dragonflies of Indiana" *pentacantha* will run out to the genus *Epiaeschna*. The genus *Nasiaeschna* is distinguished from *Epiaeschna* by the supplementary sector between the subnodal and median sectors being separated from the subnodal by one row of cells (two rows in *Epiaeschna*), by having the face excavated, by the absence of a dorsal spine on abdominal segment 10 in the male, and by the superior appendages of the male being shorter and less dilated.

10. *Aeschna multicolor* Hagen. Calvert (Odonata of Baja California, p. 509) has the following paragraph relating to the range of this species. "*Distribution*. Mexico (Cordova, Baja California), California, Texas, Dakota, Colorado, Yellowstone, British Columbia (Victoria)." In Bull. Geol. Surv. Terr. 1875, p. 591, Hagen says of it, "A decidedly western species." To find it in Indiana is a surprise. The following description is found in the Syn. Neur. N. A., 1861, p. 121. "Fuscous, spotted with blue, head blue (♂) or luteous (♀), front with a T spot, each side terminated with yellow, and a band before the eyes, black; thorax fuscous, dorsum each side with a stripe (interrupted or absent in the female), sides, each side with two oblique ones blue (♂) or yellow (♀); feet black, femora

rufous above, the apex black, anterior femora beneath, luteous; abdomen moderate, slender, cylindrical, narrow behind the inflated base; fuscous, spotted with blue (♂) or yellow (♀), segments 3–10 with two large, apical spots, segments 3–8 with two triangular spots upon the middle, and a basal, divided spot each side, segment 2 with a medial interrupted fascia, and a broad apical one, blue or yellow; superior appendages of the male black, long, foliaceous, narrow, the base narrower, inwardly carinated, straight, curved inwardly before the apex, an elevated triangular lamina above, and a longer tooth placed more inferiorly; the apical tip acute, curved downwards; the inferior appendage, pale fuscous, one-half shorter, elongately triangular; appendages of the female moderate, fuscous, foliaceous, broader; wings hyaline, those of the female towards the apex, subflavescent, pterostigma short, fuscous, or luteous (♀); membranule fuscous, the base white; 16–17 antecubitals; 8–9 postcubitals. Length 65–67 mm. Alar expanse 90–100 mm. Pterostigma 3–3½ mm." Calvert (Odonata of Baja California, p. 503) describes the superior appendage as having the apex distinctly forked when viewed in profile. "Front wings with discoidal triangle 4–6-celled, internal triangle 2-celled, rarely free, 3–4 other median cross-veins, 1–2 supratriangulars, first and sixth or seventh antecubitals thicker. Hind wings with discoidal triangle 4–5-celled, internal triangle 2-celled, 2–3 other median cross-veins, 1–2 supratriangulars, first and fifth or sixth antecubitals thicker. Male: anal triangle 3-celled; 10 with a small, median, basal, dorsal tooth and a smaller one on each side. Abdomen ♂ 47–51, ♀ 49. Hind wing ♂ 43–47, ♀ 45–47." (Calvert, Odonata of Baja California, p. 508).

11. *Didymops transversa* Say. Simonton Lake, May 15 and 20, 1900; and St. Joe River, Elkhart, May 29, 1900. R. J. Weith.

12. *Epicordulia princeps* Hagen. St. Joe River, Elkhart, July 7, 1900. R. J. Weith.

13. Males of *Sympetrum rubicundulum* and *Sympetrum obtrusum* exhibit but little difference in coloration. *Rubicundulum* has the face light brown, yellowish, darker above; *obtrusum* has the face white. The general body color of females of the two species is distinctive. *Obtrusum* and *rubicundulum* seem specifically distinct for the following reasons: both sexes offer differences in color and structure; they occur together, often in the same isolated swamp; and there seem to be no intermediate forms. On September 9, 1900, *obtrusum*, *rubicundulum* and *albifrons* were associated together in a small swamp surrounded by woodland in Wells County, near Bluffton. At a glance both sexes of *albifrons* may be recognized by the face, white below, shading above into a clear china blue, the frontal vesicle being of the same color.

14. The genus *Diplacodes* is distinguished from related genera: by the triangle of the fore wings long and narrow, free (usually) and followed by two rows of post-triangular cells (three or four rows in related genera); and by the last antenodal not continuous. *Diplacodes minusculum* could *not* be traced out by the key to genera, "Dragonflies of Indiana," p. 250. The hind lobe of the prothorax in this species is narrower than the middle lobe, sides straight, but with the hind margin emarginate, giving it a bilobed character. The supratriangular space is free and there are eight antecubitals in the front wings. In the arrangement of the genera in the "Dragonflies of Indiana" *Diplacodes* may be placed between *Pachydiplax* and *Nannothemis*. Old males of *Diplacodes minusculum*, like old males of *Nannothemis bella*, are entirely pruinose.

Eskers and Esker Lakes.

By Charles R. Dryer.

(Published in full in Journal of Geology, Vol. IX, p. 123.)

(Abstract.)

(1) The sand, gravel and till ridges around High Lake, Noble County, Indiana, with their associated lakes and kettleholes, are described and their structure and origin discussed. The till ridge is thought to be a frontal moraine, the others to be the result of subglacial drainage and the sliding or dumping of drift material into crevasses. These forms are so connected in space and related in structure as to render genetic classification difficult. The system as a whole constitutes an esker-kame-moraine.

(2) The esker system of Turkey Creek, Noble County, Indiana, is described. These sand ridges traverse the valley floor and nearly inclose the basin of Gordy's Lake. High and Gordy's lakes seem to constitute a distinct species for which the name *esker lakes* is proposed.

The paper is accompanied by two maps.

Spy Run and Poinsett Lake Bottoms*.

By J. A. Price and Albert Shaaf.

Spy Run and Poinsett Lake are located near Fort Wayne, Indiana, and to understand their history a knowledge of the region about Fort Wayne is necessary. This region is situated in that portion of the State which was formerly covered by the Erie ice-lobe. At different periods in its recession the end of the Erie ice-lobe was stationary, for a long time depositing large terminal moraines. Four of such moraines were thus formed, upon one of which, the first Erie moriane, Fort Wayne is located.

The territory in question lies on the first Erie moraine, a full description of which may be found in the Sixteenth, Seventeenth and Eighteenth Annual Reports of the State Geologist, and in Charles Dryer's "Studies of Indiana Geography." This moraine, a massive, well defined ridge with a hommocky surface, enters the State at the southeast corner of Adams County and follows the Wabash River to the northwest corner of Wells County, running parallel to the present shore line of Lake Erie; it then turns to the north and northeast and enters the southwest corner of Allen County. Increasing in width, it continues in a northeasterly direction and leaves the State at the northeast corner of Dekalb County.

As the ice continued to recede a large lake was formed northeast of the present site of Fort Wayne. The surplus waters of this glacial lake were drained into the head waters of the Wabash through the Erie-Wabash channel. Glacial Maumee Lake, as it was called, probably existed for many years, but as its eastern bank was a massive wall of ice it was doomed to destruction. As the ice melted the lake was slowly drained until it was entirely destroyed, and as the waters of the lake ebbed away its outlet dwindled and was finally silted up. St. Joseph and St. Mary's rivers, which had emptied at the point where the Erie-Wabash channel left the lake, now turned back and formed the Maumee, a slow, sluggish, meandering stream which wound itself across the old lake bottom.

The territory covered by the accompanying map lies about one and a half miles northwest of Fort Wayne, and north of the Wabash-Erie

*Credit is due Robert Feustel for his work on the accompanying map.

channel and west of the St. Joseph River. The Lake Shore and Michigan Southern Railroad passes along its eastern and the Grand Rapids and Indiana road along its western edge. It is crossed by two wagon roads, the Lima and the Goshen. Both basins are oblong, Spy Run Lake basin being about four-sevenths of a mile long and two-sevenths of a mile broad, Poinsett Lake basin being about one mile long and one-half of a mile broad.

The topography in general is smooth and level, with gentle swells here and there, characteristic of lake bottoms. The region is drained by Spy Run Creek and its tributary, the Poinsett. Numerous artificial channels are led into these streams which make the drainage more perfect. Where these channels do not occur, swamps are found as indicated on the accompanying map.

The origin of Poinsett and Spy Run lakes dates from interglacial times. These two lakes belonged to a large class of lakes which once diversified the surface of parts of the glaciated portion of the State, but which now have become extinct; irregular basins with rich soil and level bottoms remain to tell the story of their former existence. A number of these lakes were formed by glacial dams and may be divided into two classes: those produced by the irregular deposits of moranic material and those caused by the ice itself during the period of its continuance. It is quite probable that both of these causes united to form the two lakes under consideration. As the Erie ice-lobe withdrew to the northeast irregular deposits of glacial debris were left in its wake, forming knolls and basins; these basins were in the course of time filled by subsequent rains. The streams entering these basins may have been dammed by the ice front, when it occupied the position indicated by the lines *a b* on the accompanying map. The basins are enclosed at most places by rather steep banks, varying in height from ten to thirty or more feet. Between the basins and north of the stream the bank is low and gentle, running back for some two or three hundred yards. Indications of a shore line may be seen about half-way up this gentle slope, indicating a union of the two lakes.

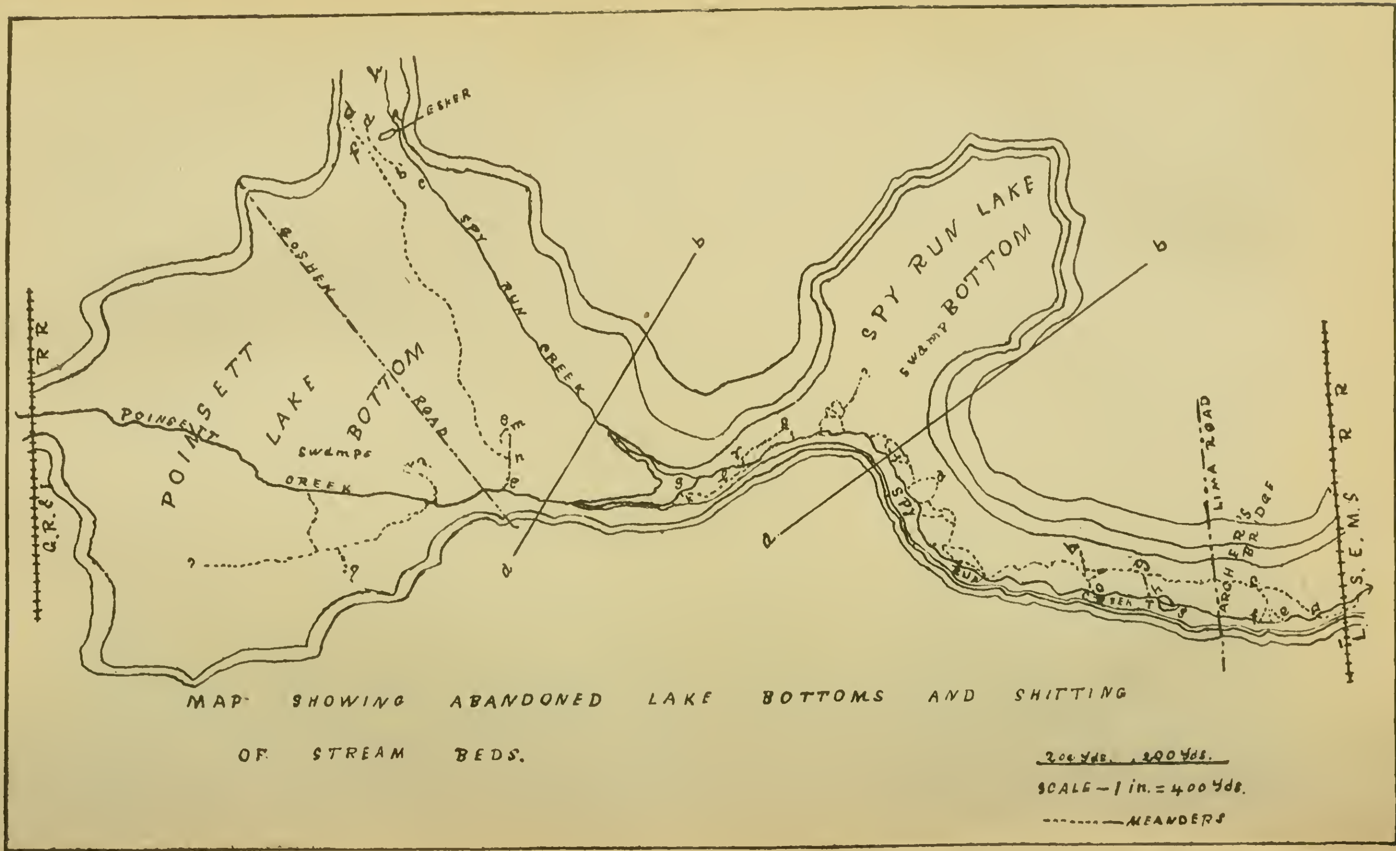
The length of time during which these lakes existed may be inferred from the depth of the silt which accumulated over their bottoms. The accumulation of this silt has made favorable the growing of crops. Man has taken advantage of these conditions and where it is not too swampy is cultivating the soil. This is only one instance where the former existence of glacial lakes has made favorable the conditions for man's occupancy. Maumee Lake basin, mentioned above, has a very rich soil, and yields some of the finest crops grown in the vicinity. Beyond the boundaries of our own State, and south of the line marking the farthest extension of the ice during the ice age, and south of lines marking periods of rest in its recession are many such basins; rivers were dammed, new lakes formed, and old ones enlarged, until to-day thousands of square miles of rich farming lands are found in the United States which would not otherwise have been here. The great wheat growing region and fine pasture lands of North Dakota are thus explained. "Such was the heritage which the great glacier of the ice age left as its parting gift, thus assuring the permanent prosperity of large and widespread regions of North America."

Abandoned Meanders of Spy Run Creek.

By J. A. Price and Albert Shaaf.

Spy Run Creek rises in the north central part of Washington Township, Allen County, and empties into the St. Mary's River, near Fort Wayne. It is a small, insignificant stream, but has, however, some noteworthy features, foremost of which is the marked shifting of its bed in and below Spy Run lake basin.

The head waters of this creek probably existed before the final retreat of the Erie ice lobe from the site of the first Erie moraine. The creek was dammed by the ice front, thus helping to form Spy Run Lake. The waters of the lake followed the ice in its gradual retreat and in this manner the lower extension of the creek was formed. At this time this part of the stream was probably much larger than at present. Its increased volume was due to the supply of water received from the lakes. It is impossible to say how long the stream was occupied in draining these lakes. At present, however, the stream has a well developed flood plain varying in width from two to three hundred yards. As a rule there are two or three annual overflows, during which time the waters cover a part or all of the flood plain. The depth of the water varies from six to eighteen or more inches. The strength of the current over the flooded area may be inferred from the fact that several years ago a rail fence



MAP SHOWING ABANDONED LAKE BOTTOMS AND SHITTING OF STREAM BEDS.

crossing the bottoms was carried away. As the waters disappear from the flood plain very little sediment is left behind, owing to the fact that at this time the lower parts of the old lake bottoms are covered with water which serves as a filter. If this were not the case the old meanders that are now found on the flood plain would doubtlessly be filled up.

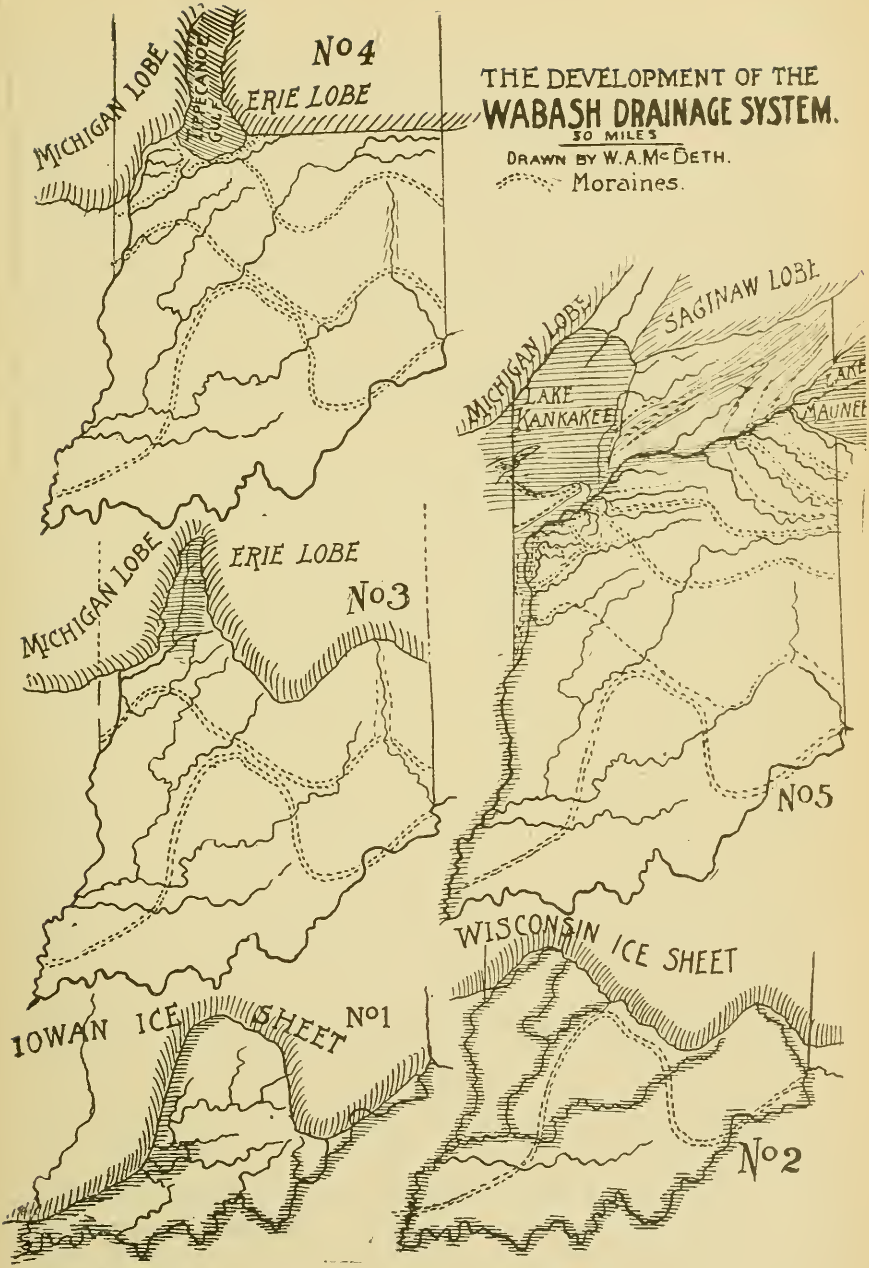
An inspection of the accompanying map will reveal the complexity of these meanders. In Poinsett Lake bottom the complexity is less than in and below Spy Run Lake bottom. There is one long abandoned channel (*fe*) crossing the bottoms from north to south parallel to the present channel of the stream, and entering Poinsett Creek below Poinsett bridge. The north half of this channel is well defined, having a width of three to six feet and a depth of one to three feet. Its bottom and banks are covered with a heavy growth of underbrush. Its northern end gradually decreases and finally disappears; this may be due to the fact that this part of the basin has been longer under cultivation. One hundred and fifty yards south of the north end of channel *fe*, and twenty-five yards east, lies a portion of an old meander marked *ab*. This channel is probably younger than that part of *fe* indicated by *de*. The stream left the old channel at *d* and occupied *abcg*, a part of which, *cg*, is still occupied; channel *cg* has probably been straightened by man. North of *c* the present channel is artificial, cutting diagonally through the east end of an esker at *p*. This portion as far north as was examined seems to be very young. The channel through the esker is narrow, with steep sides about ten or twelve feet high. This esker is eight or ten feet high and about one hundred and twenty-five yards long; it was connected with the uplands at *p*. Channel *fe* connects with a short, crooked channel, marked *mn*, in the southeastern part of the basin. This channel marks the lowest part of the southeastern portion of the lake bottom and was probably the last part covered by the lake waters. This last fact is indicated by the crookedness and blind ending of the channel. Between points *e* and *g* there are two or three small meanders along Poinsett Creek not marked on the map. Two abandoned meanders are found between the lakes; one, *kl*, belongs to Poinsett Creek, and the others, *rs*, to Spy Run Creek. The former is very recent, the stream having been turned from its course by the artificial channel *kg*. Below point *l*, at the sharp turn in the creek, the bank on the east and convex side is steep and nearly perpendicular; on the opposite side a flood plain is developing. In the southwest part of Spy Run Lake bottom occurs a complex system of old channels which indicate the part of the lake last drained. This is further shown by the more or less swampy condition of this part. Below the lake bottom the system of meanders is so complex that it is impossible to trace out, with any degree of certainty, the different stages which occurred in the shifting of the stream bed. Along the north side of the flood plain there is an old channel which seems to be the oldest in the system. Near the south side, where the stream is now located, the channels are less obscured, indicating that the creek has shifted its position from north to south and suggesting that probably the complex system of meanders is due to this migration. A number of cross channels connect the old channel on the north with the present one. In developing this system of meanders the stream may have followed channel *abc*, leaving it at *c* and entering its present channel, first at *d* and then at *e* and *f*. It then probably left the old channel at *g* and crossed to its present one by the cross channel *gh*, and at *b* by channel *bo*. Above this point the complexity increases, the meanders are smaller, with a greater number of cross channels. Four very young meanders lie south of the stream, one of which, *rs*, is at times occupied by part of the stream, forming a small island.

The Development of the Wabash Drainage System and the Recession of the Ice Sheet in Indiana.

By W. A. McBeth.

The development of the Wabash drainage system has now been worked out to such an extent as to show that it is not only a subject of interest in itself, but also has an important bearing on the question of the movement and recession of the North American ice sheet. The whole of the axial stream, except a few miles near its mouth and perhaps 30,000 of the 33,000 square miles comprised in its basin, were buried beneath the ice one or more times, and there is scarcely a tributary which does not show plainly the effects of the influence of the ice sheet in determining its course and its drainage area.

Along the line of the lower Wabash, the earlier ice approached within twelve or fifteen miles of the Ohio River, and almost to the limit of ice



THE DEVELOPMENT OF THE
WABASH DRAINAGE SYSTEM.
30 MILES
DRAWN BY W.A.McBETH.
Moraines.
No 4
MICHIGAN LOBE
TIPPECANOE GULF
ERIE LOBE
No 3
MICHIGAN LOBE
ERIE LOBE
SAGINAW LOBE
MICHIGAN LOBE
LAKE KANKAKEE
LAKE MAUMEE
No 5
IOWAN ICE SHEET
No 1
WISCONSIN ICE SHEET
No 2

movement the evidence of obstruction and readjustment appears. Near the southern limit of the drift the Patoka River is an example of a stream made up of several sections. Three northwestward flowing streams were obstructed in their lower courses by the ice, and compelled to seek westward outlets across divides along the ice border. The lower course of White River was also obstructed and the part within the unglaciated area ponded up in its deep valley through the Knobstone. In the main stream and in many of its tributaries temporary lakes were formed which overflowed over the ice or along the ice border.

West White River is conspicuously a border drainage line as far up as northern Monroe County, as shown in its course through Owen, Greene and Daviess counties.

The position of the Shelbyville moraine indicates that Raccoon Creek was in existence through half its length before the Wabash was uncovered north of Vigo County. Further recession northward brought Sugar Creek into existence. This stream is very distinctly of border drainage type, as shown by the prominent moraine along its north bank from its mouth to southwestern Clinton County. After further recession of the ice sheet Coal Creek took its way north of a region of morainic uplands, until it came against a strong north and south moraine which deflected its north branch in a great bend, remarkably like that of the Wabash. The part of this stream above its great bend is comparatively meandering and its valley, which is very shallow, is in marked contrast with the deep, broad valley below the bend. South Shawnee Creek runs west parallel with North Coal Creek and bends to the north within a mile of where this creek bends to the south. A broad, marshy valley connects the two bends, indicating that South Shawnee Creek formerly turned south. These creeks have their sources at the crest of the kame moraine, which runs northwest from Darlington, Montgomery County, toward Independence, Warren County, and are guided by moraines trending east and west. To the east of the Darlington-Independence divide, the streams flow northeast in a direction opposite to that of the Wabash. They are turned northwest into that stream by a moraine running southeast from a point about five miles south of Lafayette to the southeast corner of Tippecanoe County. The three forks of Wild Cat Creek coming from the east turn north along the western side of a moraine, which lies along the western edge of a till plain rapidly rising to the east. This moraine, in my opinion, is the strong outer moraine of the Erie lobe and marks the westward limit of Erie ice as a separate lobe. The Wild Cat creeks, above their northward bend, are bordered along their northern bluffs by weak, but distinct, moraines.

Returning to the Wabash, at the great bend we find it following the south side of a strong moraine from the mouth of Tippecanoe River to the point of its southward deflection. The drainage on the south side of the stream through this section was all to the south and west previous to the recession of the ice to the north side of the river. Above the mouth of the Tippecanoe the Wabash becomes probably a distinctly terminal drainage stream of the Erie lobe, and its tributaries have come into existence in pairs on opposite sides of the main stream as the ice withdrew toward its source. The head waters of the southern tributaries have in several instances been pirated by the stream to the south and west of them, as in the case of the deflection by the Mississinewa of a tributary of West White River north of Muncie, and the capture of the Salamonie by the Wabash above Ceylon. The development of these upper tributaries and the former connection of the St. Mary's and St. Joseph rivers and the glacial Maumee Lake with the Wabash by way of the broad valley of Little River extending from Ft. Wayne to Huntington have become familiar facts through the investigations made by Dr. C. R. Dryer and published in the Sixteenth, Seventeenth and Eighteenth Reports of the State Geologist of Indiana. The Tippecanoe River, after the manner of the upper tributaries of the Wabash, may be paired with the Wild Cat Creek. Below the great bend of the Tippecanoe, in Starke County, it drains the western edge of the Erie drift; above that bend it receives its water supply from the Saginaw drift. From its mouth to New Buffalo, ten miles north of Monticello, it has a deep valley (100 feet at Monticello) and varying from one-half of a mile to a mile in width. Above this deep portion, the character of its valley changes rather abruptly to a very narrow and superficial channel, not much too large to carry its flood waters. This shallow valley is remarkably meandering, much of the general course being originally guided by sand ridges. The lower portion of the Tippecanoe was evidently the former outlet of a lake of considerable extent, which covered the country north of Monticello. The earliest lake area may have extended southward to the immediate vicinity of the mouth of the river, where the strong moraine running along the north bluffs of the Wabash changes abruptly near the Tippecanoe battleground to a chain of low gravel mounds, which continue across Pretty Prairie, a gravelly terrace plain, a distance of three miles to the mouth of the Tippecanoe River. The crest of this moraine at the Soldiers' Home, four miles north of Lafayette, is higher than the surface of the plain at Monticello or Winamac, and the gap has the appearance of having been once the passageway for a large stream from the north. The part of the Tippecanoe from New Buffalo to the great bend is the newest part of the stream. It established its meandering course among the sand ridges along the eastern side of the lake bed and connected the part above the bend, which formerly flowed into the lake, with the part which was the lake outlet, giving an interesting example of a spliced stream.

The description of the development of the drainage of the Wabash system has been traced to the above extent in order to group its main facts together and bring them to bear on the question of the manner of recession of the ice sheet from its basin and some of those basins adjoining it.

Several writers on problems connected with the drift area seem to assume that the ice sheet could not have receded in any other way than from west to east. The Kankakee Lake, the western Indiana bowlder belts and various other problems are perplexing problems on this assumption. While in a general way the view is doubtless true that the recession was in this direction, the solution of several interesting points connected with Indiana drainage becomes simple by the acceptance of good evidence that in western Indiana the recession was from east to west.

The Michigan, Huron and Erie depressions were doubtless lines of southward and southwestward movement which became filled with ice and overflowed before the country between was invaded. Gradually the ice accumulated and covered the crests of the divides, becoming a confluent area with smooth, regular slopes on the surface, but conforming generally on the under side to the relief of the rock surface below. Valleys and low tracts of the preglacial surface would become lines of more rapid flow and the ice would move farther forward along these lines than elsewhere. The arrangement of the moraines in Illinois, Indiana and Ohio shows the influence of this lobate movement to the limits of the drift of any period.

The curving to the north of the glacial boundary in Indiana is easily explained by the stranding of the ice along the north and south belt of resistant rocks, including the Knobstone in that part of the State, while the lower regions to the east permitted the advance of the ice to the Ohio River, and on the west the ice crept south almost to the mouth of the Wabash in Indiana and nearly to the mouth of the Ohio in Illinois. The last general invasion sent ice much further south in Illinois than in western Indiana.

The recession of the ice was in general the inverse of its advance. It melted away on the divides, became differentiated again into lobes, which gradually withdrew up the depressions along their lowest lines. The evidence is abundant to show that the last ice sheet disappeared along a line running east of the Wabash River from Terre Haute through Crawfordsville to Lafayette before the region traversed by the present river below Lafayette was uncovered. Probably this interlobate melting continued northward along the line of the lower Tippecanoe and upper Kankakee into Michigan.

The evidence that the last ice in western Indiana occupied the region south and east of the great bend of the Wabash after it had receded from the country farther east is embraced in the condition and arrangement of numerous moraines, many overflow channels, and temporary lake beds with their traversing stream lines of different ages.

The moraines along Raccoon Creek, Sugar Creek, the southward flowing part of Coal Creek and the east and west ridges extending across Fountain County, together with a high, sharp, and in some places very narrow moraine running east from the town of West Point, Tippecanoe County, to a point five or six miles southeast of Lafayette, do not seem to have been overridden or much disturbed since they were laid down. They were deposited by ice from west and north of the present river line and according to their shape and trend, evidently by the Lake Michigan lobe. The heavy moraine north of the Wabash and west of the mouth of the Tippecanoe has not been overridden. It is a moraine of the Michigan lobe called, by Mr. Frank Leverett, the "Bloomington moraine," and extends twenty-five or thirty miles farther northeast than he has mapped it.* Moraines trending northwest and southeast in southern Tippecanoe County seem to be outposts of minor advances of the ice from the Erie lobe around the southern edge of the Michigan lobe. These ridges run across the line of division between the lobes and have numerous gaps through them.

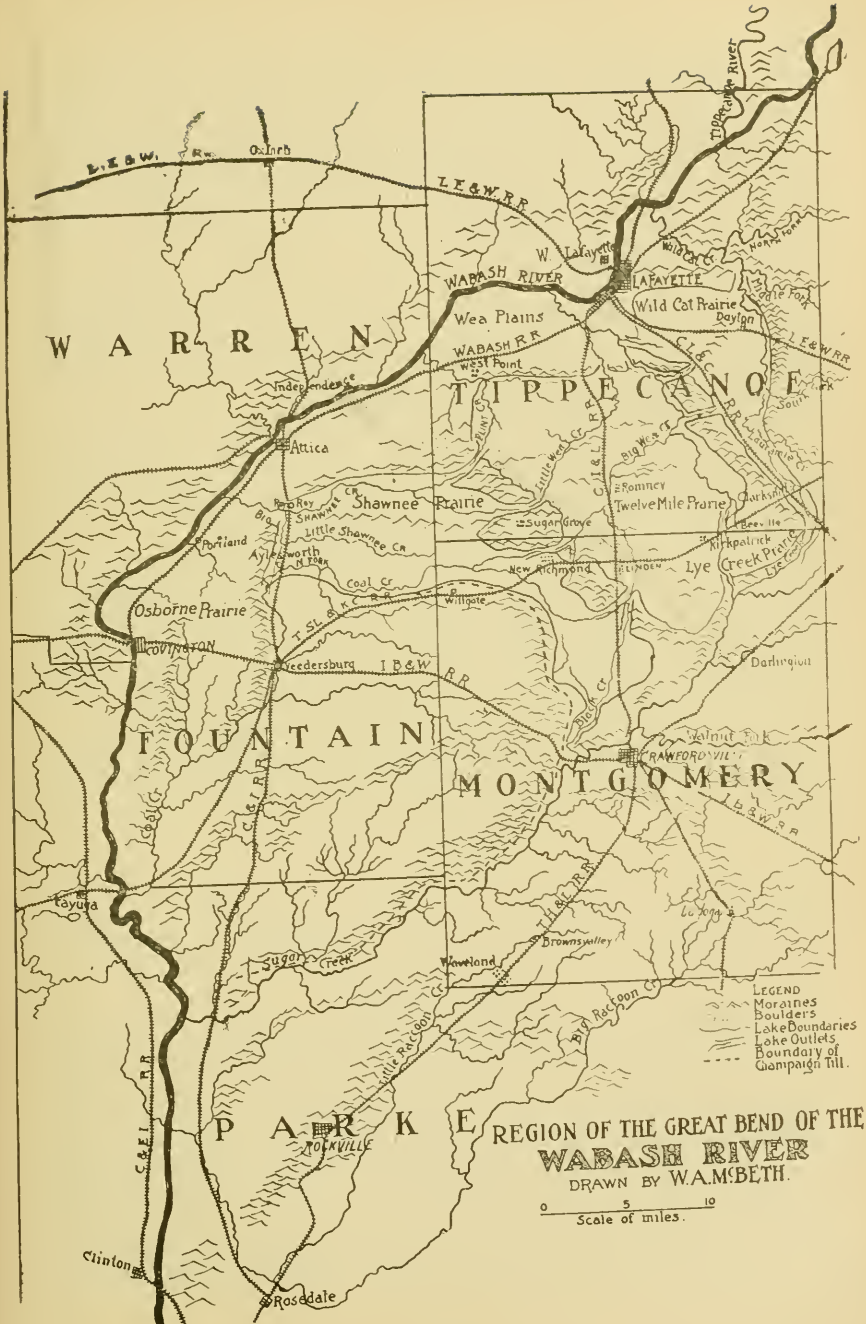
---

*See map pp. bet. 24–25, in his late U. S. G. S. Monograph XXXVIII on the Illinois Lobe.

These gaps and old channels are numerous and conspicuous in northern Montgomery and southern Tippecanoe counties particularly. Lye, Potato and Black creeks, flowing south into Sugar Creek, have their present sources at gaps in the divide to the north, where they approach in some cases within a few feet of the sources of streams flowing northeast and north into the Wabash.

A map and discussion of this region was presented to this body at its last winter meeting, and the points reviewed are referred to in connection with the present question of recession. The Independence-Darlington moraine has at least six overflow channels across it, from which the water formerly flowed south between this ridge and the eastern edge of what Mr. Leverett calls the "Champaign Till Sheet" in his report mentioned above. This till sheet approaches in the vicinity of New Richmond, Montgomery County, within a mile of the Independence-Darlington ridge, the space between showing long stretches of very fertile level prairies, doubtless the beds of former lakes. North Coal Creek now flows west along the northern border of this portion of the Champaign till sheet, to the great bend where it flowed against the eastern edge of the Michigan lobe and was turned south within six miles of the present line of the Wabash and compelled to make its way twenty-five miles to the south before joining it. South Shawnee Creek turned south then and joined Coal Creek at the bend through the marshy sag now connecting their abrupt elbows.

A comparison of the altitudes of these gaps with the altitudes of stations along the Cloverleaf Railway (T., St. L. & K. C.) shows very well the westward slope of the country along the divide between the streams flowing north into the Wabash and those flowing south into Sugar Creek. In the order of their occurrence from east to west the stations and their altitudes are: Clark's Hill, 818 feet; Beeville, 792 feet; Kirkpatrick, 787 feet; Linden, 783 feet; New Richmond, 776 feet; Wingate, 776 feet; and Aylesworth, at the bend of Coal Creek, on the C. & E. I. R. R., 644 feet. Aylesworth is 150 feet lower than Beeville and 130 feet lower than New Richmond. The water then must have been held in by a barrier approximating 150 feet in height to account for the overflow channels south along the eastern edge of the Champaign sheet. The altitude of the overflow channels toward the south would give the lake lying north and east of the divide a depth increasing with the northeastern slope to more than 100 feet at Dayton in eastern Tippecanoe County, whose altitude is 673 feet, as compared with 787 feet at Kirk-


WARREN
TIPPECANOE
FOUNTAIN
MONTGOMERY
PARKE
WABASH RIVER
LAFAYETTE
Wild Cat Prairie
Wea Plains
Shawnee Prairie
Twelve Mile Prarie
Lye Creek Prairie
Osborne Prairie
Attica
COVINGTON
Veedersburg
CRAWFORDSVILLE
Rockville
Clinton
Rosedale
Cayuga
Legend
Moraines
Boulders
Lake Boundaries
Lake Outlets
Boundary of Champaign Till.
REGION OF THE GREAT BEND OF THE
WABASH RIVER
DRAWN BY W.A.McBETH.
0 5 10
Scale of miles.

patrick or 776 feet at New Richmond. The recession of the ice from the present line of the Wabash removed the back wall from this arrangement of features and the gradual cutting down of the valley of the Wabash eventually drained the larger and several succeeding smaller lakes and permitted the establishment of the present drainage of southeastern Tippecanoe County.

It may now be said that an extension of the same process further north and the disappearance of the ice along the line of the Tippecanoe to its great bend, and along the upper Kankakee, while the ice still occupied the country to the west, would make quite simple the problem of Lake Kankakee and other temporary glacial lakes.

The arrangement of moraines along the north bank of the three forks of Wild Cat Creek together with the pirating of the heads of several southern tributaries of the Wabash indicates a comparatively rapid northward recession of the southern edge of the Erie lobe.

The region embraced in the Wabash basin still doubtless presents in almost every county interesting problems for the intelligent investigator who may care to look for them, and the facts and opinions here set forth are intended as suggestions to be verified or rejected by others or myself, after further investigation.

Note: In No. 3 and No. 4 of maps illustrating the development of the Wabash drainage system I have indicated the probable line of interlobate melting. I have suggested the name Tippecanoe Gulf for this reentrant area.

A Theory to Explain the Western Indiana Bowlder Belts.

By W. A. McBeth.

The proximity of the bowlder belt southeast of Independence, Warren County, to the moraine which parallels it a little distance to the west, is a marked relationship. The bowlders lie on and along the foot of the eastward slope of the moraine. Where the slopes are gentle the belt widens out, and on the abrupt slopes the width decreases and the bowlders are more numerous. There are also patches of them on the ridges and knolls that lie to the east at levels lower than the main divide. Bowlders are not infrequent anywhere in the whole of western Indiana, but are considerably more numerous in the belt than elsewhere. They are also more numerous about the eastern ends of the sags or low valleys through the Independence-Darlington moraine. They are very numerous in the valley of the Wabash at Independence where the belt crosses the river. Here in the lowest part of the valley, and on the terrace north of the river, they lie so thick over the surface that a man might cross a field stepping from one to another. The belt is not continuous, but there are gaps both south and north of Independence.

A number of theories to explain these bowlder belts has been proposed. The theory which was in some way suggested to Mr. T. C. Chamberlin, that they are beach lines, was dismissed by him with scant notice. His objections to the theory were that the slopes are all to the southwest and that there could be no ponding of great extent in front of the ice sheet. The general slope indeed is to the west, but the slopes on which the bowlder belts lie are eastward slopes. Further, the belts lie at the western side of areas that have been for considerable periods of time covered with water.

The belt southeast of Independence is conspicuously related to the western border of such a lake area. The belt northwest of the Wabash follows quite closely the western curve of the border of the south arm of Lake Kankakee, as mapped by Mr. Leverett.*

This belt is not necessarily or probably a continuation of the belt south of the Wabash River. Nor are the bowlders lying across the valley at Independence certainly to be correlated with the belts to the north and south. All the bowlders were probably deposited by floating ice, at the western shallow edges of the lakes, where bergs and floe ice would strand and drop their loads. They were deposited in the river valley at Independence while the river was at that point the outlet of an extensive lake held in the deep preglacial valley extending upstream to the mouth of the Tippecanoe River and of unknown width and extent. This lake has since been filled by gravel deposits, but bergs stranding about the outlet may have deposited the bowlders at the top of the terrace, and they have since dropped to lower levels as the valley was cut deeper. Reasons for believing that the ice sheet disappeared from the region to the east of the present southward flowing course of the Wabash and along the Tippecanoe River are stated in the article on "The Development

* In his Monograph on the Illinois Lobe, pages between 24 and 25.

of the Wabash Drainage System," in this volume. The westward wall of ice along this Tippecanoe Gulf helps to explain the laking which was due to the obstruction of drainage toward the west.

Commenting on the theory proposed, Dr. C. R. Dryer mentioned that the Iroquois Beach in New York is thickly strewn with bowlders in much the same way as the Indiana belts mentioned.

Aids in Teaching Physical Geography.

By V. F. Marsters.

Harper's Ferry Sheet.

The past decade has witnessed a growing interest in and a corresponding advancement along rational lines in geography, now justly regarded as a technical science. One of the pertinent reasons for this is that the seeker after knowledge, long before the college is reached, is becoming cognizant of the fact that the mere accumulation of geographical facts does not constitute geographical knowledge in the scientific sense. To know *where* the Blue Ridge is, is simply memorizing a *fact;* to know *what* it is, and, still further, to find out for one's self something about the sequential history of this topographic feature, constitutes *real geographic knowledge.* The former calls for observation and the sole exercise of memory; the latter demands that we not only accumulate facts, but that we seek a rational explanation of the facts observed. And just so far as we can see the relationships of the factors concerned in a geographical problem, and the role each has played in producing the observed results, to that degree have we gained real and useful scientific knowledge.

It was with this fundamental principle in mind that I have set about to prepare some geographical helps to attain this end. Any piece of apparatus such as a geological model, or map which properly expresses an evident relation between the geology or rock structure and the topography provides good material from which may be gained genuine geographical knowledge. Such material, however, is often in poor form and shape for laboratory use, and more often quite useless for lecture purposes, the scale being too small, or facts not well expressed. The material I describe below is intended primarily for use in lecture work. It consists of a lantern slide of a model representing a type of land form, and showing at once the relief of the land as well as the rock structure in two cross sections. With the picture of a model which brings out clearly the relations of structure to topography, and all the larger features of adjustment of drainage to structure, the lecturer can actually show up the facts as well as the arguments leading to his interpretation of the actual history of the land form discussed. Such details as could not be shown on ordinary maps may be clearly depicted by this method of illustration.

The data used in the construction of the illustrated model were gathered from the Geological Atlas sheets published by the United States Geological Survey. The area selected is that covered by the Harpers Ferry sheet. From the data therein contained, a model was constructed on the scale of one inch to the mile, vertical scale one inch to sixteen hundred feet.

The method used in the construction of the base may be aptly termed the contour method. The course of procedure was as follows: The topographic sheet was first enlarged to the desired scale. In the case of Harpers Ferry it was enlarged from two miles to the inch to one mile to the inch. The culture in addition to the topography was also transferred to the enlarged sheet and the whole traced on tracing cloth. The next step was to determine the vertical scale which would give the most expressive and yet close approach to the natural appearance of the topography when combined with a given horizontal scale. In the illustration selected it was found that sixteen hundred feet to the vertical inch gave the most effective result. Inasmuch, then, as the contour interval used on the topographic sheet was one hundred feet, and we wished to adopt in the construction of the model the scale mentioned above, it follows that sixteen sheets of strawboard, one-sixteenth of an inch in thickness, placed one upon another, would provide the vertical scale desired. This determined, each contour, beginning with the lowest, was then traced on separate sheets of strawboard, carefully cut out, piled in their proper succession and location, and tacked to a well seasoned wooden base or platform. The model at this stage presented a terrace-like appearance. This objectionable feature so often seen on geographical models, was easily obliterated by covering the entire surface with a sheet of clay, taking care of course to preserve as much of the details of relief as was shown on the original map. A plaster negative was next made from the original and from it a final positive was prepared. After thorough drying, the surface was painted a dead white. The partings or the contacts between adjacent formations as indicated on the geologic sheets referred to above, were carefully plotted and drawn on the white surface, in well defined black lines, sufficiently broad to be clearly photographed on a scale small enough to be transferred to a lantern slide. Before taking this step, however, another addition was made to the model. Two cross sections expressing the structural geology, one from east to west and the other from north to south, the former located on the south end and the latter along the east side of the model, were prepared. The outline of the topography along the respective sections was also traced on each section and cut out. These sections were then fastened to the end and side of the model in their proper vertical position, so that the relief, partings and structure were correctly correlated. The model was then photographed in a tilted position so that both sections could be clearly seen and the relief at the same time well expressed by obtaining moderately strong light and shade. It is especially important that the lines of contact be clearly brought out, as they determine the limits of the formations to be subsequently colored. A slide was next made from the negative and sent with a copy of the Harpers Ferry Atlas sheet to a photographic artist, with instructions to color the slide, adopting of course, so far as might be feasible, the same scheme of colors as appear on the geologic sheets.

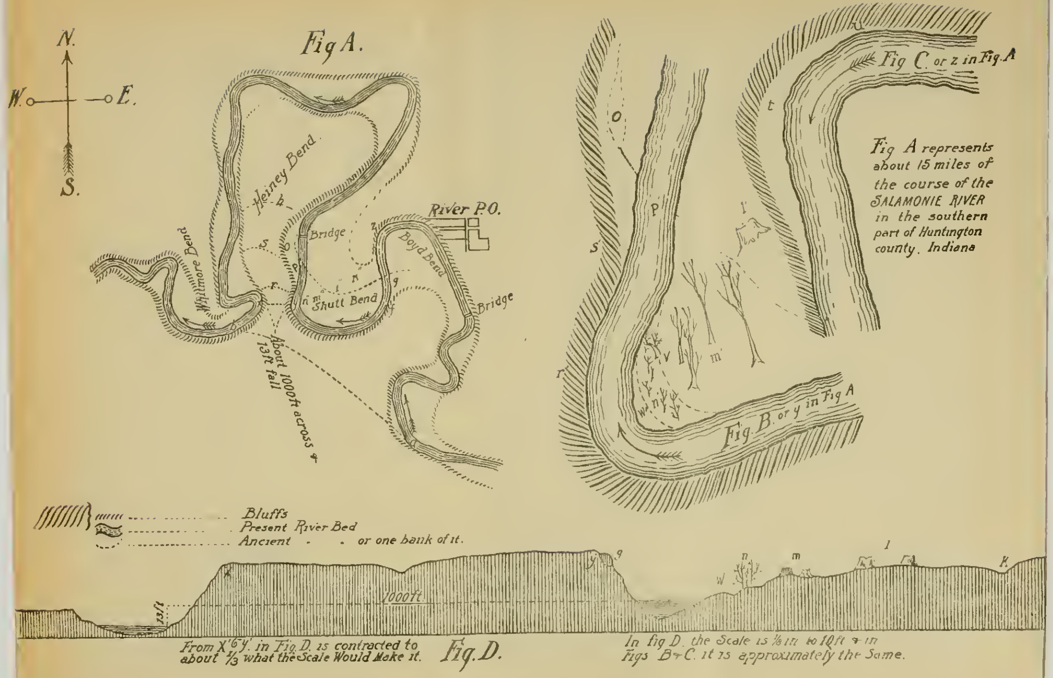


Fig A.
N.
W.
E.
S.
Heiney Bend
Whitmore Bend
Bridge
River P.O.
Boyd Bend
Shutt Bend
Bridge
About 1000ft across & 13ft fall
Fig C. or z in Fig. A
Fig. B. or y in Fig A
Fig A represents about 15 miles of the course of the SALAMONIE RIVER in the southern part of Huntington county, Indiana
Bluffs
Present River Bed
Ancient " " or one bank of it.
1000ft
13ft
From X' to y' in Fig. D. is contracted to about 1/3 what the Scale Would Make it.
Fig. D.
In fig D. the Scale is 1/8 in to 10ft & in Figs B & C. it is approximately the Same.

Use.—In conclusion it should be said that a trial of the first slide made it evident that the use of such illustrations would materially increase the facilities for teaching geography and increase the educational value of the work accomplished. Such material may not only help the lecturer to avoid technical description of features usually not illustrated at all, when simplicity of treatment is demanded, but with this aid he is enabled to show his class or audience a mass of facts upon which he bases his interpretation of the phenomena discusssed. By this means, the lecturer may even treat somewhat technical and involved problems so that they may be made easy to comprehend, and, most important of all, whatever geographical knowledge be absorbed, is properly attained through the exercise of observation, comparison and deduction. For just so far as the student subjects himself to such mental discipline, in the same degree does he acquire a scientific knowledge and the power of analysis that is lasting and of true educational value.

The picture attached below is a copy from the negative from which the lantern slide was prepared.*

River Bends and Bluffs.

By Wm. M. Heiney.

Bends and bluffs of rivers are interdependent. While under the universal river law of taking the course of least resistance, the embryonic bluff must first exist, the matured bluff is the product of the river's course. But, early the relation begins shifting, and the bend becomes the consequence of the bluff. Again, however, the bend batters down the bluff, so that the relations first attained are repeated.

The above propositions are verified by tracing the historical relation of the bluffs and bends in a very crooked section of about fifteen miles of the Salamonie River, found in the southern part of Huntington County, Indiana.

Fig. A represents the stream in its present course, with the bluffs and their connecting ridges, which define the territory over which the stream

---

*I will be glad to correspond with any person who desires to obtain copies of these slides for school or college collections. Others are being prepared.

has been shifting its course during the past few centuries. The dotted lines indicate the location of ridges, which when carefully traced are found to mark one or the other of the banks of the more ancient stream.

I will return to this after detailing some of the operations of the agencies which I have observed during the past quarter of a century.

At z, Fig. A (enlarged section, Fig. C), is a small tableland (t), which twenty to twenty-five years ago was broader and extended upstream five to seven rods further than it now does. In half a century more, at the present rate of erosion, the part of the tableland still remaining will all have disappeared, and what is now a well defined ridge will have become a bluff. Both the ridge and the tableland are covered with forest trees, while the bluff for a mile up the stream, and from the point of contact (u) of river and ridge, is barren, indicating constant and rapid weathering, and consequently a gradual northward movement of the stream bed. I shall return to this again after giving fuller observations of similar changes at the bend y, Fig. A.

This bend is best studied in Fig. B. More than twenty years ago I was familiar with the bar, n', lying under but upstream from the sycamore tree, v, which still stands. Then the bar, n' (see n, Fig. D), was the only one, and formed the river bank. It was of pure, washed sand and had no vegetation whatever growing upon it. It now has willow and sycamore trees five or six inches in diameter. Now, also, there is another bar (w' in Fig. B and w in Fig. D), which is the one bordering the river, of pure, washed sand and without vegetation.

These facts stimulated further investigation and furnished the key to deeper secrets. I examined the topography farther east and found a considerable elevation about forty feet wide (m' in Fig. B and m in Fig. D), and succeeded by a lowland; then, again, another rise, l (l'), extending eastward for two hundred and fifty feet, and in turn succeeded by a sink, better marked than any of the others (see k in Fig. D and k', Fig. A). Both these bear evidence of being former bars, and their relative ages are evidenced by the trees, which I have tried to indicate in my drawings, by trees and stump. Those trees which have grown upon m (m') are not larger than fifteen inches in diameter, while those upon l (l') were large forest trees, many three and four feet in diameter. This last is all cleared of its timber now and is a well cultivated field. In Fig. A, n'', m'', l''. and k' do not represent the correct relative distances. only relative position.

From f to y, Fig. A, is a barren bluff and gives evidence of the river bed's gradual southward movement, but at y (enlarged section of which is found in Fig. B) the westward movement of both bed and bluff is quite marked. Within the time of my own observation, I am certain that from twelve to fifteen feet of the bluff, which is some fifty feet in height, has disappeared. A year ago a mass of earth (see g in Fig. D) 6x8x30 feet dropped down five feet at the north end, but still clings to the surface at the south end. It is rapidly yielding to the elements, and two years hence no trace of it will remain. As this bluff moves westward the one at x is moving eastward at about the same rate of speed. Thus in the course of two thousand years will occur a phenomenon rarely found on this stream, i. e., a waterfall or rapid—a fall of thirteen feet in one thousand, and possibly a canyon, also.

Yet there will still remain enough bend to renew the northward movement of the channel and in time the highland of the "Heiney Bend" will disappear—the stream will bend far to the north—the bottom lands will lie south of the stream, with the adjoining bluff of the river on its north bank. The newly formed bottom lands will lie much lower than those of the "Sheet Bend" at present.

Now let us leave the present and future of the stream and go back to its past. Following the old bed as indicated by its right bank (the dotted line, pq, in Fig. A, and p′, Fig. B), and taken in relation with some sink holes (o in Fig. A and o′ in Fig. B), along the foot of the ridge, it is evident that the old bed crossed its present bed at p and q, and that the "Shutt Bend," which is extending itself southward, was once much smaller than now. This bend has been greatly eroded. It is considerably lower than its neighbor on the west, the south part of the "Heiney Bend," and as a consequence does not bear the remains of as ancient river beds as the latter. In Fig. B, I have endeavored to show the low places in the surface by shortening the lines which indicate the bluffs and ridges; thus r′ and s′ correspond with the dotted lines r and s in Fig. A, and doubtless locate the successive channels of the river before it settled down between the ridges and bluffs which bound its present immediate basin, or what the farmers term the "first bottom," more generally recognized as the "lower terrace." From the present topography it is certain that after the river left its channel, r, and before it took its present general course between the ridges, it crossed at s, and again at h. A far more ancient channel than any of these, however, is found from a to b. This rises on much higher ground at a and though not so well marked as the more recent channel its lower course, as it nears b, has become well emphasized by recent drainage of the adjacent country.

The stream will probably forage its way to all the bounding ridges and denude them—render them bluffs—before cutting its new channel, xy, when it will again leave them to weather themselves into symmetrical shapes, dress in forest verdure and present history as well as future possibilities, which speculation in this age is unable to suggest.

Notes on the Ordovician Rocks of Southern Indiana.

By Edgar R. Cumings.

The present paper dealing with the stratigraphy of the Ordovician of Indiana is preliminary to a more complete report on this interesting series of rocks, which the writer has in preparation. In the latter paper an extended discussion of the faunas of these rocks will be possible. At present the study of the large collections obtained is not sufficiently advanced to admit of any such presentation. It is therefore proposed to give here practically nothing but the notes taken in the field, with such supplementary remarks as may seem necessary.

The work of the Indiana University Geological Survey during the field season of 1900 covered the counties of Dearborn, Switzerland, Ohio and Jefferson. The following sections were measured and from most of them extensive collections were made:

Section in Kentucky opposite the mouth of the Miami River (5.9A):*

	Ft.	*In.*
51—Covered to top of hill	112	..
50—Fragments of Strophomenoid shells	..	7
49—Shale	1	..
48—Limestone. Fragments of Brachiopods	..	6
47—Shale	1	..
46—Hard limestone with *Rafinesquina*	..	5
45—Shale	2	4
44—Limestone. *Rafinesquina* abundant	..	5
43—Covered, probably shale	17	6

* This section in Kentucky is given because it is the farthest east of any section showing exposures of rock to river level.

	Ft.	In.
42—Shale	2	6
41—Limestone	5	2
40—Shale with thin layers of sandstone	8	6
39—Limestone with Bryozoa and *Rafinesquina*	..	3
38—Mostly shale	10	8
37—Crystalline limestone. *Rafinesquina* and *Dalmanella*	9	..
36—Shale	2	3
35—Thin layers of bryozoal limestone	1	..
34—Shale	6	9
33—Bryozoal limestone	..	6
32—Shale	7	..
31—Limestone, shale at top. *Dalmanella* (aa)	..	7
30—Covered	42	..
29—Compact highly crystalline limestone; few fossils	..	3
28—Shale	2	9
27—Highly crystalline limestone containing fragments of *Asaphus*	..	7
26—Shale	..	5
25—Compact limestone containing *Dalmanella*	..	5
24—Covered, probably some limestone	16	..
23—Brachiopod limestone (?)	..	4
22—Covered	8	4
21—Limestone. *Rafinesquina* and Trilobites	..	3
20—Shale	6	4
19—Covered (probably shale)	16	..
18—Limestone (in place?)	..	6
17—Shale	10	8
16—Limestone. Bryozoa, *plectambonites*	..	3
15—Shale	1	..
14—Limestone. *Balmanella*, *Plectambonites*	..	2
13—Shale	..	7
12—Sandstone	..	3
11—Shale	2	9
10—Limestone with *Dalmanella*	..	3
9—Shale, possibly some sandy layers	5	..
8—Hard compact limestone, very few fossils	..	5
7—Shale	6	..
6—Layer of crystalline, crinoidal limestone	..	..
5—Partly covered, mostly shale	33	..
4—Sandy layer with *Trinucleus concentricus*	..	1
3—Shale	5	4
2—Limestone containing *Dalmanella* (aa*)	2	3
1—Shale to level of Ohio river	6	2
Total section	361	..

* a, abundant; aa, very abundant; c, common; r, rare.

In the high hill just south of Aurora the rocks are exposed as follows (§1.35 A):

	Ft.	In.
45—A few layers at the top contain *Rafinesquina*, the remainder covered	60	..
44—Limestone with *Platystrophia*, *Hebertella*, *Rafinesquina*, *Monticulipora*, etc	16	..
43—Highly fossiliferous limestone. *Platystrophia*, *Hebertella*, etc	1	6
42—Shale with occasional layers of limestone	4	4
41—Limestone with *Zygospira* and Gastropoda	3	4
40—Limestone. Rafinesquina (aa)	1	6
39—Shale	..	8
38—Same as 32	..	4
37—Covered	1	8
36—Coarsely crystalline highly fossiliferous limestone	..	2
35—Covered	6	10
34—Same as 32	..	3
33—Shale	1	8
32—Coarse-grained fossiliferous limestone, with yellow argillaceous material in streaks	..	8
31—Shale	..	6
30—Limestone. *Zygospira* and *Hebertella*	..	6
29—Shale and shaly limestone	1	3
28—Very fine grained compact limestone, no fossils	..	3
28—Shale	1	..
26—Limestone intercalated with shale	1	6
25—Shale	..	9
24—Sandstone	..	3
23—Covered	2	6
22—Coarse-grained, blue limestone, mottled with brown. Large thick-shelled *Rafinesquinas*	..	8
21—Shale	..	8
20—Hard blue crystalline	..	8
19—Covered	1	4
18—Limestone (in place?)	..	10
17—Covered, probably limestone	10	8
16—Steel-blue finely crastalline limestone with *Rafinesquina*	..	5
15—Shale	..	8
14—Shaly sandstone	..	3
13—Coarse crystalline limestone	..	8
12—Shale	..	6
11—Compact limestone, gray mottled with yellow	..	6
10—Shale	..	9
9—Compact fine-grained drab limestone. Few fossils	..	9
8—Shale	1	..

	Ft.	In.
7—Compact, hard, coarsely crystalline limestone containing *Rafinesquina*	..	7
6—Shale	..	10
5—Blue crystalline limestone. *Rafinesquina*	..	4
4—Shale	.	6
3—Crystalline limestone with *Rafinesquina*, *Platystrophia*, *Monticulipora*, etc	..	6
2—Talus with immense number of fossils	85	..
1—Covered to the level of the river. *Dalmanella* abundant in the loose pieces near the bottom	180	..
Total section	393	..

On the north side of Laughery Creek, opposite Hartford, the following section was measured: (§ 1.36 A.)

	Ft.	In.
34—To top of the hill, loose pieces of limestone containing *Platystrophia* and *Hebertella*	60	..
33—Thin bedded limestone	..	5
32—Covered	2	8
31—Same as 29	..	3
30—Shale	..	4
29—Limestone with argillaceous streaks	..	5
28—Covered	2	8
27—Hard compact limestone	..	4
26—Covered	..	8
25—Coarse-grained crystalline argillaceous limestone	..	4
24—Covered	..	6
23—Limestone containing Gastropoda and *Rafinesquina*	..	6
22—Covered	5	..
21—Same as 18	..	3
20—Covered	1	..
19—Same as 18	..	4
18—Limestone coarsely crystalline, light colored	..	3
17—Sandstone	..	3
16—Same as 14	..	2
15—Same as 14	..	4
14—Drab crystalline limestone	..	3
13—Covered	..	6
12—Same as 10	..	5
11—Covered	6	..
10—Thin-bedded crystalline limestone	6	5
9—Covered	1	4
8—Coarse crystalline limestone	..	6
7—Covered	..	6

	Ft.	In.
6—Coarse crystalline limestone	..	10
5—Covered	10	8
4—Same as 2	..	3
3—Covered	..	2
2—Very hard compact limestone. *Rafinesquina*	..	9
1—Covered to level of road	150	..
Total section	255	..

In the bluff on the north side of Laughery Creek, a little over a mile west of Milton, the following section was measured: (§ 1.36 B)

	Ft.	In.
18—To top of hill. *Platystrophia. Hebertella*, etc., in loose pieces	38	6
17—Limestone with *Platystrophia laticosta*	..	3
16—Covered	19	..
15—Same as 11	..	8
14—Covered	9	6
13—Same as 11	..	3
12—Covered	5	6
11—Coarse crystalline limestone, gray mottled with yellow	..	3
10—Covered	2	..
9—Thin-bedded limestone with *Rafinesquina*, crinoids, etc	1	2
8—Covered	4	2
7—Very coarse gray crystalline limestone. *Rafinesquina* (fragments) very abundant	.	4
6—Covered	43	..
5—Limestone with Bryozoa	..	6
4—Covered	48	..
3—Crystalline limestone with *Dalmanella*	..	6
2—Covered to road	43	4
1—Covered to creek level	20	..
Total section	237	..

In the north bluff of Laughrey Creek, one mile south of the mouth of Hayes branch, is the following section: (§ 1.36 C.)

	Ft.	In.
45—Covered to top of hill	40	..
44—Same as 43	10	..
43—Limestone with *Platystrophia* and *Hebertella*	1	..
42—Covered	5	6
41—Coarse crystalline limestone streaked with yellow. *Rafinesquina*	..	8
40—Partly covered. Limestone with *Rafinesquina*	12	6
39—Drab to bluish compact limestone, no fossils	..	8
38—Coarse gray crystalline limestone	1	4

	Ft.	In.
37—Covered	10	..
36—Coarse limestone streaked with yellow. Contains Bryozoa	1	6
35—Covered	4	..
34—Very hard compact limestone. Lower layer contains Brachiopoda and Bryozoa	..	3
33—Limestone containing large numbers of *Rafinesquina*	1	3
32—Covered	5	..
31—Coarse limestone. *Rafinesquina*	..	6
30—Covered	1	9
29—Limestone with layer of sandstone at the top	..	8
28—Covered	2	4
27—Limestone with Bryozoa and crinoids	..	7
26—Covered	1	4
25—Coarse blue limestone streaked with sandstone	1	..
24—Covered	1	8
23—Blue coarse-grained limestone with Brachiopoda and Bryozoa	..	4
22—Covered	..	6
21—Coarse-grained blue compact limestone	..	3
20—Covered	20	9
19—Coarse lumpy argillaceous limestone. Bryozoa	..	7
18—Covered	..	6
17—Very coarse, ferruginous, Bryozoal limestone	1	2
16—Covered	5	4
15—Yellow-mottled limestone. Bryozoa	..	5
14—Covered	5	..
13—Blue coarse limestone. Fragment of *Rafinesquina* very abundant.	.	5
12—Covered	1	2
11—Fine grained limestone. Bryozoa	..	6
10—Covered	3	4
9—Gray limestone with large white crystals of calcite. Many fragments of fossils	..	9
8—Covered	16	.
7—Coarse, crystalline, drab, unfossiliferous limestone	..	3
6—Covered	1	6
5—Thin limestones. Bryozoa very abundant	..	1
4—Coarse gray crystalline limestone. *Dalmanella* (aa)	..	5
3—Covered	22	..
2—Blue-mottled crystalline limestone	..	5
1—Covered	50	..
Total section	235	

Level of the creek.

Just south of the Weisburg station, in the bank of the creek to the west of the railroad, the upper layers of the Ordovician are exposed. From this exposure a large and very satisfactory collection of fossils was obtained. A section at this point is as follows (§ 1.34 A):

	Ft.	In.
15—A number of feet of barren limestones		
14—Blue compact fine-grained limestone. No fossils	1	..
13—Covered	5	..
12—Compact limestone. *Rhynchotrema capax*	..	6
11—Thin-bedded limestone	1	..
10—Very compact, fine-grained limestone	..	8
9—Calcareous shale with *Strophomena*	..	7
8—Limestone. Fragments of *Asaphus*	..	4
7—Shale	..	9
6—Limestone with *Hebertella*	..	3
5—Limestone same as 4	..	8
4—Blue limestone with *Rafinesquina* edgewise (aa)	..	3
3—*Rafinesquina* flatwise (a)	..	3
2—Shale	..	2
1—Coarse compact limestone, no fossils	..	10
Total section	12	

Level of creek below railroad culvert.

Continuing on down the creek from this point, the following layers are passed over (§ 1.34 B):

	Ft.	In.
4—Limestone	..	8
3—Irregular lumpy shale	2	6
2—Limestone and shale with *Rafinesquina* and *Hebertella*	1	4
1—Very coarse-grained limestone. *Rhynchotrema* (aa)	2	3

Down stream from this point no measurements were made, owing to the effect of rainy weather upon the barometer, but the characteristic fossils of the successive layers were noted. These are as follows from the last mentioned layer downward (§ 1.34 C):

16—*Plectambonites sericea* (aa).
15—*Strophomena rugosa* (aa).
14—Barren shale.
13—*Strophomena.*
12—*Streptelasma* (aa).
11—*Hebertella* (aa).
10—*Streptelasma.*
9—*Leptæna rhomboidalis* (aa).

8—*Dinorthis subquadrata* (a).
7—*Heberteila occidentalis* (a).
6—*Rafinesquina, Streptelasma, Platystrophia, Leptæna.*
5—*Rafinesquina, Monticulipora.*
4—*Dalmanella* (shaly limestone).
3—*Rafinesquina.*
2—*Asaphus, calymene. Rafinesquina.*
1—*Rafinesquina.*

Rafinesquina remains the dominant fossil for some distance farther down the creek, where its place is taken by the several varieties of *platystrophia biforata.*

No good sections of the Ordovician are to be found in the vicinity of Rising Sun. Numerous exposures of the various members may, however, be seen at a number of points. These exposures show that the lower members are, as in the other localities already studied, characterized by the great abundance of *Dalmanella* and *Plectambonites.* These fossils are succeeded in the beds next above by a number of species of *Trepostomata,* which in places completely fill the rocks.

Above the Bryozoa beds *Rafinesquina alternata* becomes abundant, though of course occurring in limited numbers at almost every level. Next follows the zone of *Platystraphia biforota* and its varieties. This is in turn succeeded in the tops of the hills by a zone in which a varietal form of *Rafinesquina alternata* is abundant, to the exclusion in places of almost every other fossil. The higher zones are not present in the vicinity of Rising Sun.

Vevay, in Switzerland county, is one of the best localities in the State for the collection of Ordovician fossils, and especially of the various forms of Platystrophia. Two detailed sections were measured at this place. These are designated A and B. Section A begins at the head of Main Cross street and extends up the little gully just east of the Orphan Asylum.

This section (A) is as follows (½ 1, 38 A.):

	Ft.	*In.*
87—Covered to the top of the hill	80	..
86—Limestone with *Platystrophia* and *Hebertella*	6	..
85—Yellowish argillaceous sandstone	..	4
84—Thin-bedded limestone containing *Platystrophia* and *Hebertella*	12	..
83—*Platystrophia biforata*	..	6
82—Yellow sandstone	..	4
81—Covered	3	3
80—Argillaceous arenaceous limestone	..	4
79—Some covered, mostly thin layers with *Rafinesquina*	14	..
78—Limestone with *Rafinesquina* and Bryozoa	..	5
77—Covered	3	8
76—Compact limestone with *Rafinesquina*	..	4

	Ft.	in.
75—Covered	..	6
74—Same as 72	3	8
73—Covered	1	3
72—Coarse-grained limestone *Zygospira Bryozoa*	..	4
71—Covered	3	..
70—Fine-grained limestone. *Zygospira*	..	3
69—Shale	..	6
68—Coarse limestone *Rafinesquina* (aa)	..	5
67—Covered	1	8
66—Thick, coarse, light gray limestone. Fragments of *Rafinesquina* (aa). *Zygospira* (c)	1	..
65—Thin-bedded light colored limestone. Bryozoa	8	..
64—Covered	6	..
63—Bryozoal limestone	..	6
62—Covered	..	8
61—Limestone. *Dalmanella* (aa)	1	2
60—Covered	8	8
59—Dark drab limestone. *Dalmanella*	..	4
58—Covered	2	..
57—Compact limestone with *Dalmanella* (aa)	..	7
56—Covered, probably limestone	25	..
55—Coarse limestone with large white crystals of calcite	..	6
54—Shale	..	6
53—Limestone, fragments of *Rafinesquina* (aa)	..	3
52—Shale	..	10
51—Limestone flecked with large flakes of calcite	..	3
50—Shale	2	8
49—Coarse grained limestone. *Dalmanella* (aa)	..	6
48—Shale	1	..
47—Limestone with *Dalmanella* and Bryozoa	..	3
46—Yellow weathering shale	2	..
45—Thin layers of limestone with *Dalmanella*	5	..
44—Shale	2	3
43—Layers of calcareous sandstone	..	6
42—Shale	3	..
41—Limestone	..	2
40—Shale	3	8
39—Crinoidal limestone	..	8
38—Shale	5	..
37—Bryozoal limestone in thin layers	2	6
36—Shale and thin limestone	2	6
35—Bryozoal limestone	5	..
34—Shale	2	..
33—Massive hard limestone. Fragments of *Dalmanella* and Bryozoa	..	10

	Ft.	In.
32—Thin limestone and shale. *Dalmanella*	2	4
31—Limestone. Very perfect specimens of *Dalmanella* (aa)	..	4
30—Shale	1	8
29—Limestone. *Rafinesquina* (aa)	..	7
28—Shale	..	8
27—Sandstone	..	4
26—Shale with thin layers of limestone	6	3
25—Dark crystalline limestone. Few fossils	..	4
24—Shale	5	4
23—Limestone. Crinoids. Bryozoa. Trilobites. *Dalmanella*	..	7
22—Shale	2	6
21—Limestone. Fragments of Trilobites and *Dalmanella*	..	3
20—Shale	..	7
19—Thin layers of limestone with intercalated shale	1	..
18—Shale	7	..
17—Limestone. Fragments of *Dalmanella*, *Rafinesquina* and Bryozoa	..	3
16—Shale	2	6
15—Same as 13	..	6
14—Shale	..	5
13—Compact Bryozoal limestone	..	3 to 5
12—Shale, with occasional layers of limestone containing stems of Bryozoa	6	4
11—Limestone spotted with argillaceous material and containing large Bryozoa	..	3
10—Shale with occasional thin lenticles of limestone	2	3
9—Thin layers of fine-grained compact limestone containing *Dalmanella* and Bryozoa	1	..
8—Shale	1	..
7—Limestone with argillaceons material in spots. Contains *Dalmanella*	..	5
6—Shale	4	..
5—Same as 3	..	10
4—Shale	4	6
3—Dark blue crytalline limestone. *Plectambonites* and *Dalmanella* (aa)	..	6
2—Blue clay shale	6	..
1—Covered to river level	101	..
Total section	389	..

Along the road (not the pike) running over the hill back of Vevay most of the rocks of section A are exposed together with *all* of the rocks represented by No. 87 (covered) of that section. The latter are very important, inasmuch as they include the greater part of the platystrophia beds, here ideally exposed for the collection of fossils. In fact several hundred specimens of this species were obtained, most of them in an excellent state of preservation. An exact record was kept of the layer from which each specimen came, thereby rendering the material of the utmost value for the study of variation.

This section (B) is as follows (§ 1.38 B):

	Ft.	In.
60—Heavy compact limestone. Few fossils	27	..
59—Shaly limestone with *Platistrophia lynx*. *Hebertella*, *Monticulipora*, etc., *P. laticosta* toward the top	49	..
58—Shaly limestone. *Hebertella* (aa) some *Platystrophia* and *Rafinesquina*	10	8
57—Shaly limestone. *Rafinesquina* and *Hebertella*	2	..
56—Thin argillaceous limestone	16	..
55—Limestone. Base of *Platystrophia* zone	..	3
54—Limestone	..	3
53—Limestone. *Rafinesquina*	2	10
52—Limestone with *Zygospira*	..	5
51—Limestone with *Rafinesquina*	6	4
50—Very coarsely crystalline gray white-spotted limestone	..	6
49—Sandstone	..	1
48—Crinoidal limestone with fragments of *Raf.* (aa)	..	4
47—Covered	7	..
46—Mostly limestone with *Rafinesquina*	5	4
45—Fine grained limestone with *Rafinesquina*	..	2
44—Covered	2	4
43—Limestone with Bryozoa (aa)	..	3
42—Limestone with *Rafinesquina*	..	5
41—Covered	1	10
40—*Rafinesquina*. Bryozoa	..	8
39—Covered	17	..
38—Thin layer of light colored limestone with *Rafinesquina* (shells weathering red)	1	3
37—Covered	2	4
36—Same as 35	1	..
35—Limestone with *Dalmanella* (aa). Bryozoa (aa) *Rafinesquina* (fragments)	4	..
34—Limestone. Soft, gray. *Dalmanella* (aaa)	1	6
33—Covered: some exposed shale and limestone	12	..
32—Thin limestones	1	8
31—Coarsely crystalline light gray limestone containing *Dalmanella* and Bryozoa	..	8
30—Covered	5	6
29—Compact limestone. *Dalmanella* and Bryozoa	1	..
28—Shale	..	4
27—Limestone	..	4
26—Shale	7	..

	Ft.	In.
25—Limestone. *Dalmanella* (aa) Bryozoa. Fragments of *Rafinesquina*	1	3
24—Shale with thin layers of Bryozoal limestone	4	..
23—Bryozoal limestone with some shale	4	4
22—Shale	2	2
21—Limestone with Bryozoa and *Zygospira*	..	5
20—Shale	1	2
19—Bryozoal limestone	..	4
18—Shale	..	10
17—Thin layers of Bryozoal limestone	1	9
16—Shale	1	6
15—Two four-inch layers of Bryozoal limestone	..	8
14—Blue shale	5	4
13—Bryozoal limestone	..	6
12—Mostly compact Bryozoal limestone	5	..
11—Coarse crystalline Bryozoal limestone	..	10
10—Covered, probably shale	5	6
9—Limestone and shale. *Dalmanella*	2	6
8—Layers of limestone with *Dalmanella* Bryozoa, etc	1	..
7—Covered, probably shale	2	2
6—Compact limestone with *Dalmanella*. Lower part consisting of sandstone	..	8
5—Covered	5	6
4—Limestone with *Rafinesquina* (aa)	..	6 to 8
3—Shale	5	6
2—*Dalmanella* layer	..	..
1—Covered to river level	140	..
Total section	385	..

The *Platystrophia* beds are to be seen about Mt. Sterling and in the banks of the east branch of Indian Creek. They reach the bed of the creek two miles northwest of the former place. In the bed of the creek just west of Mt. Sterling the zone of *Dalmanella* is exposed and extends up the creek for a mile and a half. Here it is succeeded by the *Rafinesquina* zone and then by the *Platystrophia* zone, as stated. One mile northwest of Bennington along the road the zone of *Rhynchotrema capax* is exposed, and between the latter place and the *Platystrophia* zone are abundant exposures of the upper zone of *Rafinesquina*. Large collections were obtained from all of these zones and await description in another paper.

The Ordovician and Silurian rocks of Madison, Jefferson County, Indiana, have for many years been the subject of more or less detailed study by geologists and paleontologists. The sections of the Madison hill in the railroad cut as given by Owen and Borden* are certainly far from being accurate. The writer

*Geol. surv. Ind., 1874, E. T. Cox; pp. 164-166.

obtained from Mr. W. B. Blake, engineer of the P., C., C. & St. L. Railway, accurrate data in regard to the per cent. of grade, length and depth of the cuts, and distance between same, for the steep Madison hill grade of the road above mentioned. The elevation of the terrace upon which Madison stands is approximately 60 ft. above river level, and the elevation of North Madison above Madison is 427 ft. The old reservoir at the south end of the big cut is given in Borden's report (loc. cit.) as 210½ ft. above low water of the Ohio River. The data given me by Mr. Blake are as follows: Grade, five and eighty-nine one-hundredths per cent. (5.89%); distance of south end of south cut from low water mark on north side of Ohio River, 2,700 ft.; distance through south cut, 800 ft.; distance from north end of south cut to south end of north cut, 1,100 ft.; distance through north cut, 1,100 ft.; besides this there are north of the north cut about 1,500 ft. of cut in places 40 ft. deep. The maximum depth of the south cut is 60 ft. and of the north cut 100 ft. The section which follows was measured independently of these figures and departed very little from them. One or two corrections have been made, however, in accordance with the above data. Section of the cut at Madison (§ 1.12 A.):

	Ft.	*In.*
71—Massive whitish limestone	10	.
70—One layer of bluish-white limestone	5	..
69—Thin-bedded limestone like No. 70	5	..
68—Blue shale	2	6
67—White arenaceous limestone	3	10
66—Shaly sandstone and shale	8	3
65—Massive white arenaceous limestone (Niagara)	2	6
64—From a few inches to nearly a foot of pinkish or yellowish to salmon colored crystalline limestone (Clinton?)	1	..
63—Massive white arenaceous limestone	4	2
62—Thick-bedded argillaceous arenaceous limestone	9	8
61—Same as 62, but banded on weathered surface with pink, gray, and buff	12	10
60—One massive conspicuous arenaceous layer	3	6
59—Thin-bedded, argillaceous, arenaceous, weathering brownish, with some calcareous layers containing Bryozoa	7	..
58—Nothing to four inches of coarse limestone with Ordovician fossils	..	4
57—Sandstone with lenticles of limestone containing Bryozoa	3	..
56—Argillaceous layer. *Faristella stellata*	2	..
55—Shale	6	..
54—*Faristella stellata*	1	2
53—Thin layers of limestone alternating with argillaceous and sandy layers. Bryozoa (aa). *Rafinesquina*. *Hebertella*	5	3
52—Massive soft sandstone	7	8

	Ft.	In.
51—Blue fossiliferous limestone shale and arenaceous layers.........	6	..
50—Fine shale with layers of limestone, *Rhynchotrema*, *Hebertella*, *Monticulipora*, *Calymene*, *Rafinesquina*	10	..
49—Same as 50. *Strophomena*, *Streptelasma*, *Plectambonites*, *Dalmanella*, *Platystrophia laticosta*, *Ambonychia*	8	..
48—Probably shale and thin layers of limestone; covered by talus ...	22	..
47—Heavy layers of limestone seen in the *west* side of the south cut, at the top.		
46—Heavy layers of limestone seen in the *east* side of the south cut, at the top. The lowest layers in the big cut (north cut) are 24 feet above the top of No. 45 if the foot of the big cut be taken as 210 feet above the river. Part of the layers of No. 46 would therefore be repeated in 45. Allowance is made for this fact. Nos. 46 and 47 together	24	..
45—Shale. The top of No. 45 is at the culvert just north of the south cut..	10	..
44—Several layers of limestone with *Cyclonema*, *Rafinesquina*, *Calymene*, etc	1	2
43—Shaly limestone. *Cyclonema*	2	8
42—Limestone. *Ambonychia*, *Cyclonema*, *Rafinesquina*, *Monticulipora*, Crinoids	2	..
41—Limestone and shale. *Ambonychia*..........................	5	..
40—Compact close-grained limestone. *Rafinesquina*.................	..	3
39—Limestone and shale. *Zygospira*, *Ambonychia*..................	2	4
38—Limestone. *Rafinesquina* edgewise (aaa)	..	4
37—Argillaceous compact limestone. *Rafinesquina*..................	6	9
36—Limestone. Bryozoa	..	6
35—Shaly limestone..	5	8
34—Limestone	..	8
33—Shaly limestone..	2	8
32—Limestone. *Rafinesquina*, *Calymene*, *Hebertella* (?), Gastropoda, Bryozoa	..	8
31—Shale, with occasional 2-inch to 3-inch layers of limestone.......	10	8
30—Limestone. *Rafinesquina* edgewise (aaa)........................	..	3
29—Shaly limestone. *Rafinesquina* (aa), *Modiolopsis* (aa), *Zygospira* (aa)...	6	9
28—Similar to 26..	..	4
27—Shaly limestone..	1	4
26—Blue fine-grained limestone. *Zygospira* (aaa)..................	..	3
25—Shaly limestone. *Rafinesquina*, etc	13	..
24—Very compact fine-grained limestone; no fossils.................	..	6
23—Shale and limestone, with excellently preserved specimens of *Rafinesquina* (aa)...	4	2

	Ft.	In.
22—Limestone, with top of layer composed of immense numbers of *Zygospira modesta*	..	3
21—Rather coarse shale	2	..
20—Lumpy, shaly limestone. *Asaphus*, *Rafinesquina*	3	..
19—Coarse to fine-grained barren limestone	..	8
18—Lumpy, shaly limestone. *Rafinesquina* (aa), Trilobites (a), *Zygospira*, Streptelasma, Bryozoa	12	..
17—Limestone, with *Rafinesquina*, *Zygospira* (aa), Bryozoa, *Orthoceras*.	5	10
16—Shale, with thin layers of limestone	1	..
15—Very compact, fine-grained blue barren limestone	..	6
14—Shale	..	8
13—Compact limestone. *Calymene*, *Zygoapira*, etc	..	5
12—Limestone. *Calymene* (aa), Bryozoa, *Rafinesquina*, *Orthoceras*	1	3
11—Shale, with thin layers of limestone	3	8
10—Thin argillaceous limestone with *Calymene* and Bryozoa (a)	1	..
9—Massive blue limestone. *Rafinesquina*, Trilobites, Bryozoa	..	7
8—Limestone. *Rafinesquina*, *Zygospira*, Bryozoa	2	9
7—Thin argillaceous yellow-spotted limestone. *Platystrophia*, *Hebertella*. *Rafinesquina*, Bryozoa	1	..
6—Limestone. *Hebertella* (aa), *Rafinesquina nasuta*, *Platysstrophia lynx*.	1	2
5—Bryozoal limestone	..	4
4—Covered, probably shale	1	..
3—Limestone with Trilobites, *Zygospira*, etc	..	2
2—Coarse crystalline limestone. *Hebertella*	..	6
1—Covered to river level	62	..
Total section	357	

Number 7 of this section represents the top of the Platystrophia zone. At Vevay the top of the same zone is 358 feet above river level, and at Lawrenceburg about 390 feet. The Madison section affords an excellent opportunity to study the upper Rafinesquina zone. It is in the upper zone that this fossil is so constantly associated with *Zygospira modesta* and a number of species of Lamellibranchs. In the lower zone it has no such constant associates.

Section along Clifty creek (§ 1.12 B):

	Ft.	In.
22—Limestone. *Rafinesquina*, Lamellibranchiata, Gastropoda, Crinoids	..	6
21—Limestone and coarse lumpy shale	7	4
20—Shale and limestone. Top, a heavy layer of limestone with conspicuous wave-like markings	21	4
19—Partly covered, but represented by heavy layers of limestone in the bank above 18	11	..
18—Limestone and shale	14	4
17—Limestone. *Rafinesquina* (aaa), *Hebertella*	5	..

	Ft.	In.
16—Shale, shaly limestone, some thick layers of limestone. *Rafinesquina*, Bryozoa, Trilobites, *Zygospira* (aaa) in some layers......	40	..
15—Heavy layer of limestone....................................	..	6
14—Shale and shaly limestone. Trilobites (a)......................	9	6
13—Limestone. *Rafinesquina*, *Asaphus*, *Calymene*, *Platystrophia*........	8	6
12—Mostly shale...	4	10
11—Argillaceous compact layer. Trilobites, Gastropods.............	..	6
10—Shaly limestone..	2	9
9—Limestone and shale. *Platystrophia*. *Hebertella*.................	3	..
8—Limestone. *P. lynx* and *laticosta*. *Hebertella*....................	3	6
7—Covered	10	..
6—Limestone, more shaly than 5. *Hebertella* (form with dorsal fold), *P. lynx* and *laticosta*..	3	..
5—Same as 4 but *P. laticosta* more abundant	3	10
4—Thin shaly limestone. *Hebertella*	1	2
3—Thin shaly limestone. *Hebertella*, *P. laticosta*, *Monticulipora* (aa).	1	..
2—Thin shaly limestone. *P. lynx* (aa), *laticosta* (a), *Hebertella occidentalis* (c) Trilobites, *Monticulipora*	1	..
1—Covered to river level..	45	..
Total section..	198	

This section shows some 30 feet more of the Platystrophia beds than the Madison section; otherwise it is the same in the main as the basal part of that section.

P. lynx is here abundant in the lower layers and *laticosta* in the upper layers.

From the detailed sections now described of the Ordovician rocks of Indiana it will at once be seen that there are certain well-defined faunal zones which may be traced without fail over the whole area. It has long been known that the zone characterized by the presence in abundance of *Platystrophia*, forms a well-marked and persistent stratum; but apparently the other zones, if recognized at all, have been minimized in importance. Any one of them is however as persistent and as easily traced as the Platystrophia zone.

These zones are in ascending order as follows (the thickness is given in parentheses):

1—Dalmanella multisecta (200–240 feet).
2—Rafinesquina alternata 50–70 feet).
3—Platystrophia (60–80 feet).
4—Rafinesquina alternata var. fracta (100 feet ±).
5—Dalmanella Meeki (20 feet ±).
6—Streptelasma.
7—Strophomena (10 feet ±).
8—Rhynchotrema capax (10 feet ±).

Some Developmental Stages of Orthothetes Minutus N. Sp.

By Edgar R. Cumings.

The specimens discussed in this paper are from the abandoned quarry known as the Cleveland Stone Company's quarry, located one mile north of Harrodsburg. Monroe County, Indiana. This quarry is in the so-called Bedford limestone, and the specimens come from the top of the quarry—and also from near the summit of the formation. They are, so far as I can ascertain without having seen the original specimens of Hall.* specifically the same as Spergen hill forms referred by the latter gentleman to the Orthis (Terebratulites) umbraculum of Schlotheim.†

Description of the shell:

Shell semiovate to subquadrate in old individuals; hinge line usually less than the greatest width of the shell, especially in young individuals; cardinal extremities forming an obtuse, or sometimes a right angle with the lateral margins. Surface finely plicated; plications increasing toward the margin by interstitial addition. Crests of the plications crenulated by equally spaced fine concentric lines.

Ventral valve concave with a pronounced tendency to irregular growth about the beak. In mature individuals the beak becomes strongly retrorse and is greatly elevated, equaling in height one-half the length of the shell. Area well defined, flat, showing in well preserved specimens a low ridge on each side of the prominent deltidium and parallel with its margins. The younger specimens seem to show a perforation at the apex of the deltidium.

Dorsal valve regularly convex, greatest elevation about one-third of the way from the beak to the front margin, though there is considerable variation in this respect in shells of different age. Usually some flattening at the cardinal extremities. Area very narrow or usually scarcely at all conspicuous.

Interior of the ventral valve showing rather prominent teeth, which diverge widely. Cardinal process in the dorsal valve elevated, projecting

---

*Acting under the impression that some of the original specimens of Hall were in the Albany Museum, the writer sent a number of specimens of the form under consideration to Dr. John M. Clarke to compare with Hall's specimens. While owing to the fact that Hall's specimens are not at Albany, Dr. Clarke could not make the comparison, nevertheless he gives it as his opinion that the two are *probably* identical.

†Petrefk. I, 256; Schnurr, Brachiop. der *Eifel* 216; Bronn Lethæa Geog. I, 361. See Hall, Trans. Alb. Inst. 4, p. 12.

somewhat beyond the hinge line; notch shallow, the grooves on the posterior faces of the apophyses very faint.

Ratio of breadth to length in an average adult specimen about as 11 to 8.

This species can not be referred to the *O. (Terebratulites) umbraculum* of Schlotheim, from which it differs in the less length of the hinge line, fewer number of plications, greater proportionate height of the area, which in the present species tends to become strongly retrorse in mature individuals, and the subquadrate rather than semicircular outline of the shells. The figures of Schlotheim's species also show it to possess a strongly quadrilobate cardinal process, while in the present form the notch in the process is very shallow and the grooves very faint.

The species to some extent resembles *O. lens*, from which it differs in the form of the cardinal process and in the greater proportionate length of the latter.

Development.—In the search for specimens of this rather rare species (about 50 specimens were found among several thousand of the common Spergen hill forms) a number of very young stages was obtained. While even the adult individuals share in the general stunting so characteristic of the entire Spergen hill fauna, no complete specimen in the writer's collection having a length of more than 5mm,* nevertheless these larger individuals present the usual features of maturity.

The smallest individual observed has a breadth of .9mm and a length of .6mm. In this specimen the ventral valve is roughly conical, though slightly more convex toward the beak, which projects over the hinge line and is very prominent. The surface shows 18 plications as against 40 in the largest individual observed, while the posterior third of the shell is without surface ornamentation except a few obscure concentric markings. The area is high and the deltidium less sharply marked off from it than in the older specimens. The dorsal valve has its greatest convexity at the center and is also smooth for a considerable distance from the beak. It shows no sign of an area.

Individuals of the length of 2mm have the area perpendicular to the plane of separation of the valves, and the ventral valve showing a slight concavity toward the front. The number of plications also has increased

*Since the above was written, the author has found at Stinesville, Monroe County, Indiana, specimens of this species over one inch in breadth, but agreeing in all essential features with the adult specimens described here.

to 22 or 23, and the region of greatest convexity in the dorsal valve has approached, somewhat, the beak. The youngest individual is conspicuously shorter on the hinge line than farther forward. In fact it in every respect approaches the generalized type of Brachiopod shell, as Beecher & Clarke have shown to be the case in the species of the Waldron fauna.*

The Cold-Blooded Vertebrates of Winona Lake and Vicinity.†

By Earl E. Ramsey.

Winona Lake is located in sections 15, 16, 17, 21 and 22 of Township 32 north, Range 6 east, in Kosciusko County, Indiana. The main body of the lake is about one mile southeast of Warsaw. It is one of the series of lakes belonging to the Mississippi drainage system and is drained into the Tippecanoe River. It lies about six miles south of the watershed between the St. Lawrence and the Mississippi basins.

The lake is irregular in outline and has an area of 0.98 square miles. The greatest length is from north to south and is somewhat more than one mile. The average width is about five-eighths of a mile. The greatest depth is 81 feet.

The lake, like all the small lakes of northern Indiana, is of glacial origin. The catchment basin is large as compared with the size of the lake itself. Unusually heavy rains change the lake level as much as two to two and one-half feet. The tributary streams are three in number. The largest is Cherry Creek, which flows into the lake on the southeast. For the most part it flows through woodland. Two other streams, the larger of which is Clear Creek, enter the lake at its extreme southern part. The output of Clear Creek is nearly as much as that of Cherry Creek. Numerous springs on the Winona Assembly grounds drain into the lake. Lands lying to the north are drained into Pike Lake and Center Lake, both of which lie about one mile northwest of Winona Lake.

The outlet is situated at the southern part of a small bay connecting with the main lake on the northwest. It empties into Tippecanoe River at a point about one mile northwest of Warsaw.

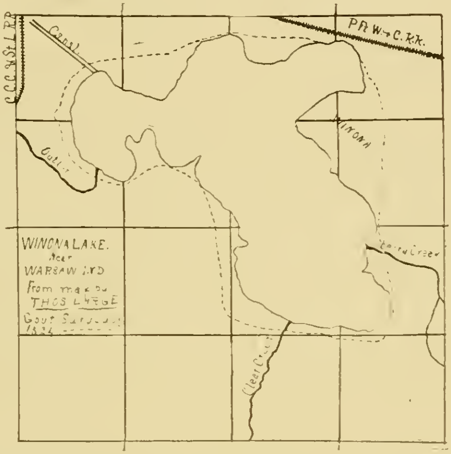
The shore line, for the most part, is low. On the north, a small stretch of cultivated land rises rapidly to a ten-foot elevation line. The Winona Assembly grounds on the east have the greatest elevation. This

---

*Memoirs of the N. Y. State Museum, Vol. I, No. 1.

†Contributions from the Zoölogical Laboratory of the Indiana University, C. H. Eigenmann, Director, No. 39.

elevation is from ten to fifty rods back from the lake. The other parts of the ground lie below a ten-foot line. The south shore is uniformly low and swampy. On the west, an abrupt raise is found at Yarnelle's Landing. To the north of the landing, the shore is low, and the elevation gradual. Natural woodland is found at Yarnelle's, at the outlets of both Clear Creek and Cherry Creek and on the Assembly grounds.



The shores are about equally divided between sand and turf formation. A peninsula extending into the lake from the Winona grounds is of turf. On the south a great part of the shore, as well as the shore of the bay on the west of the main lake, is of such a formation. Other parts are sandy. In a general way, that part of the land which has lately been reclaimed from the lake has a coast line formed of decayed plant life—turf.

By reference to the map of Eagle Lake (now Winona Lake) prepared by the U. S. Survey in 1834, it will be seen that the lake was considerably larger at that time than now. The difference in the lake has been brought about, first by dredging the outlet channel and lowering the level of the lake: second, by the encroachment of plant life upon the lake proper, and the luxuriant plant life on the land partially dried by lowering the lake level. As noted farther on, the plant life of the lake is abundant. The dense banks of Scirpus, Nuphar, etc., tend to collect material that may float into them, and they also contribute their own growth to the formation of new lake bottom. A third agency which has acted in some parts of the lake—notably the southern part—is that of the ice. With the lowerin of the lake level, stretches of lake bottom were left barely covered by water and were in most cases separated from the land by deeper water. As the ice formed, it pushed the ground higher on these shallow places. The ice cracks in excessively cold weather, the cracks fill with water and freeze again. This crowds the ice and the substratum of earth still farther shoreward. Very much of the south shore of the lake shows such a formation. The ice-beach near the outlet of Clear Creek is at least thirty inches above lake level and separates a dense swamp from the lake. In this swamp thus isolated from the main lake, the semi-aquatic plants readily establish themselves and thus finally reclaim the swamp land.

The plant life in the lake is abundant. A bank of Scirpus practically encircles the lake. Nuphar, Nymphaea, Typha, Potamogeton, Ceratophyllum and Chara are also abundant. The outlet is now entirely "overgrown" by Nuphar, Nymphaea, Typha and Scirpus arranged in water zones.

The average temperature of the water from July 6 to August 23, 1899, at a depth of two feet, was 80°; the air temperature for the same time was 81.5°. The deep water of the lake marked 41° and was, of course, subject to no diurnal changes, nor even to any considerable seasonal variation. The prevailing winds during the summer months are west to southwest.

THE FISHES.

The number of species of fishes thus far secured is forty-one. Considering the great variety of physical conditions, the number of species is small. But the number of individuals in each species is much more disappointing. The scarcity of the larger food fishes is due to the great amount of fishing in the lake. But the scarcity of the smaller fishes, the Cyprinidae, many species of the Darters, Labidesthes, etc., is not accounted for in this way.

To show the relative numbers of a very common form which serves as food for the larger species, I may take the Labidesthes sicculus. As many as a gallon of this form may be secured in either Turkey Lake or Tippecanoe Lake at a single haul of the seine. Not more than three or four dozen were secured in Winona Lake during the entire summer. This fact in itself will partially account for the scarcity of the larger food fishes. The same relative proportions are true of many other forms. The following list gives the species and locality from which they were secured. The column marked (X)* gives some notion of the relative abund-

*In some cases the number of specimens collected is marked; (+) indicates that the species is abundant; (×), not so abundant; (—), but few.

ance. Thirteen families are represented and thirty-three genera. The +'s in the other columns indicate the localities in which the various species are found.

SPECIES.	Cherry Creek.	Clear Creek.	Lake.	Outlet.	Tippecanoe R.	N.
Lampetra wilderi, Gage	..	..	..	+	..	1
Lepisosteus osseus (L)	..	..	+	..	..	1
Lepisosteus platostomus, Rafinesque	..	..	+	..	..	×
Amia calva, L	..	..	+	..	..	—
Ameiurus nebulosus (Le Sueur)	..	..	+	..	..	×
Ameiurus melas (Rafinesque)	..	..	..	+	..	2
Schilbeodes gyrinus (Mitchill)	..	..	..	+	..	3
Carpiodes (Sp——)*	..	..	+	+	..	2
Catostomus nigricans, Le Sueur	+	+	+	+	..	×
Catostomus commersoni (Lacépède)	..	+	..	..	..	—
Erimyzon sucetta oblongus (Mitchill)	..	..	..	+	..	×
Minytrema melanops (Rafinesque)	..	+	..	..	..	1
Campostoma anomalum (Rafinesque)	+	+	..	..	..	+
Pimephales notatus (Rafinesque)	+	..	+	..	..	+
Notropis whipplei (Girard)	+	..	+	+	..	+
Notropis cornutus (Mitchill)	+	..	..	+	..	×
Hybopsis kentuckiensis (Rafinesque)	+	+	..	..	..	—
Semotilus atromaculatus (Mitchill)	+	+	..	+	..	+
Abramis crysoleucus (Mitchill)	..	..	+	..	..	×
Umbra limi (Kirtland)	+	..	..	..	..	5
Lucius vermiculatus (Le Sueur)	+	..	+	+	..	×
Fundulus notatus (Rafinesque)	..	..	+	..	..	+
Fundulus dispar (Agassiz)	..	..	..	+	..	—
Labidesthes sicculus (Cope)	+	..	+	+	..	—
Pomoxis sparoides (Lacépède)	..	..	+	..	..	1
Ambloplites rupestris (Rafinesque)	+	..	+	+	+	+
Chænobryttus gulosus (Cuv. and Val.)	+	..	+	+	..	×
Lepomis pallidus (Mitchill)	+	..	+	+	+	+
Lepomis megalotis (Rafinesque)	..	..	..	+	+	×
Eupomotis gibbosus (Linnaeus)	+	..	+	+	..	×
Micropterus dolomieu Lacépède	..	..	..	..	+	5
Micropterus salmoides (Lacépède)	+	..	+	+	+	+
Percina caprodes (Rafinesque)	+	..	+	..	+	×
Hadropterus aspro (Cope and Jordan)	+	..	+	..	+	3
Boleosoma nigrum (Rafinesque)	+	+	+	+	+	+
Diplesion blennioides Rafinesque	..	..	..	..	+	2
Etheostoma iowæ, Jordan and Meek	+	..	..	+	..	—
Etheostoma coeruleum, Storer	+	+	+	+	+	+
Microperca punctulata, Putnam	..	..	..	+	..	—
Perca flavescens (Mitchill)	+	..	+	+	..	×
Cottus ictalops (Rafinesque)	+	+	..	+	..	+

*Two large specimens taken by fishermen were seen. The species was probably C. Velifer (Rafinesque), but no positive identification further than genus could be made.

BATRACHIANS.

This group is represented by but few species.

1. Necturus maculosus (Rafinesque). Three or four specimens were found by workmen who were deepening the channel of Cherry Creek.

2. Bufo lentiginosus americanus (Le Conte).

3. Acris gryllus gryllus (Le Conte).

4. Acris gryllus crepitans (Baird).

5. Hyla versicolor (Le Conte). But two specimens of this interesting little animal were taken.

6. Rana pipiens Kalm. This is the most abundant of the frogs.

7. Rana clamitans Latreille. The individuals of this species are nearly as numerous as those of R. pipiens.

8. Rana catesbeana Shaw. But one or two specimens found.

SNAKES.

Eight species of snakes have been found:

1. Storeria dekayi (Holbrook), is rare.

2. Clonophis kirtlandi (Kennicott). Only two or three specimens were taken.

3. Two varieties of the garter snake, Thamnophis sirtalis parietalis (Say), and Thamnophis sirtalis sirtalis L., were taken. This snake is the most abundant of the forms found in this locality. On July 19, a female bearing thirty-one well developed embryos was killed. On August 5, one kept in a pen gave birth to young. The number of young could not be ascertained.

4. Regina leberis (L.). The leather snake is abundant. It is third in this locality in point of number. On August 12, 1899, a gravid female was found having ten well developed embryos. Its haunts are along creeks.

5. Natrix sipedon (L.). This species is plentiful. On July 23, 1900, a female containing twenty-six embryos was killed. The water snake is a swamp-loving form, and is of a sullen and vicious disposition.

6. The blue racer, Bascanion constrictor (L) is the largest snake in this locality, and is comparatively abundant. When captured and put in a pen, it soon tames and seems to take delight in being handled. Its movements and shape are peculiarly graceful. Its food consists of frogs, garter snakes, etc. A specimen forty-two inches long swallowed a garter snake twenty-eight inches long. I have known it to lay its eggs about the middle of June, and have found the young hatching about the middle of September. Its egg-laying habit is worthy of note. One specimen selected the soft ground between two rows of potatoes and pushed her way under the ground. As she crawled along in this underground passage, the eggs, twenty-two in number, were laid in the channel which her body had made. Another laid her eggs in the hollow root of a half decayed stump. The eggs are white in color, and about one inch in length, and have a uniform diameter of one-half inch. The soft shell is so tough that it will sustain a weight of more than one hundred pounds without breaking. The young, when first hatched, are seven or eight inches in length. The first action when the little head is thrust through the shell is to stick out its tongue. The blue racer frequents the woods or high grass and weeds.

7. Lampropeltis doliatus triangulus (Boie) is found rarely.

8. Sistrurus catenatus (Rafinesque) is second in point of numbers. The garter snake is more plentiful than the prairie-rattler. During the summer of 1899 eleven specimens were caught, and nine were taken during the following summer. They are usually found in low land and run but little during the day unless disturbed. Nothing was learned concerning their food, since they persistently refused to eat when kept in confinement. A female kept in a pen gave birth to seven young on August 13. Several of the little ones were kept in a glass aquarium for a time. On August 17 they drank drops of water from a pipette and ate a few small bits of fresh meat. Three days later they began their first moult. They were about eight and one-half inches long at birth. A case was reported to me in which thirteen young were born. The adults are inoffensive and move slowly. They are easily captured by means of a noose slipped over their heads or by an insect net.

TURTLES.

The land and water forms together number eight species. Of these the soft-shelled turtle, the speckled tortoise, Blanding's tortoise and the box tortoise are rare. Even the commoner species are not very abundant. No more than two dozen eggs were found. They were of the Aromochelys odoratus (Latreille), and were laid in heaps of debris which had been washed up along the shore. The species are as follows:

1. Aspidonectes spinifer (Le Sueur).
2. Chelydra serpentina (L.).
3. Aromochelys odoratus (Latreille).
4. Graptemys geographicus (Le Sueur).
5. Chrysemys marginata (Agassiz).
6. Clemmys guttatus (Schneider).
7. Emydoidea blandingi (Holbrook).
8. Terrapene carolina (L.).

I desire to acknowledge the helpful suggestions of Dr. C. H. Eigenmann in the preparation of this brief report. Dr. S. E. Meek has also kindly aided me in preparing a partial catalogue of the fishes, and has mapped out the general plan of the paper.

INDEX, 1900.

INDEX OF PROCEEDINGS 1891-1900

(INCLUSIVE)

* First published annual report of Proceedings.

Proceedings of the

Indiana Academy of Science

1901

PROCEEDINGS

OF THE

Indiana Academy of Science

1901.

EDITOR, - - DONALDSON BODINE.

ASSOCIATE EDITORS:

C. A. WALDO,
C. H. EIGENMANN,
V. F. MARSTERS,
M. B. THOMAS,
W. A. NOYES,
STANLEY COULTER,
THOMAS GRAY,
JOHN S. WRIGHT.

INDIANAPOLIS, IND.
1902.

INDIANAPOLIS:
Wm. B. Burford, Printer.
1902.

TABLE OF CONTENTS.

AN ACT TO PROVIDE FOR THE PUBLICATION OF THE REPORTS AND PAPERS OF THE INDIANA ACADEMY OF SCIENCE.

[Approved March 11, 1895.]

Preamble.

WHEREAS, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory body, assist in the direction and execution of any investigation within its province, without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State, and,

WHEREAS, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form, and,

WHEREAS, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement, therefore,

Publication of the Reports of the Indiana Academy of Science.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

Editing Reports.

SEC. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such services, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports, shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less

Number of printed Reports.

than 1,500 nor more than 3,000 copies of each of said reports shall be published, the size of the edition within said limits, to be determined by the concurrent action of the editors and the Commissioners of Public Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894.

Proviso.

Disposition of Reports.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

Emergency.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage.

AN ACT FOR THE PROTECTION OF BIRDS, THEIR NESTS AND EGGS.

[Approved March 5, 1891.]

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That it shall be unlawful for any person to kill any wild bird other than a game bird, or purchase, offer for sale any such wild bird after it has been killed, or to destroy the nests or the eggs of any wild bird. Birds.

SEC. 2. For the purpose of this act the following shall be considered game birds: the Anatidæ, commonly called swans, geese, brant, and river and sea ducks; the Rallidæ, commonly known as rails, coots, mudhens, and gallinules; the Limicolæ, commonly known as shore birds, plovers, surf birds, snipe, woodcock and sandpipers, tattlers and curlews; the Gallinæ, commonly known as wild turkeys, grouse, prairie chickens, quail, and pheasants, all of which are not intended to be affected by this act. Game birds.

SEC. 3. Any person violating the provisions of Section 1 of this act shall, upon conviction, be fined in a sum not less than ten nor more than fifty dollars, to which may be added imprisonment for not less than five days nor more than thirty days. Penalty.

SEC. 4. Sections 1 and 2 of this act shall not apply to any person holding a permit giving the right to take birds or their nests and eggs for scientific purposes, as provided in Section 5 of this act. Permits.

SEC. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science to any properly accredited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to said Board written testimonials from two well-known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege and pay to said Board one dollar to defray the necessary expenses attending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of such permit has killed Permits to Science. Bond. Bond forfeited.

any bird or taken the nests or eggs of any bird for any other purpose than that named in this section and shall further be subject for each offense to the penalties provided in this act.

Two years. SEC. 6. The permits authorized by this act shall be in force for two years only from the date of their issue, and shall not be transferable.

Birds of prey. SEC. 7. The English or European House Sparrow (Passer domesticus), crows, hawks, and other birds of prey are not included among the birds protected by this act.

Acts repealed. SEC. 8. All acts or parts of acts heretofore passed in conflict with the provisions of this act are hereby repealed.

Emergency. SEC. 9. An emergency is declared to exist for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

OFFICERS, 1901-1902.

PRESIDENT,

HARVEY W. WILEY.

VICE-PRESIDENT,

W. S. BLATCHLEY.

SECRETARY,

JOHN S. WRIGHT.

ASSISTANT SECRETARY,

DONALDSON BODINE.

PRESS SECRETARY,

GEORGE W. BENTON.

TREASURER,

J. T. SCOVELL.

EXECUTIVE COMMITTEE.

Harvey W. Wiley,
W. S. Blatchley,
John S. Wright,
Donaldson Bodine,
G. W. Benton,
J. T. Scovell,
M. B. Thomas,
D. W. Dennis,
C. H. Eigenmann,
C. A. Waldo,
Thomas Gray,
Stanley Coulter,
Amos W. Butler,
W. A. Noyes,
J. C. Arthur,
J. L. Campbell,
O. P. Hay,
T. C. Mendenhall,
John C. Branner,
J. P. D. John,
John M. Coulter,
David S. Jordan.

CURATORS.

BOTANY	J. C. Arthur.
ICHTHYOLOGY	C. H. Eigenmann.
HERPETOLOGY, MAMMALOGY, ORNITHOLOGY	Amos W. Butler.
ENTOMOLOGY	W. S. Blatchley.

COMMITTEES, 1901-1902.

PROGRAM.

M. B. Thomas, M. E. Crowell.

MEMBERSHIP.

M. J. Golden, W. A. McBeth, Glenn Culbertson.

NOMINATIONS.

C. A. Waldo, W. A. Noyes, A. J. Bigney.

AUDITING.

W. K. Hatt, W. S. Blatchley.

STATE LIBRARY.

A. W. Butler, Stanley Coulter, C. A. Waldo, J. S. Wright.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

Stanley Coulter, John S. Wright, M. B. Thomas.

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, W. S. Blatchley.

EDITOR.

Donaldson Bodine, Wabash College, Crawfordsville.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, Donaldson Bodine, M. B. Thomas, J. C. Arthur, Stanley Coulter.

RELATIONS OF THE ACADEMY TO THE STATE.

D. W. Dennis, A. W. Butler, R. W. McBride, G. W. Benton.

GRANTING PERMITS FOR COLLECTING BIRDS AND FISHES.

A. W. Butler, Stanley Coulter, W. S. Blatchley.

DISTRIBUTION OF THE PROCEEDINGS.

A. W. Butler, J. S. Wright, G. W. Benton.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885–6	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886–7	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887–8	J. P. D. John	Amos W. Butler			O. P. Jenkins.
1888–9	John C. Branner	Amos W. Butler			O. P. Jenkins.
1889–90	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890–1	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891–2	J. L. Campbell	Amos W. Butler			C. A. Waldo.
1892–3	J. C. Arthur	Amos W. Butler	Stanley Coulter. W. W. Norman.		C. A. Waldo.
1893–4	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894–5	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895–6	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896–7	Thomas Gray	John S. Wright	A. J. Bigney		W. P. Shannon.
1897–8	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.
1898–9	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899–1900	D. W. Dennis	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900–1901	M. B. Thomas	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901–1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine	Geo. W. Benton	J. T. Scovell.

In Memoriam.

PHILIP SCHAFFNER BAKER,

Born, Evansville, Indiana, 1851.

DIED, ASHEVILLE, NORTH CAROLINA, SEPTEMBER SECOND, 1901.

VICE-PRESIDENT

OF THE

INDIANA ACADEMY OF SCIENCE, 1901.

CONSTITUTION.

ARTICLE I.

Section 1. This association shall be called the Indiana Academy of Science.

Sec. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigation and discussions as may further the aims and objects of the Academy as set forth in these articles.

Whereas, the State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or of one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

Section 1. Members of this Academy shall be honorary fellows, fellows, non-resident members or active members.

Sec. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and there-

after an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men, and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a President, Vice-President, Secretary, Assistant Secretary, Press Secretary, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-Presidents of the Academy, shall constitute an Executive Committee. The President shall, at each annual meeting, appoint two members to be a committee which shall prepare the programs and have charge of the arrangements for all meetings for one year.

SEC. 2. The annual meeting of this Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the

Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past Presidents, together with the officers and Executive Committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not specially provided for in this constitution, in the interim between general meetings.

SEC. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The President shall deliver a public address on the morning of one of the days of the meeting at the expiration of his term of office.

3. The Press Secretary shall attend to the securing of proper newspaper reports of the meetings and assist the Secretary.

4. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

5. No bill against the Academy shall be paid without an order signed by the President and countersigned by the Secretary.

6. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

7. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

FELLOWS.

R. J. Aley	*1898	Bloomington.
J. C. Arthur	1893	Lafayette.
George W. Benton	1896	Indianapolis.
A. J. Bigney	1897	Moore's Hill.
A. W. Bitting	1897	Lafayette.
Donaldson Bodine	1899	Crawfordsville.
W. S. Blatchley	1893	Indianapolis.
H. L. Bruner	1899	Irvington.
Severance Burrage	1898	Lafayette.
A. W. Butler	1893	Indianapolis.
J. L. Campbell	1893	Crawfordsville.
John M. Coulter	1893	Chicago, Ill.
Stanley Coulter	1893	Lafayette.
Glenn Culbertson	1899	Hanover.
D. W. Dennis	1895	Richmond.
C. R. Dryer	1897	Terre Haute.
C. H. Eigenmann	1893	Bloomington.
Percy Norton Evans	1901	Lafayette.
A. L. Foley	1897	Bloomington.
Katherine E. Golden	1895	Lafayette.
M. J. Golden	1899	Lafayette.
W. F. M. Goss	1893	Lafayette.
Thomas Gray	1893	Terre Haute.
A. S. Hathaway	1895	Terre Haute.
Robert Hessler	1899	Logansport.
H. A. Huston	1893	Lafayette.
Arthur Kendrick	1898	Terre Haute.
Robert E. Lyons	1896	Bloomington.
V. F. Marsters	1893	Bloomington.
C. L. Mees	1894	Terre Haute.
W. J. Moenkhaus	1901	Bloomington.
Joseph Moore	1896	Richmond.
D. M. Mottier	1893	Bloomington.
W. A. Noyes	1893	Terre Haute.
L. J. Rettger	1896	Terre Haute.
J. T. Scovell	1894	Terre Haute.
Alex. Smith	1893	Chicago, Ill.
W. E. Stone	1893	Lafayette.

*Date of election.

Joseph Swain	*1898	Bloomington.
M. B. Thomas	1893	Crawfordsville.
C. A. Waldo	1893	Lafayette.
F. M. Webster	1894	Wooster, Ohio.
H. W. Wiley	1895	Washington, D. C.
John S. Wright	1894	Indianapolis.

NON-RESIDENT MEMBERS.

George H. Ashley	Charleston, S. C.
M. A. Brannon	Grand Forks, N. D.
J. C. Branner	Stanford University, Cal.
D. H. Campbell	Stanford University, Cal.
A. Wilmer Duff	Worcester, Mass.
B. W. Evermann	Washington, D. C.
Charles H. Gilbert	Stanford University, Cal.
C. W. Green	Stanford University, Cal.
C. W. Hargitt	Syracuse, N. Y.
O. P. Hay	Washington, D. C.
Edward Hughes	Stockton, Cal.
O. P. Jenkins	Stanford University, Cal.
D. S. Jordan	Stanford University, Cal.
J. S. Kingsley	Tufts College, Mass.
D. T. MacDougal	Bronx Park, New York City
T. C. Mendenhall	Worcester, Mass.
Alfred Springer	Cincinnati, Ohio.
L. M. Underwood	New York City.
Robert B. Warder	Washington, D. C.
Ernest Walker	Clemson College, S. C.

ACTIVE MEMBERS.

G. A. Abbott	Indianapolis.
Frederick W. Andrews	Bloomington.
George C. Ashman	Frankfort.
Edward Ayres	Lafayette.
Edwin M. Blake	Lafayette.
Lee F. Bennett	Valparaiso.
Charles S. Bond	Richmond.
Fred. J. Breeze	Pittsburg.

* Date of election.

E. M. Bruce ....
A. Hugh Bryan ....Indianapolis.
E. J. Chansler ....Bicknell.
Howard W. Clark ....Culver.
George Clements ....Peru.
Charles Clickener ....Tangier.
Mel T. Cook ....Greencastle.
U. O. Cox ....Mankato, Minn.
William Clifford Cox ....Columbus.
J. A Cragwall ....Crawfordsville.
Albert B. Crowe ....Ft. Wayne.
M. E. Crowell ....Franklin.
Edward Roscoe Cumings ....Bloomington.
Alida M. Cunningham ....Alexandria.
Lorenzo E. Daniels ....Laporte.
H. J. Davidson ....Baltimore, Md.
Charles C. Deam ....Bluffton.
Martha Doan ....Westfield.
J. P. Dolan ....Syracuse.
Herman B. Dorner ....Lafayette.
Hans Duden ....Indianapolis.
Joseph Eastman ....Indianapolis.
E. G. Eberhardt ....Indianapolis.
M. N. Elrod ....Columbus.
Samuel G. Evans ....Evansville.
Carlton G. Ferris ....Big Rapids, Mich.
E. M. Fisher ....Urmeyville.
Wilbur A. Fiske ....Richmond.
W. B. Fletcher ....Indianapolis.
Austin Funk ....New Albany.
Charles W. Garrett ....Logansport.
Robert G. Gillum ....Terre Haute.
Vernon Gould ....Rochester.
Victor K. Hendricks ....Logansport.
Mary A. Hickman ....Greencastle.
John E. Higdon ....Indianapolis.
Frank R. Higgins ....Terre Haute.
John J. Hildebrandt ....Logansport.
J. D. Hoffman ....Lafayette.
Allen D. Hole ....Richmond.
Lucius M. Hubbard ....South Bend.
Alex. Johnson ....Ft. Wayne.
Edwin S. Johonnott, Jr. ....Terre Haute.
Ernest E. Jones ....Kokomo.
Chancey Juday ....Madison, Wis.

O. L. Kelso .... Terre Haute.
Charles T. Knipp.............................. Bloomington.
V. H. Lockwood .... Indianapolis.
William A. McBeth .... Terre Haute.
Robert Wesley McBride........................ Indianapolis.
Rousseau McClellan .... Indianapolis.
Richard C. McClaskey .... Terre Haute.
Lynn B. McMullen .... Indianapolis.
James E. Manchester. .... Vincennes.
W. G. Middleton .... Richmond.
John A. Miller .... Bloomington.
H. T. Montgomery .... South Bend.
Walter P. Morgan .... Terre Haute.
Fred. Mutchler .... Terre Haute.
J. P. Naylor .... Greencastle.
Charles E. Newlin .... Irvington.
John Newlin .... West Lafayette.
John F. Newsom .... Stanford University, Cal.
R. W. Noble .... Chicago, Ill.
D. A. Owen .... Franklin.
Rollo J. Peirce .... Logansport.
Ralph B. Polk .... Greenwood.
James A. Price .... Ft. Wayne.
Frank A. Preston .... Indianapolis.
A. H. Purdue .... Fayetteville, Ark.
J. H. Ransom .... Lafayette.
Ryland Ratliff .... Bloomington.
Claude Riddle .... Lafayette.
Giles E. Ripley .... Decorah, Iowa.
George L. Roberts .... Greensburg.
D. A. Rothrock .... Bloomington.
John F. Schnaible .... Lafayette.
E. A. Schultze .... Ft. Wayne.
John W. Shepherd .... Terre Haute.
Claude Siebenthal .... Indianapolis.
J. R. Slonaker .... Bloomington.
Richard A. Smart .... Lafayette.
Lillian Snyder .... Rockville.
Retta E. Spears .... Elkhart.
William Stewart .... Lafayette.
J. M. Stoddard .... Crawfordsville.
Charles F. Stegmaier .... Greensburg.
William B. Streeter .... Indianapolis.
Frank B. Taylor .... Ft. Wayne.
J. F. Thompson .... Richmond.

A. L. Treadwell .... Oxford, Ohio.
Daniel J. Troyer .... Goshen.
A. B. Ulrey .... North Manchester.
W. B. Van Gorder .... Worthington.
Arthur C. Veatch .... Rockport.
H. S. Voorhees .... Ft. Wayne.
J. H. Voris .... Huntington.
B. C. Waldemaier .... West Lafayette.
Jacob Westlund .... Lafayette.
Fred C. Whitcomb .... Delphi.
William M. Whitten .... South Bend.
Neil H. Williams .... Indianapolis.
William Watson Woollen .... Indianapolis.
J. F. Woolsey .... Indianapolis.

Fellows	44
Non-resident members	20
Active members	112
Total	176

LIST OF FOREIGN CORRESPONDENTS.

AFRICA.

Dr. J. Medley Wood, Natal Botanical Gardens, Berea Durban, South Africa.

South African Philosophical Society, Cape Town, South Africa.

ASIA.

China Branch Royal Asiatic Society, Shanghai, China.

Asiatic Society of Bengal, Calcutta, India.

Geological Survey of India, Calcutta, India.

Indian Museum of India, Calcutta, India.

India Survey Department of India, Calcutta, India.

Deutsche Gesellschaft, für Natur- und Völkerkunde Ostasiens, Tokio, Japan.

Imperial University, Tokio, Japan.

Koninklijke Naturkundige Vereeniging in Nederlandsch-Indie, Batavia, Java.

Hon. D. D. Baldwin, Honolulu, Hawaiian Islands.

EUROPE.

V. R. Tschusizu Schmidhoffen, Villa Tannenhof, Halle in Salzburg, Austria.

Herman von Vilas, Innsbruck, Austria.

Ethnologische Mittheilungen aus Ungarn, Budapest, Austro-Hungary.

Mathematische und Naturwissenschaftliche Berichte aus Ungarn, Buda pest, Austro-Hungary.

K. K. Geologische Reichsanstalt, Vienna (Wien), Austro-Hungary.

K. U. Naturwissenschaftliche Gesellschaft, Budapest, Austro-Hungary.

Naturwissenschaftlich-Medizinischer Verein in Innsbruck (Tyrol), Austro-Hungary.

Editors "Termeszetrajzi Fuzetk," Hungarian National Museum, Budapest, Austro-Hungary.

Dr. Eugen Dadai, Adj. am. Nat. Mus., Budapest, Austro-Hungary.

Dr. Julius von Madarasz, Budapest, Austro-Hungary.

K. K. Naturhistorisches Hofmuseum, Vienna (Wien), Austro-Hungary.

Ornithological Society of Vienna (Wien), Austro-Hungary.

Zoologische-Botanische Gesellschaft in Wien (Vienna), Austro-Hungary.

Dr. J. von Csato, Nagy Enyed, Austro-Hungary.

Botanic Garden, K. K. Universitat, Wien (Vienna), Austro-Hungary.

Malacological Society of Belgium, Brussels, Belgium.

Royal Academy of Science, Letters and Fine Arts, Brussels, Belgium.

Royal Linnean Society, Brussels, Belgium.

Societé Belge de Geologie, de Paleontologié et Hydrologie, Brussels, Belgium.

Societé Royale de Botanique, Brussels, Belgium.

Societé Geologique de Belgique, Liège, Belgium.

Royal Botanical Gardens, Brussels, Belgium.

Bristol Naturalists' Society, Bristol, England.

Geological Society of London, London, England.

Dr. E. M. Holmes, British Pharm. Soc'y, Bloomsbury Sq., London, W. C., England.

Jenner Institute of Preventive Medicine, London, England.

The Librarian, Linnean Society, Bulington House, Piccadilly, London W., England.

Liverpool Geological Society, Liverpool, England.

Manchester Literary and Philosophical Society, Manchester, England.

"Nature," London, England.

Royal Botanical Society, London, England.

Royal Kew Gardens, London, England.
Royal Geological Society of Cornwall, Penzance, England.
Royal Microscopical Society, London, England.
Zoölogical Society, London, England.
Lieut.-Col. John Biddulph, 43 Charing Cross, London, England.
Dr. G. A. Boulenger, British Mus. (Nat. Hist.), London, England.
F. DuCane Godman, 10 Chandos St., Cavendish Sq., London, England.
Mr. Howard Saunders, 7 Radnor Place, Hyde Park, London W., England.
Phillip L. Sclater, 3 Hanover Sq., London W., England.
Dr. Richard Bowlder Sharpe, British Mus. (Nat. Hist.), London, England.
Prof. Alfred Russell Wallace, Corfe View, Parkstone, Dorset, England.

Botanical Society of France, Paris, France.
Ministérie de l'Agriculture, Paris, France.
Societé Entomologique de France, Paris, France.
L'Institut Grand Ducal de Luxembourg, Luxembourg, Lux., France.
Soc. de Horticulture et de Botan. de Marseille, Marseilles, France.
Societé Linneenne de Bordeaux, Bordeaux, France.
La Soc. Linneenne de Normandie, Caen, France.
Soc. des Naturelles, etc., Nantes, France.
Zoölogical Society of France, Paris, France.
Baron Louis d'Hamonville, Meurthe et Moselle, France.
Pasteur Institute, Lille, France.
Museum d'Histoire Naturelle, Paris, France.

Bontanischer Verein der Provinz Brandenburg, Berlin, Germany.
Deutsche Geologische Gesellschaft, Berlin, Germany.
Entomologischer Verein in Berlin, Berlin, Germany.
Journal für Ornithologie, Berlin, Germany.
Prof. Dr. Jean Cabanis, Alte Jacob Strasse, 103 A., Berlin, Germany.
Augsburger Naturhistorischer Verein, Augsburg, Germany.
Count Hans von Berlspsen, Münden, Germany.
Braunschweiger Verein für Naturwissenschaft, Braunschweig, Germany.
Bremer Naturwissenschaftlicher Verein, Bremen, Germany.
Ornithologischer Verein München, Thierschstrasse, 37½, München, Germany.

Royal Botanical Gardens, Berlin W., Germany.

Kaiserliche Leopoldische-Carolinische Deutsche Akademie der Naturforscher, Halle a Saale, Wilhemstrasse 37, Germany.

Königlich-Sächsische Gesellschaft der Wissenschaften, Mathematisch-Physische Classe, Leipzig, Saxony, Germany.

Naturhistorische Gesellschaft zu Hanover, Hanover, Prussia, Germany.

Naturwissenschaftlicher Verein in Hamburg, Hamburg, Germany.

Verein für Erdkunde, Leipzig, Germany.

Verein für Naturkunde, Wiesbaden, Prussia.

Belfast Natural History and Philosophical Society, Belfast, Ireland.

Royal Dublin Society, Dublin.

Royal Botanic Gardens, Glasnevin, County Dublin, Ireland.

Societa Entomologica Italiana, Florence, Italy.

Prof. H. H. Giglioli, Museum Vertebrate Zoölogy, Florence, Italy.

Dr. Alberto Perngia, Museo Civico di Storia Naturale, Genoa, Italy.

Societa Italiana de Scienze Naturali, Milan, Italy.

Societa Africana d' Italia, Naples, Italy.

Dell 'Academia Pontifico de Nuovi Lincei, Rome, Italy.

Minister of Agriculture, Industry and Commerce, Rome, Italy.

Rassegna della Scienze Geologiche in Italia, Rome, Italy.

R. Comitato Geologico d' Italia, Rome, Italy.

Prof. Count Tomasso Salvadori, Zoölog. Museum, Turin, Italy.

Royal Norwegian Society of Sciences, Throndhjem, Norway.

Dr. Robert Collett, Kongl. Frederiks Univ. Christiana, Norway.

Academia Real des Sciencias de Lisboa (Lisbon), Portugal.

Comité Geologique de Russie, St. Petersburg, Russia.

Imperial Academy of Sciences, St. Petersburg, Russia.

Imperial Society of Naturalists, Moscow, Russia.

Jardin Imperial de Botanique, St. Petersburg, Russia.

The Botanical Society of Edinburgh, Edinburgh, Scotland.
John J. Dalgleish, Brankston Grange, Bogside Sta., Sterling, Scotland.
Edinburgh Geological Society, Edinburgh, Scotland.
Geological Society of Glasgow, Scotland.
John A. Harvie-Brown, Duniplace House, Larbert, Stirlingshire, Scotland.
Natural History Society, Glasgow, Scotland.
Philosophical Society of Glasgow, Glasgow, Scotland.
Royal Society of Edinburgh, Edinburgh, Scotland.
Royal Physical Society, Edinburgh, Scotland.
Royal Botanic Garden, Edinburgh, Scotland.

Barcelona Academia de Ciencias y Artes, Barcelona, Spain.
Royal Academy of Sciences, Madrid, Spain.

Institut Royal Geologique de Suède, Stockholm, Sweden.
Societé Entomologique a Stockholm, Stockholm, Sweden.
Royal Swedish Academy of Science, Stockholm, Sweden.

Naturforschende Gesellschaft, Basel, Switzerland.
Naturforschende Gesellschaft in Berne, Berne, Switzerland.
La Societé Botanique Suisse, Geneva, Switzerland.
Societé Helvetique de Sciences Naturelles, Geneva, Switzerland.
Societé de Physique et d'. Historie Naturelle de Geneva, Geneva, Switzerland.
Concilium Bibliographicum, Zürich-Oberstrasse, Switzerland.
Naturforschende Gesellschaft, Zürich, Switzerland.
Schweizerische Botanische Gesellschaft, Zürich, Switzerland.
Prof. Herbert H. Field, Zürich, Switzerland.

AUSTRALIA.

Linnean Society of New South Wales, Sidney, New South Wales.
Royal Society of New South Wales, Sidney, New South Wales.
Prof. Liveridge, F. R. S.. Sidney, New South Wales.
Hon. Minister of Mines, Sidney, New South Wales.

Mr. E. P. Ramsey, Sidney, New South Wales.
Royal Society of Queensland, Brisbane, Queensland.
Royal Society of South Australia, Adelaide, South Australia.
Victoria Pub. Library, Museum and Nat. Gallery, Melbourne, Victoria.
Prof. W. L. Buller, Wellington, New Zealand.

NORTH AMERICA.

Natural Hist. Society of British Columbia, Victoria, British Columbia.
Canadian Record of Science, Montreal, Canada.
McGill University, Montreal, Canada.
Natural Society, Montreal, Canada.
Natural History Society, St. Johns, New Brunswick.
Nova Scotia Institute of Science, Halifax, N. S.
Manitoba Historical and Scientific Society, Winnipeg, Manitoba.
Dr. T. McIlwraith, Cairnbrae, Hamilton, Ontario.
The Royal Society of Canada, Ottawa, Ontario.
Natural History Society, Toronto, Ontario.
Hamilton Association Library, Hamilton, Ontario.
Canadian Entomologist, Ottawa, Ontario.
Department of Marine and Fisheries, Ottawa, Ontario.
Ontario Agricultural College, Guelph, Ontario.
Canadian Institute, Toronto.
Ottawa Field Naturalists' Club, Ottawa, Ontario.
University of Toronto, Toronto.
Geological Survey of Canada, Ottawa, Ontario.
La Naturaliste Canadian, Chicontini, Quebec.

La Naturale Za, City of Mexico.
Mexican Society of Natural History, City of Mexico.
Museo Nacional, City of Mexico.
Sociedad Cientifica Antonio Alzate, City of Mexico.
Sociedad Mexicana de Geographia y Estadistica de la Republica Mexicana, City of Mexico.

WEST INDIES.

Botanical Department, Port of Spain, Trinidad, British West Indies.
Victoria Institute, Trinidad, British West Indies.
Museo Nacional, San Jose, Costa Rica, Central America.
Dr. Anastasia Alfaro, Secy. National Museum, San Jose, Costa Rica.
Rafael Arango, Havana, Cuba.
Jamaica Institute, Kingston, Jamaica, West Indies.
The Hope Gardens, Kingston, Jamaica, West Indies.

SOUTH AMERICA.

Argentina Historia Natural Florentine Ameglino, Buenos Ayres, Argentine Republic.
Musée de la Plata, Argentine Republic.
Nacional Academia des Ciencias, Cordoba, Argentine Republic.
Sociedad Cientifica Argentina, Buenos Ayres.
Museo Nacional, Rio de Janeiro, Brazil.
Sociedad de Geographia, Rio de Janeiro, Brazil.
Dr. Herman von Jhering, Dir. Zoöl. Sec. Con. Geog. e Geol. de Sao Paulo, Rio Grande do Sul, Brazil.

Deutscher Wissenschaftlicher Verein in Santiago, Santiago, Chili.
Societé Scientifique du Chili, Santiago, Chili.
Sociedad Guatemalteca de Ciencias, Guatemala, Guatemala.

. . . PROGRAM . . .

OF THE

SEVENTEENTH ANNUAL MEETING

OF THE

INDIANA ACADEMY OF SCIENCE,

STATE HOUSE, INDIANAPOLIS,

December 26, 27 and 28, 1901.

EXECUTIVE COMMITTEE.

MASON B. THOMAS, President. P. S. BAKER, Vice-President. JOHN S. WRIGHT, Secretary.
E. A. SCHULTZE, Asst. Secretary. G. W. BENTON, Press Secretary.
J. T. SCOVELL, Treasurer.

D. W. DENNIS,	STANLEY COULTER,	J. L. CAMPBELL,	J. P. D. JOHN,
C. H. EIGENMANN,	AMOS W. BUTLER,	O. P. HAY,	JOHN M. COULTER,
C. A. WALDO,	W. A. NOYES,	T. C. MENDENHALL,	DAVID S. JORDAN.
THOMAS GRAY,	J. C. ARTHUR,	JOHN C. BRANNER,	

The sessions of the Academy will be held in the State House, in the rooms of the State Board of Agriculture.

Headquarters will be at the Hotel English. A rate of $2.00 and up per day will be made to all persons who make it known at the time of registering that they are members of the Academy.

Reduced railroad rates for the members can not be obtained under the present ruling of the Traffic Association. Many of the colleges can secure special rates on the various roads. Those who can not do this could join the State Teachers' Association and thus secure a one and one-third round trip fare.

ROBT. J. ALEY,
KATHERINE GOLDEN,
Committee.

GENERAL PROGRAM.

THURSDAY, DECEMBER 26.

Meeting of the Executive Committee at Hotel Headquarters........................8 p. m.

FRIDAY, DECEMBER 27.

General Session ....9 a. m. to 12 m.
Sectional Meetings ....2 p. m. to 5 p. m.

SATURDAY, DECEMBER 28.

General Session, followed by Sectional Meetings.......................... 9 a. m. to 12 m.

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

PROFESSOR M. B. THOMAS,

At 11 o'clock Friday morning.

Subject: "Forestry in Indiana."

The following papers will be read in the order in which they appear on the program, except that certain papers will be presented "*pari passu*" in sectional meetings. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another whose time is approximately the same. Where no time is sent with the papers, they have been uniformly assigned ten minutes Opportunity will be given after the reading of each paper for a brief discussion.

N. B.—By the order of the Academy, no paper can be read until an abstract of its contents or the written paper has been placed in the hands of the Secretary.

GENERAL.

1. Correlation of Forestry and the Sciences, 10 m......W. H. Freeman
2. The Center of Population of the United States, 5 m......J. A. Miller
3. The Relation of Scientific Organizations to Manufacturers, 10 m ....R. B. Polk
4. Mounds and Burial Grounds of Bartholomew County, Indiana, 5 m............J. J. Edwards
5. Experiments in the Hybridization of Fishes, 15 m..W. J. Moenkhaus
6. Microscopic Organisms Found in the Lafayette, Indiana, Reservoir, 10 m............Severance Burrage

MATHEMATICS, PHYSICS AND ASTRONOMY.

7. Investigations in the Electro-deposition of Platinum, 8 m., J. A. Cragwall
8. Note on Some Experimental Work with a New Form of Pressure Regulator, 10 m............Wm. K. Hatt
9. Elastic Changes in Bars of Nickel Steel, 10 m..........Wm. K. Hatt
10. Kirkwood Observatory, 10 m............J. A. Miller
11. Daylight Meteors (by title)............J. A. Miller
12. Physical Observations of Mars at the Opposition of 1901, 10 m............W. A. Cogshall
13. On the Density and Surface Tension of Liquid Air, 10 m..C. T. Knipp

14. A Few Experiments with Liquid Air, 3 m..............C. T. Knipp
15. The Bitangential of the Quintic, 20 m.................U. S. Hanna
16. A Theorem in Geometry, 3 m..........................J. C. Gregg
17. A Simple Proof that the Medians of a Triangle Concur, 3 m...J. C. Gregg
18. Note on an Attempted Angle Trisection, 3 m.............R. J. Aley
19. A Problem in Geometry, 3 m......................J. A. Cragwall

ZOOLOGY.

20. An Aberrant Etheostoma, 3 m...................W. J. Moenkhaus
21. The Spinning of the Egg-sac in Lycosa, 5 m........W. J. Moenkhaus
22. The Culture of Amoeba, 2 m.........................A. J. Bigney
23. Protective Coloring of Terns, 5 m.....................A. J. Bigney
24. Effect of Pressure on Developing Eggs, 10 m............A. J. Bigney
25. Zoölogical Survey of Minnesota, 10 m...................U. O. Cox
26. The Eyes of the Rhineura Floridana, the Blind Amphisbaenian from Florida, 10 m.................C. H. Eigenmann
27. The Eyes of the Blind Shrimp from the Artesian Well at San Marcos, Texas, 10 m.........................E. M. Neher
28. Report of the Biological Station, under the direction of C. H. Eigenmann
    (a) Maps of Winona, Pike and Center Lakes, 10 m....A. A. Norris
    (b) The Mollusca of Winona Lake, 10 m.............A. A. Norris
    (c) The Dragonflies of Winona Lake, 10 m.......E. B. Williamson
    (d) The Flora of Eagle Lake and Vicinity, 10 m......H. W. Clark
    (e) Plant Ecology of the Winona Lake Region, 10 m..Lucy Youse
29. Variation Notes, 5 m........C. H. Eigenmann and Clarence Kennedy
30. The History of the Eye of Amblyopsis; Abstract, 10 m., C. H. Eigenmann
31. Zoölogical Miscellany, 10 m......................C. H. Eigenmann

GEOLOGY AND GEOGRAPHY.

32. Niagara Group Unconformities in Indiana, 10 m........M. N. Elrod
33. The Valley of the Lower Tippecanoe River, 10 m......F. J. Breeze
34. Concerning a Series of Well-defined Ripple Marks in the Hudson River Group, Richmond, Indiana, 10 m., Joseph Moore and A. D. Hole
35. Variation in the Spires of Seminula Argentia (Shepard) Hall, 10 m.....................................J. W. Beede

*36. Note on the Changes of Fauna at the Beginning of the Kansas Permian, 5 m. . . . . .J. W. Beede

37. Topography and Geography of Bean Blossom Valley, Monroe County, Indiana, 3 m. . . . . .V. F. Marsters

*38. Note on Cross-bedding in the St. Louis Limestone, Monroe County, Indiana, 5 m. . . . . .V. F. Marsters

39. Wabash River Terraces in Tippecanoe County, Indiana, 12 m. . . . . .Wm. A. McBeth

40. History of Wea Creek, Tippecanoe County, Indiana, 12 m., Wm. A. McBeth

41. Paleontology of Bartholomew County, Indiana, Mammalian Fossils, 5 m. . . . . .J. J. Edwards

CHEMISTRY.

42. Organic Acid Phosphides, 5 m. . . . . .P. N. Evans

43. Adsorption of Dissolved Substances, 10 m. . . . . .P. N. Evans

44. The Determination of Manganese in Iron and Steel, 10 m., W. A. Noyes and G. H. Clay

45. A New Hydroxy-dihydro-alpha-Campholytic Acid, 10 m., W. A. Noyes and A. M. Patterson

BOTANY.

46. Some Drug Adulterations of Note, 10 m. . . . . .John S. Wright

47. Notes on Apple Rusts, 8 m. . . . . .H. Whetzel

48. Notes on the Genus Stemonitis, 8 m. .H. Whetzel

49. Vegetation of Abandoned Rock Quarries, 10 m. . . . . .Mel T. Cook

*50. The Phytogeographic Regions of Indiana, 10 m. . . . . .Stanley Coulter

51. Contributions to the Flora of Indiana, 5 m. . . . . .Stanley Coulter

52. Germinative Power of Conidia of Aspergillus Oryzae, 10 m., Mary F. Hiller

53. A Study of the Histology of the Wood of Certain Species of Pines, 10 m. . . . . .Katherine E. Golden

54. A Comparison of the Microscopic Structure of Cuban, Mexican and Philippine Mahoganies, 10 m. . . . .Katherine E. Golden

*55 Some Characteristic Plants of Tennessee, 10 m. . . . . . . .G. W. Martin

*56. Interesting Phases in the Development of Cypress "Knees," 10 m. . . . . .G. W. Martin

* Paper not presented.

57. Spore Resistance of Loose Smut of Wheat to Formalin and
Hot Water, 10 m.............................Wm. Stuart
58. Some Additions to the Flora of Indiana, 3 m............Wm. Stuart
59. Effect of Composition of Soil Upon the Minute Structure
of Plants, 15 m..........................Herman B. Dorner
60. A Collection of Myxomycetes, 10 m.................Fred Mutchler

THE SEVENTEENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The seventeenth annual meeting of the Indiana Academy of Science was held in Indianapolis, Friday, December 27, 1901, preceded by a session of the Executive Committee of the Academy, 8:30 p. m., Thursday, December 26th.

At 9:15 a. m., December 27, President Mason B. Thomas called the Academy to order in general session, at which committees were appointed and other routine and miscellaneous business transacted. Following the disposition of the business, papers of general interest were read until 11 o'clock, at which time the retiring President, Mason B. Thomas, made his address; subject, "Forestry in Indiana."

At 2 p. m. the Academy met in two sections—biological and physico-chemical—for the reading and discussion of papers. President Thomas presided over the biological section and Dr. Thomas Gray acted as chairman of the physico-chemical division. Both sections adjourned about 4:30 and the Academy was assembled in general session for the transaction of business.

Adjournment, 5 p. m.

THE FIELD MEETING OF 1901.

The members assembled at Orleans, Orange County, leaving this point in carriages early Friday morning, May 24. They visited the region of Lost River, which is rich in geological, botanical and zoölogical features. From this locality the party went to West Baden, in which district Saturday, May 25, was spent.

PRESIDENT'S ADDRESS.

MASON B. THOMAS.

FORESTRY IN INDIANA.

It seems strange that while European countries, with their vast tracts of forests, were spending money, energy and time in an effort to secure a conservative and economical management of their timber lands and, in most cases, had brought the whole question to a very practical and wise solution resulting in the maintenance of the steady value of the forest crop and securing by careful and well managed cutting the largest possible yearly production and revenue, the United States did practically nothing to arouse her citizens to some such rational forestry management. It was not until 1873 that the American Association for the Advancement of Science, at its Portland meeting, appointed a committee to urge Congress to some action in connection with our forestry interests. The recommendations of this committee were favorably received, but not until 1876 was the Commissioner of Agriculture required to appoint a man to study our forestry resources, the consumption and exportation of our timber, the extent of our supply, the effects of forests on our climate and the best methods to employ in conserving them. Since that time the work of the Department at Washington has grown under the care of Messrs. F. B. Hough, N. H. Eggleston, B. E. Fernow, and the present Forester, Mr. G. Pinchot, who in the order named have been in charge of it. They have, with very meager appropriations—to 1899 but $247,216.85—collected and published a large amount of valuable information relating to our forests, their use, care and abuse, and have secured the coöperation of many public-spirited men and not a few scientists, who have started, in many States, active campaigns educating the public in forestry matters and securing proper forestry legislation. Our federal government can not obtain the desired results without the active coöperation of the States and the support of its private citizens. Our own fair Indiana has been very remiss in the discharge of her duties in this matter, and the neglect has resulted in a great loss to our timber interests and the consequent injury to its numerous dependencies.

The State of Indiana is a part of the North Central Division of our country and includes 36,350 square miles, with an acreage of 23,264,000.

When the early explorers paddled their birch canoes from the Ohio up the Wabash and its tributaries they passed through a great wilderness of native forests of giant oaks, elms, maples and beeches. From the very banks of the streams where they landed to the tops of the highest hills was one unbroken covering of the forest primeval. The tall sycamores, lining the river banks like sentinels, crowded into the rushing waters the overhanging willows at their feet and guarded the giant elms, hardy soft maples and buckeyes of the rich river bottoms, while from the higher ground looked down the tall and rugged oaks, the mighty beeches and hard maples, walnuts, ashes and hickories, with here and there a towering tulip, all vying with each other for soil and sunshine. The lowlands of the north were clothed to the very water's edge with tamarack, ash and soft maples and the sterile soil of the south supported a thick growth of cedars and scrub oaks. Everywhere trees and shrubs of lesser size struggled with each other and with multitudes of herbaceous plants for every inch of soil and ray of sunshine. The records of the dimensions of some of these giants of our virgin forest seem past belief. A few illustrations will suffice.

Red maple—Height, 108 feet; circumference, 13 feet.

Hickory—Height, 150 feet.

Tulip—Height, 190 feet; circumference, 25 feet.

Sycamore—Height, 120 feet; diameter, 13 feet.

Cottonwood—Height, 150 feet; diameter, 8 feet.

White Oak—Height, 150 feet; circumference, 20 feet.

Basswood—Height, 190 feet; circumference, 17½ feet.

The forest floor was a spongy mass of forest litter that held in its pores the products of many rains and freely gave of its wealth to thirsty soil of open areas and to the multitudes of springs that kept the rivers to a uniform volume. Birds and animals of many kinds and in great numbers found here a suitable home, while the streams were stocked with an abundance of fish whose nearly ideal environment gave no suggestion of future extermination. Such was the picture of the forest primeval.

This condition, contrasted with the one we now see about us, tells of striking changes during a short period. Everywhere level fields of beautiful corn, wheat, and other crops clothe the tracts that were once covered with forests.

In 1870 the State contained 7,189,334 acres of forest, which was one-third of its era. This acreage placed Indiana well up in the list of forest States. In 1880 this had been reduced to 4,335,161 acres, or one-fifth of the State's area. The records show that up to that time the forests had been removed mostly in the interests of agriculture and that no large bodies of the original tracts remained. At this period Indiana ranked fifth in her lumber manufacturing interests, but the statistician records the warning that, at the present rate of consumption, the forests of the State must soon cease to be commercially important.

In 1890 one-twelfth of our total area remained in forests, and the decade between 1880 and 1890 may be said to mark the greatest real loss to the State. The large decrease before this period was so closely connected with the clearing by settlers for cultivation that little of the timber in tracts not suitable for argiculture had been disturbed.

Between 1870 and 1880 2,854,143 acres of timber were removed and 3,829,459 added to cultivated lands, indicating a great demand for all tracts cleared in the past and also such open areas as might be tillable, while between 1880 and 1890 2,604,005 acres were cleared and but 1,173,744 acres added to cultivated fields. Over 260,000 acres were cleared annually during this period, or an excess of 60,000 acres yearly over what was removed in the most active immigration period just preceding. Timber was cut for revenue, and the demands of the manufacturing and shipping interests caused the owners to forget the relation of forests to our general prosperity. How the statistician's prediction has been fulfilled may be realized by reference to the statement of a well-known forester who, last year in reviewing the forestry interests of each State, says of Indiana that her forests have long since ceased to be of any value commercially. While this is not strictly true, it does illustrate the drift the State is making in this direction, since we now have but 1,227,141 acres, or one-twentieth of our whole area, in forests, and much of this has been cut over and the valuable part removed. The State no longer has any important supplies of valuable timbers, like oak, walnut, poplar, etc.

At present our largest tracts of timber are in the extreme southern part, in Franklin, Harrison, Brown, Jackson, Lawrence, Martin, Perry and Washington counties and a small tract in the north in Allen and Kosciusko counties. A few scattered tracts may be found elsewhere, but in the main these bodies are small and the timber of little consequence. The western border of the State contains but little timber and is the eastern edge of the great treeless region that extended over the north in Benton, Newton and Jasper counties and over much of Lake, Porter, Laporte, Pulaski, White, Tippecanoe and Warren. Some of this is now covered with young forests that will eventually add much to the forest resources of the State.

An examination of the topography of the State shows that the cleared lands include the headwaters of our principal rivers and streams. The entire basin of the Wabash and its tributaries has been more or less denuded, or at least does not contain any considerable area of timber land. The basins of a few small streams, like the Blue and Pigeon Rivers and a part of White River, are still wooded and the influence of the remaining tracts here, as elsewhere, is manifest in the less conspicuous changes in the streams so protected. Truly the problem of securing the proper maintenance and control of the forests of the State is grave and important.

In order to appreciate fully the real value of our forests to our State let us consider their general influence upon some of our natural conditions and industries affecting the general prosperity of our commonwealth.

One of the most important assertions made by those who advocate rational forestry management is that the forests exercise a very large influence on our climate and rainfall. So great have been the claims of these zealous advocates that I sometimes feel that the whole cause of forest care is seriously injured by claims for which no convincing proof is forthcoming and which do not appeal to educated people accustomed to think for themselves. In fact, too often scientific men have indulged in pleasant contemplations on this subject and made statements that were not founded on sufficient data to satisfy a man who did not believe things because he wished them to be so. For the thorough examination of this problem we must have accurate data of climatic conditions for many years and in connection with these careful records of forestry changes for the same territory. In the study of these it should be kept in mind that general climatic variations occur in all countries even where no changes have been made in forestry matters and it accordingly becomes difficult to determine the exact relation of the forest changes to climatic variations in other countries where marked changes have taken place in the forests. Notwithstanding the fact that different climatologists maintain exactly opposite views regarding forest influences on the climate, there are certain facts that are hardly controvertible. It is doubtful if the forest tract influences very largely the climatic conditions or total rainfall of a country except in a very few favorably located regions, but the important thing for us to consider is the value of Indiana forests to our own commonwealth and if possible the extent to which we would be justified in devoting time and money to secure certain forestry regulations.

The soil of a forest is less susceptible to sudden variations in temperature than that of the fields outside, and consequently warms more slowly in summer and its cooling is delayed in the winter. The summer effect is much more marked than the winter effect. The mean annual temperature of the forest soil is about 21 degrees lower than that outside. In the summer this cool soil will temper the air above it, start currents in the direction of adjoining fields and lower their temperature.

The average annual evaporation within the forest is but fifty per cent. of that in the open, and the difference between the two is greatest in the summer when the saving for the forest is the largest and most needed. About twelve per cent. of the precipitated water is evaporated in the year from forest soil and forty per cent. from open fields, the presence of the forest litter effecting a saving in some cases of seven-eighths of what would otherwise evaporate directly. Much of this difference is due to the looseness of forest soil and its poor capillarity that fails to draw the water to the surface. That the forest serves as a windbreak, in preventing currents of air from rushing over adjoining fields and depriving them of their moisture, is obvious to all.

The extent to which the forest influences affect the adjoining fields, and the distance to which this may be felt, depends on the nature of the forest, its size, composition, age, exposure, underbrush, elevation, proximity of streams, etc.

A collection of all of the published records of temperature and rainfall taken in the State has been studied, but they do not furnish such data as would in any way bear on the problem in hand. The earliest records were made in 1867 at but two points in the State. The central office at Indianapolis was not organized until 1882 and its first publication was in 1884. In a half dozen places records were kept from 1872 to 1881 and then discontinued. All of these stations were cities or towns and do not afford data for the forests about. Certain it is that statistics to support our claims are not forthcoming in Indiana, but our conditions are not unlike those of other States from which these facts were gathered, and the results are applicable to our own territory.

The influence of the forests on the fertility or productiveness of our land has been discussed from may points of view and it is hardly safe to generalize in a matter so dependent on the controlling influences of local conditions. The forests do affect climatic conditions in their immediate vicinity, and further, their influence is along the line of those changes that would act most beneficially to agricultural crops. The preservation of the rainfall by the forests is also of great advantage to our agricultural interests. These beneficial influences in Indiana are, in my judgment, evident only in the immediate vicinity of forests, and their removal has not, as far as statistics show, affected the production of certain crops in the whole State in any prejudicial way. The general disastrous effect will not be evident for some years. The great richness of our soil and its general suitableness for agriculture delays the certain penalty, but it is sure to come, and then the restoration will be a long and difficult process.

The annual yield of corn per acre has been gradually increasing in the whole State during the last thirty years, as the averages for these five-year periods will show:

1876—1880	23.55 bushels per acre
1881—1885	23.48 bushels per acre
1886—1890	29.77 bushels per acre
1891—1895	30.4 bushels per acre
1896—1900	37.2 bushels per acre

While it is doubtless true that some of this increase may be due to better methods of cultivation, yet it is hardly likely that this has produced any appreciable change during the last ten years, while during that period we have removed 509,045 acres of our forests, or more than one-third of the whole amount that remained. The average yield for each of the last three years is larger than for any previous year in the history of the State. Practically the same is true of our wheat, as these records will show:

1880—1884	12.3 bushels per acre
1885—1889	13.2 bushels per acre
1890—1894	15.8 bushels per acre
1895—1900	12.46 bushels per acre

This nearly steady increase is interrupted by the very low acreage of 1895 and 1896, when the yield per acre was below that of any previous year for which records exist, and certainly this falling off could not be due to deforestation since the three succeeding years returned to the normal yield per acre. The year 1891 produced the largest yield in the history of the State, 20.9 bushels per acre. With oats the records show practically the same:

1878—1880	19.3 bushels per acre
1881—1885	30.56 bushels per acre
1886—1890	27.39 bushels per acre
1891—1895	26.26 bushels per acre
1896—1900	29.99 bushels per acre

These fluctuations do not indicate the constant deleterious influences of deforestation, and in 1899 and 1900 the yield per acre reached its maximum.

The same general conditions are found to exist in the case of other cereals.

While these things are true for the whole State, in those localities that have suffered most from deforestation the amount of wheat and other grains produced on an acre has fallen off with the steady decline of the forests. These local losses seem to be made good by the heavy yields of newly cleared ground which has not yet felt the full effect of cutting away its adjoining timber, but the time must certainly come when what has been true in so many countries will be found true here. The world is full of examples of barren and sterile areas that were once verdant and productive, and the change has been brought about as the result of deforestation.

The whole Mediterranean country was once the garden of the world, but with the ruthless destruction of the forests came the blight of drought, cruel winds, storms and snows, that ruined rich plantations, made vine-clad slopes unproductive and impoverished the entire basin. Parts of Germany, France and Spain have taken alarm at the approach of similar conditions and, at great expense, have restored to the lands their covering of trees and the return of prosperity has demonstrated the necessity of forests to the fertility of the soil.

One of the direct results of the destruction of our forests has been the disappearance of our springs, the consequent failure of our domestic water supply and the variation in volume and regularity of our streams. The annual rainfall has varied but little during the last fifty years, but the method of its disposal has materially changed. The great water capacity of forest soil and litter, the rapidity with which water percolates through it, the irregularity of the forest floor and the general absence of ditches and gullies, decreases surface drainage during precipitation. The uniform covering of snow in winter prevents the soil from freezing and when the snow melts this body of water is retained. The great mass of water formerly held by the forest and gradually given out to the streams as they carried off the more immediate supply now flows from unprotected fields like rain from gravel streets, washing away the best of the upland, inundating the lowlands, and making agriculture along the banks of many streams most uncertain.

Then, too, the navigability of our streams has been seriously affected. The headwaters no longer contain sufficient water to float even the old-time flatboat, and farther down the stream the channel is simply a labyrinth of bars and shoals, products of denuded fields above, making navigation impracticable. The failure of our streams to compete as formerly in the commerce of our State increases the cost of living and destroys what otherwise might be a great industry.

The Wabash River, extending northward from the Ohio, receives tributaries from almost every section and drains four-fifths of our commonwealth. The central and southern parts are reached by the north and east branches of the White River and the north and north central parts by the Wabash and Tippecanoe. The records of the early navigation of these streams is full of interest. The head of navigation for boats of small draught was Monticello on the Tippecanoe, Logansport on the Wabash, Indianapolis on the White River, and on the east fork of the White and Muscatatuck rivers, as far east as Scott County. On the southeast the White River was navigable to Brookville.

Some of these early boats had really a large carrying capacity. One built at Terre Haute for the navigation of the Wabash was one hundred and thirty feet long and twenty-nine feet wide, with a carrying capacity of three hundred and fifty tons.

From the heads of navigation and below, and from the smaller tributaries of all of Indiana's streams from many miles in the interior, flat boats carried lumber, pork, poultry, corn, wheat, oats, fruits and hoop-poles down the Mississippi to New Orleans and the returning river steamers distributed great quantities of freight up many of these streams into the State. To some extent the smaller tributaries of the Ohio that reached into the State through one or two counties were factors in our transportation system. But all of this has passed away and from only a few places on the lower Wabash do we receive any practical advantage from our waterways. It would be unreasonable to claim that deforestation has been the cause of all this, for cultivation of open fields and the extensive underdrainage of level areas has contributed very materially to these results.

Our lumber interests are of sufficient importance to demand our very careful protection. They represent the second largest industry in the State and with the disappearance of the supply of raw material our very large income from them will be seriously curtailed. For many years our timber industries have drawn raw material from the best of our timber resources at a comparatively low price, but now the quality of this material is decreasing and the price increasing. Both of these factors make it difficult for our manufactures to compete with corresponding establishments located in timbered districts. To be sure, much of the raw material could be shipped in, and indeed about eighty per cent. of it is now imported, but this additional cost makes it impossible for our manufacturers to compete successfully and they are compelled to move to other States. We have already lost some of our important plants to Kentucky, Missouri and Arkansas.

In 1840 our lumber production (raw material for our factories) amounted to $420,791, in 1877 to $10,791,428, and in 1893 to $18,403,267.

The last ten years has seen an almost phenomenal increase both in number and variety of wood industries. More than fifty different kinds of establishments are using wood as their raw material, and to supply this demand timber has been cut without reference to its effect on the land or the State.

Some interesting and striking facts are discovered from an examination of our fruit crops in connection with the deforestation of our lands. The discoveries are certainly suggestive of a very close relation between the two.

In 1880 the eleven counties producing the largest yield of apples were as follows:

Counties.	Bushels of Apples.	Acres of Forest.
Allen	1,007,576	108,132
Crawford	608,043	50,005
Harrison	610,500	81,807
Kosciusko	602,462	52,275
Laporte	617,353	33,457

Counties.	Bushels of Apples.	Acres of Forest.
Ripley	650,735	69,183
St. Joseph	780,243	43,958
Steuben	655,843	47,973
Sullivan	1,059,149	46,867
Washington	888,421	80,852
Wayne	607,377	47,265

Several of these counties are among the most heavily wooded of any in the State and, with the possible exception of Laporte, they all contain a very large acreage of forest. The history of the apple crops in connection with the history of the removal of the timber in these counties helps to substantiate our claim for their importance. In 1897 these counties made the following showing:

Counties.	Bushels of Apples.	Acres of Forest.
Allen	6,170	29,876
Crawford	9.894	22,374
Harrison	57.241	40,125
Kosciusko	721	24,052
Laporte	1,304	17,490
Ripley	7,630	27,079
St. Joseph	980	9,463
Steuben	432	1,746
Sullivan	13,123	9,718
Washington	8,202	42,381
Wayne	3,863	7,718

From these figures it appears that the counties now exhibiting the largest falling off in their apple crops show nearly corresponding reduction in their forest areas (Allen, Sullivan, Steuben, Kosciusko, St. Joseph). Similar conditions are not found all over the State, but it is certainly suggestive that those counties that formerly produced the largest apple crops and have suffered most from deforestation have fallen to the end of the list in their yield of apples (Steuben, Sullivan, St. Joseph, Allen), and the importance of the forest becomes the more significant when we discover that of the counties formerly producing the largest crops those have fallen off the least that have removed the smallest amount of timber (Crawford, Harrison, Laporte, Ripley, Washington).

These relations are too significant and constant to be simply coincident, and in my judgment do demonstrate a very close relation between the forests and the fruit crops.

It is true that many counties like Tipton, Vigo, Putnam and Hendricks, that are not now largely covered with timber, are among our best producers of apples, but in these places investigation shows that the raising of apples is attended with great difficulty and spraying and other precautions are required that twenty years ago were not necessary. I do not insist that the presence of large tracts of forests in Indiana are absolutely necessary for the production of a successful fruit crop, but the facts seem to show that such tracts are conducive to its best development. It is more than a coincidence that Harrison County, with the largest acreage of forest of any county in the State, stands second in the size of its apple crop and first in its peach crop.

The influence of the forest is manifested in their moderating effects that prevent sudden changes and extremes of temperature that would be injurious to fruit trees; also the retention of the snow in winter prevents the ground from freezing and imperiling their roots. The removal of the forests in the vicinity of orchards has caused the disappearance of the large number of birds that formerly made their homes near but are now driven to distant forests for nesting and seldom appear in the orchard. These birds formerly destroyed large numbers of insect pests that now so seriously affect both trees and fruit. The general absence of these insects in heavily timbered counties is doubtless due to the birds. It is not likely that the presence of new insect pests, introduced into the State in nursery stock and in other ways, would account for the decline in many counties since any such pest would soon be generally distributed over the State and affect all regions alike. The raising of perfect apples is attended with difficulty and yields such poor financial returns that the number of trees in the State has decreased twenty-five per cent. during the last twenty years, but the decline in the yield has been fifty-five per cent. for the same period.

There can be no question as to the influence of the forests on the abundance and condition of the fish in our streams. The presence of fish depends largely on the constancy and character of the water in the stream and this is so directly connected with the size and location of our forests that the relation is easily recognized.

Early records show that our fishing industry was very important and the source of no little revenue that provided the sole support of many of our citizens. Nearly all of this has passed away, fishing is not now an established business and the food fishes are gradually disappearing from our streams. It is true that seining, dynamiting, and other methods of illegal fishing and stream pollution are responsible for much of this, but the complete disappearance of many streams and the steady reduction of others, with the uncertainty of their volume, has been by far the largest factor in the decline. This uncertain flow and decrease in volume prevents the stream from clearing itself particularly in the summer when the danger from its pollution is greatest. Such waters are not suitable either for the homes of fish or their spawning and we must change the character of our streams if we expect to return to our former conditions.

The present condition of the forests in the State as they appear from a general examination makes us realize the magnitude of the problem we are facing. Nothing succeeds like success, and to this might be added nothing fails like failure. This is exemplified in studying the large tracts of partially cleared and neglected timber land all over our State. A great portion of this area is covered with old and ill-shapen trees of valuable woods not removed in lumbering and many thrifty trees of wood that is not now considered valuable and, in addition to this, many thrifty trees of good timber not yet large enough to be marketable, growing without any care or attention, too isolated to secure for the valuable trees the benefits of natural pruning that would result in clear stems, or to secure for the vicinity the natural advantages of a forest in retaining the forest litter or influencing the soil, water supply, and to some extent the climatic conditions. At the same time the trees are too close and afford too much shade to permit the growth of good grass. The problem is too complex for the average owner, the whole area grows steadily worse and soon ceases to excite a desire for improvement in the mind of the holder.

The causes of this decline in our forests, beyond the legitimate clearing for cultivation, have been many, but the most important of all has been man's greed and the desire for immediate realization of his heritage. This desire has not been curbed by an appreciation of the importance of our forests to our prosperity. For this educated people, who are conscious of the many important consequences resulting from the decline of our forests, are more or less responsible.

Some of the other causes of the forest's decline may be properly considered in turn.

The greatest foe that attacks our forests is fire. No other destructive agent leaves us with so little in our hands to mourn over or to form the incentive for future care and protection. The great destroyer engulfs everything it reaches and we are left with ruined and blackened fields that indicate the cost of its visit. The loss and danger is two fold: First, the destruction of old and marketable standing timber that could soon be converted into cash, and the stunting and scarring of many young trees that never recover or make at most an insufficient growth, in the end to be discarded as poor or unsound timber; second, the loss of forest humus and of young sprouts and seedlings that represent the working capital of the farmer or forester. Upon this the hopes of his future profits depend, and while the loss seems difficult to estimate at the occurrence, it becomes more manifest as time passes and the fields become simply waste land covered with herbaceous and shrubby vegetation, scattering noxious weeds over all the region and bringing no returns to the owner.

The extent to which Indiana has suffered from forest fires can hardly be discovered. We have had no historic fires, such as those of Michigan or Wisconsin, to use as a suitable text for vigorous protestations against carelessness on the part of farmers, hunters and railroads, but careful estimates show that we are annually losing large sums in this way, and a little care and foresight would relieve us of this useless waste. In 1880 90,427 acres of timber were burned over, resulting in an estimated loss of $130,335, and during that year no unusual fires occurred. This indicates approximately our annual loss. We should take immediate steps to check this waste.

Something must be done to secure immunity from the great loss we suffer from browsing animals, which now prevent the reforesting of many tracts that would otherwise soon naturally grow up to young trees. The pasturing of our wood lots prevents the possibility of natural increase in the forest acreage and deprives the forest soil of much of its value from the destruction of its litter by the stamping of cattle. This can be more efficiently remedied by securing the coöperation of the owner than by legislation.

The State also loses much from destructive lumbering. A visit to any of our large timber tracts shows the reckless waste from this cause. Without any thought of the future a tract is cleared of its timber and only the best of the logs are drawn out. Frequently large tops with their limbs that might be utilized in many ways are left. Small trees or saplings are removed for wood or are cut down in making roads and in clearing and the possibility of early reforestation is destroyed. The debris of such reckless logging operations remains on the ground to invite destructive fungi and insects and furnish fuel for fires that otherwise might run out if the ground was clear or covered with a thrifty growth of young trees.

The marked increase in the number of concerns using small and second growth timber makes it important that we watch the development of our young forests lest they, too, fall a victim to man's greed before they are of sufficient size to be profitably marketed or before plans for systematic cutting are inaugurated.

Insect ravages are a source of very serious loss to our forests in many parts of the State. Our records show occasional outbreaks in various localities and whole forests are frequently denuded. While in the majority of cases this does not at once result in the death of the tree, it does produce serious loss in its effect on the reduced growth and diminution in thickness of the annual ring, that valuable increment that represents practically the only return to the owner. Frequently deformations and abortions of various parts result from the attack of borers and other insects. In most cases it is hardly practicable to inaugurate exterminative measures when any considerable area is affected because of the great cost and difficulties in treatment, but where local outbreaks occur, due to particularly dangerous pests like the San José scale, and the whole region is threatened, the State can well afford to coöperate and promptly back such measures as will result in wiping out the cause of the danger.

A most important and practical precaution to prevent the increase in insects and fungi is to remove, as far as possible, old stumps and logs, cut down and convert into wood or lumber dead trees, or remove their bark, and thus decrease the possibility of the multiplication of the pests by destroying their usual and most frequent breeding places.

As far as I have been able to observe, our State has suffered little in the way of extensive outbreaks in any particular locality from parasitic fungi, and while a goodly number of species of these destroying agents may be found in the State, yet they are of the kind that attack very old or dead timber and could be readily controlled by proper attention to the destruction of their usual breeding places, as was suggested in the case of the insect pests. The marketing of timber deteriorating from the presence of fungi would preclude serious loss.

Of other forest enemies, storms, lightning, snow, gnawing animals, etc.. we have our occasional outbreaks, but none of sufficient magnitude in recent years to cause serious loss. The destruction frequently resulting from the first agent could usually be very much reduced if prompt measures were taken to market, as soon as possible, all timber that had in any way been irreparably injured.

We should carefully guard every avenue of waste. Our inexhaustible fuel beds should be made, as far as possible, to take the place of the more valuable timber that is now being used for wood. Many so-called worthless and cheap woods could doubtless be substituted for valuable kinds now generally used and a more accurate knowledge of the properties of our various woods by our wood workers would effect a great saving. More up-to-date methods of sawing, happily now being largely used, would also increase our resources.

The importance of our forests to our State should now be apparent. Their influence on the rainfall secures in time and place results of greatest benefit to all. They likewise influence in a beneficial way the immediate climatic conditions, the value of our soil for agricultural purposes and the production of a satisfactory fruit crop. They determine very largely the number and character of our streams, their importance as water-ways, and the abundance of food fishes. They are indispensable to flourishing manufacturing and commercial industries, thus affecting the distribution of population. I may also add, we owe something to them for the maintenance of good sanitation and low mortality.

The very much depleted condition of our forests and the danger of their complete destruction from the forces just enumerated calls for immediate and vigorous action. This should be along two well defined lines: education and legislation. The land owners of the State can be forced to do but little, but by judicious and united efforts a public sentiment can be created in favor of the movement and the majority of the forest owners will join in the efforts to secure practical results.

The State, county and township agricultural associations at all public gatherings should present forestry topics for discussion, and here, as elsewhere, competent persons should present the facts applicable to local conditions, giving to the farmers simple and practical directions for the care of their forests and the most economical methods for increasing their acreage. At fairs and meetings of associations opportunity is nearly always afforded for such work. Our teachers should be urged to give at their gatherings frequent opportunity for the presentation of such forestry matters as would be appropriate to the occasion. At our agricultural college and in connection with several of our public educational institutions courses in forestry should be given so that our coming generation of agriculturists, teachers and professional men may deal with our problems in an intelligent way. We need in every community men trained in forestry matters who, even though they may not be actively engaged in forestry work, will be the leaders of public sentiment and the organizers of movements in the direction of forest care. Some of these men may in time be encouraged to supplement the work of the State by securing control, at tax sales or in other ways, of suitable forest lands and managing them in a manner to obtain a permanent investment, that could be made to yield a reasonable return to their posterity. In some countries large estates have been left in this way, protected by proper conditions that would prevent subsequent holders from depreciating the value of the investment, that, well managed, would yield a very liberal return.

Although the State does not own forest lands, she should educate her citizens in this subject for the same reason that she now does in agricultural matters, even though she is not engaged in agriculture.

It is also important that the public schools lend their influence to this cause in devoting some part of their time to the general study of our trees and the value of our forests. This need not be introduced into the curriculum as a regular subject, but in connection with the nature work in the grades some few matters might be presented and in the high school a few talks to the whole student body each term would accomplish very much, indeed a simple recognition of the importance of the subject would greatly assist in securing a hearing with the young. A German proverb says, "Whatever you would have appear in the nation's life you must introduce into the public school, and in not doing this we are missing one of the most important means of bettering our forestry conditions."

Fortunately one day has been set apart for the consideration of our forest interests, and the proper observance of arbor day in our State affords one of the very best methods of presenting this subject to the people. This day should be carefully observed in every school district in the State as a holiday and appropriate exercises should be prepared for the occasion. In these exercises the pupils of our public schools should take as prominent a part as possible by reading suitable poems or presenting essays on various subjects connected with our trees and forests.

In addition to this there should be presented to the people at these gatherings a thoroughly practical talk by some one trained in forestry matters on subjects that will reach the farmers, who own ninety-seven per cent. of the forests, and direct them in improvements and work that will result in a betterment of our forestry conditions. An effort should be made to correct the prevailing impression that forestry means the hoarding of trees. It should be clearly explained that the application of proper methods would result in inaugurating a system of intelligent cutting that would bring to the owner the largest yearly returns without impairing his investment. It should be further explained that there is no desire to re-forest land well adapted for cultivation, but rather to cover with forests the vast areas of brush and waste land, that in 1893 represented thirty-five per cent. of our total acreage, and that only in this way can these tracts be made profitable.

The thoroughness with which the State is settled makes it likely that this land is unfit for cultivation, and if this could be added to our permanent forests, and these properly managed, our condition would be almost satisfactory. This waste land is well scattered throughout the State, but several large tracts are located in Harrison, Parke, Perry, Jackson and Crawford counties, and these should, if possible, be secured by the State. No other line of activity offers as large returns with so little labor as the reclaiming of these waste tracts. A little tree planting, pruning, and clearing of worthless stock for wood to pay the cost of the work, and the protection of these trees from forest enemies would soon secure a forest that would become, if properly managed, a permanent and paying investment. An especial effort should be made to reclaim all of this land that is located in any way to influence our streams and if possible restore to the State these important factors in our prosperity.

In some States the results from the work of arbor day have been very important. In New York, last year, the day was observed in 10,251 school districts, and in twelve years 229,616 trees have been planted. Our State should not be behind in this matter.

The next important means by which we hope to secure a betterment of our forestry conditions is through legislation. The history of forestry legislation in Indiana at the opening of the last legislature was summed up by an eminent botanist who, in discussing the forestry laws of several States, said of Indiana that she had nothing to offer in this direction. While this does represent the main facts in the case it does by no means tell the whole story. A law passed in 1899 exempted from taxation permanent forest land containing not less than 170 trees per acre and also any areas that might be planted to the same number or more, cultivated a few years and protected from cattle for a stated time. A like exemption could be secured by bringing land containing 100 or more trees to the same standard and maintaining it as a forest.

This law has in it much that is good, but the results of its operation demonstrate the difficulty of accomplishing much by legislation without provision for education. This law was intended to induce owners to secure a compactness that would make their timber lands forests in all that this term means to the forester and thus prevent the clearing of land below the point where it ceased to be a forest and became a woods pasture. The financial consideration was not enough to attract any very large number of people and the farmer was not made to see the beneficial effects of the forest so preserved or the possibility of their management to secure profitable returns. Further no attempt was made to direct the owner in his efforts to bring his depleted forests to the standard where exemption could be secured and consequently the total acreage was not increased. But 284 exemptions, including 5,312 acres, have been secured in the whole State.

The law passed by the last legislature seems to be a wise one in that it places the forestry matters of the State in charge of a properly organized board with authority to make all desirable recommendations for the regulation of our forests. The last legislature deserves our special commendation in its taking the first official step and establishing a board of forestry. I am certain that this board will receive the hearty support and co-operation of the Academy of Science and of the public spirited citizens who have for many years persistently urged attention to our forestry interests and thus have opened the way for forestry legislation. To secure any permanent benefits additional laws must be enacted, whenever such as are suitable to our local conditions are suggested, and the campaign of education inaugurated must be pushed by all friends of forestry. Had the State adopted any radical legislation without the thorough study of the situation within our borders it might have resulted in a misfit, since only those forestry laws are really effective that are based on the exact needs of a locality. Additional legislation must follow investigation and not precede it.

What it is possible to accomplish by forestry legislation may be discovered by an examination of the legislation in those States that have done most in forestry matters. A few of these States have worked out problems very similar to those that now confront us and from them we may learn much. In New York, as the pioneer in this country, the legislation has developed as the result of experiment and investigation with the single purpose of preserving to the State its valuable forests. The State first, in 1885, secured control of certain large tracts of virgin forest and placed the management of these in the hands of a forestry commission. This commission was given charge of all forestry matters, including the collection and dissemination of information, the care of forest fires, the reforestation of new lands, and, in fact, was the custodian of the State's forests. This board has been several times reorganized, until the men who compose it are each charged with the responsibility of a certain part of the State's work. The remuneration is sufficient to obtain thoroughly competent persons for each department and thus secure a businesslike service. This board has expended more than $3,000,000 in the purchase of forest lands of the Adirondacks. With it all they have wisely guided public sentiment until the people are wholly in sympathy with the work and are proud of their foresight in saving to the State so much that is vitally connected with its prosperity. In addition to this New York has established a school of forestry that has already accomplished much toward solving many problems peculiar to American forests. It is fortunate that New York has been so generous in conducting her experiments on such a large scale, for the outcome of this will be of incalculable aid to other States which have the same problems to face. We can not copy European forest methods and hope to secure the greatest efficiency in our forest work. Principles are valuable but the methods of their application must vary.

In Pennsylvania the history of forest legislation shows the usual results. Failure to fix responsibility and to arouse public sentiment made the law inoperative, but in 1897 the people were stirred to action, forest fires were promptly put out and the State has established forest reserves by retaining the land that came to it from the nonpayment of taxes and in condemning for that purpose suitable tracts at the headwaters of her principal streams. Laws relieving forest land owned by farmers from taxation has done much to encourage tree planting, and what was missed in our own law has been secured here by educating the people to a realization of the importance of immediate action.

The States of New York, Pennsylvania, Wisconsin, Minnesota and Michigan, representing the most advanced position in forestry matters and in accord with the best judgment of the foremost forestry experts in the United States, have recognized the importance of the State in the control of her forests and the dangers of leaving an industry so vitally connected with the prosperity of her people wholly in the hands of private parties. The aim of the most rational forestry legislation should be to permit the State to obtain control of large tracts, located suitably to influence the head waters of our streams and our agricultural interests and secure permanency to our lumber industries, and then place the management of these in the hands of trained foresters who would secure from them a financial profit to the State in addition to maintaining their highest efficiency as forests. Then the maintenance of smaller tracts that may be acquired from the nonpayment of taxes and adding to these, as occasion presents, lands not especially suited for agricultural purposes. This policy, in those States where its effects have been observed, has received the universal support of the people. Depredations interfering with the best development of the State reserves can be controlled by positive legislation that will fix responsibility and punish the guilty. Forest thieves, fires, browsing on public lands, etc., could all be controlled with ease. In whatever is done the State must take its citizens into its confidence and be prepared to defend each policy or line of action by careful figures based on facts secured from the local conditions. The State should likewise avoid anything that savors of a monopoly in this enterprise and should in every way encourage private capital to coöperate in the work.

It would doubtless be out of place at this time to make suggestions for radical legislation since the present forestry board will no doubt soon have plans along this line based on the very careful study of the local conditions. I wish, however, to commend to the consideration of our legislators the very comprehensive and rational law before the Michigan legislature last winter. This in my judgment is the most perfect plan of forestry legislation that has been presented in this country. This bill was prepared by a forestry commission appointed in 1899, and was based on the needs as discovered from a study of the conditions.

The organization of the fire warden force is most complete: it places responsibility carefully and makes the expense of fighting fires fall largely upon the counties in which it exists, and if any negligence on the part of the warden is discovered the whole burden falls on the county in which he is shown to be remiss. A series of State reserves are to be established in suitable localities where land can be secured from that which has come to the State because of the nonpayment of taxes. The entire management of these forests is placed in the hands of the commission, and they are empowered to appoint a trained forest warden, with assistants, who will have the immediate management of these lands and be responsible to the commission. Appropriations are made for the work, and every phase of it seems to be covered by carefully drawn and very comprehensive legislation. While the laws are based largely on those of New York, they contain a few improvements, and in some respects they might be safely adopted by our own State as more applicable to our conditions. Certain details of the laws in many States are very valuable, but the aim of our State should be toward practical results and not to experiment with any plan unless it has proven to be applicable to many cases and might be effective in our own. The people must be shown the wisdom of each step and this will make our forestry work easy.

A word of caution in connection with the subject of legislation may not be out of place. Great care should be exercised against the possibility of excessive exemption from taxation or the raising by tax of money to pay premiums on forest plantations, else the burden will fall too heavily on our agricultural regions that are not fortunately located for forests, and result in a prejudice against any forestry legislation. While such legislation is a great incentive to forest attention and does stimulate a healthy interest in forest matters, it must not be too liberal or continued beyond a period when its educational effect is desirable, since practical forestry is a profitable occupation and should stand on its own merits. True some farmers have tried it and failed, so have they tried farming and not met with success, but long experience with forests under many and varied conditions has demonstrated the success of the plans, and there can be no question as to its outcome in our State. The problems that confront us in Indiana may be briefly stated as follows:

1. Preservation of our forests now located on lands that are not suitable for agriculture and the management of these tracts so that their productiveness will be permanent.

2. The reforestation in the most economical way of similar lands, now denuded, and securing for them the very best management possible.

3. The maintenance of such other tracts as may be necessary to secure the proper protection to our agricultural, commercial, and sanitary interests.

4. The securing of all needed legislation that will place our forestry interests in the hands of competent persons and supporting them by all authority necessary to secure wise management and permanency to the proper conditions.

As bearing upon the direct solution of these problems I may be permitted to make some specific recommendations. The State should establish forest reserves in different sections where at the public expense peculiar problems connected with each locality could be worked out by experts in charge and plans presented that would be sufficiently profitable to induce private capital to engage in the undertaking. It is further desirable that the State follow the plan already inaugurated in this country and establish in connection with one of our State institutions a school of forestry where our people could be trained in this branch of industrial activity and where the forestry interests of the State could be centered.

But in all of these matters the intelligent support of Indiana's best citizens is solicited and it is only with the hearty coöperation of every one that anything worthy of our great State can be accomplished.

Many fascinating fields for work and investigation along these lines are opening in Indiana, and it is hoped that our scientific friends may be induced to coöperate with our State board in these matters.

Correlation of Forestry and the Sciences.

W. H. Freeman.

Forestry as the science of promoting and fostering the forest area by preservation and cultivation has a significant correlation with the more prominent sciences of geography, zoölogy, engineering, manufacture and government.

This as a fact is beyond questioning, but the ways, manner and extent of the correlation are not generally known, nor have educators, especially in the United States, given it merited consideration. There are excuses for this. Educators and the people generally are not to be censured for this lack of attention in the preservation and cultivation of forests, even for their own good aside from the good of science. Forestry is a subject of very recent agitation in America and especially is it so in Indiana, but it is growing steadily.

President Roosevelt voices this condition of the knowledge of forestry in the opening sentence of his message bearing on the subject. He says, "Public opinion throughout the United States has moved steadily toward a just appreciation of the value of forests." Trusting that you all are familiar with what he says about forestry in his message, I shall, expressing my appreciation for such eminent recognition of it, pass to the discussion of the connective phases mentioned at the beginning.

Forestry as a science issue, it seems to me, is far-reaching in its influences. I think with consistent reason it can be shown that there is scarcely an industrial or intellectual life which forestry does not affect directly or indirectly.

Geography and forestry are closely connected in matters of climate, drainage and surface contour. Forests by their presence have marked influences on climate in governing the phenomena of temperature, moisture and storms. It is asserted by students of the subject that the denudation of forests is the cause of the growing extremes of temperature, violent atmospheric changes, changed precipitation, moisture waste through heightened evaporation and the unhindered flow over the surfaee to the streams.

The arguments are: First, the forest foliage, as a transpiratory agent, is a great source of moisture to the atmosphere; second, the foliage by its shade prevents the sun's rays from striking the earth's surface and thus prevents evaporation; third, the forest litter, humus and roots, collect, hold and store the rainfall for the gradual and constant resource of water for streams and springs; fourth, the lack of forest litter, humus and roots permits the rainfall to flow quickly over the surface to the streams and away, thus facilitating the drying up of springs and streams and restricting the climatic agents.

In addition to the facts stated above, deforestation means the uninterrupted sway of the winds to carry destruction with them and allows the sun's rays unbroken to overheat the surface and cause abnormal atmospheric conditions resulting in violent storms.

I need only to remind you that the climatic equilibrium is different from ten years ago. The temperature extremes for the year 1886 were

101 and 25. In 1896 they were 103 and 22. More frequent storms of destructive character occur throughout the summer, and the fall and lay of snow is not so constant as formerly. I am not prepared to say that the annual precipitation is much less than before deforestation, but believe the almost certain annual drouth is heightened because the rainfall is not conserved to the soil because of the conditions before mentioned.

Forestry and drainage are reciprocal. The surface drainage is changed. No one rationally doubts it. It is contracted generally, more quickly spasmodic in overflow and becoming more intermittent. The streams in former times under conditions of dense woods contained water all the year round. The rivers dammed by fallen trees and drift prevented the hasty escape of the water from their beds. But now the drifts are gone and for the greater part of the year the streams are stagnant and dead. This is true, especially of the Pigeon, Eel and Wabash rivers. Many of the lakes have shrunken in area and the small creeks and streams no longer exist.

The same causes answer for these conditions as for the climate; lessened transpiratory agents, increased facilities for evaporation, aided escape of the rainfall and destroyed storage conditions.

The unhindered flow of the rainfall over the surface correlates forestry and erosion. Erosion is altering in many places, to a considerable extent, the contour of the State and resulting in serious damage to the streams. The surface is being gullied and the soil carried into the streams and springs, thereby clogging and filling them up.

This devastation of the streams relates forestry and zoölogy. The congestion of the streams with the erosive sediment filling up the deep holes and the intermittent flow are destructive to the propagation of many of the fishes. The drying up of the deeper sloughs and swamps is exterminating the mollusks and crustaceans. The same may be said of every other water-inhabiting species.

It may be argued that in many instances it is well such is the case, but for science it is not good.

Forestry and ornithology are mutually related. The destruction of the forests means the destruction and extinction of many of the birds. Trees are the natural homes of most of our beautiful birds. It is in the forest that they nest and hatch their young. The larger food birds of both land and water habitations are almost entirely extinct in this State. The same is true of many of the finest species of plumage and song birds.

All these facts so far given, you may say, are not because of forestry, but from the lack of it. It is sadly true, and forestry at best can not hope to retrieve, but it can, if properly conducted, nourish the neglected condition and foster the remnants. The science of engineering and forestry are mutually affected, as is also manufacture and construction. "Timber physics" is the term applied to these relations. Forestry in its most complete development should strive to make known the properties of all timbers used for purposes of engineering, manufacture and construction. This knowledge should be extended to cover the properties of timber structure, physical conditions of growth and mechanical qualities. To be of value the tests made should be of the largest number, specimen and physical limitations. A definite knowledge of these and their relation to the mechanical properties will be of inestimable value to users of wood in the lines of work mentioned.

Since we are beginning to plant forests, the production of wood merely is of the smallest consideration, but to produce at the same time quality of wood is the thing to be considered. It is the endless variability in timber physics that has kept it in the background, but I believe with the thorough inauguration of systematic forestry it must come to the front.

It is a well-known fact by all who have to handle wood in constructive connections that our knowledge, technically, of wood properties is very unsatisfactory and has resulted in untold loss in every conceivable manner.

In matters of forestry and government there are to be found at the present time some of the most scientific problems for legislation and control. The management and control of the United States forest reserves against depredations of cutting, grazing, cultivation and fires, and the problem of irrigation and irrigation reservoirs for the reclamation of the arid sections of the Middle West from regions of desolation to areas of life, industry and prosperity involve difficulties of interstate significance and large public interest.

In closing, I say it seems to me the points discussed are some of the ways in which forestry and the sciences are related. As "scientific, like spiritual truth, has ever from the beginning been descending from Heaven to man," so let it continue, and remain for science to substitute facts for appearances and demonstrations for impressions.

Facts in all these, definitely ascertained and generally disseminated and taught in the schools, will rebound in lasting good to an energetic people. This means for Indiana. The saying, "We hail science as man's truest friend and noble helper" was never more applicable than now and at home. I appeal to you as men of science to lend a helping hand and bring forth the truth to a receptive humanity.

Relation of Scientific Organizations to Manufacturers.

R. B. Polk.

In looking over the constitution and by-laws of this organization, I find stated among its objects the following: "To assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State. To arrange and prepare for publication such reports of investigation and discussions as may further the aims and objects of the Academy as set forth in these articles."

Being identified with the manufacture of certain food products, and being a member of this organization, has induced me to give some thought to the results which might be produced if there could be consummated a closer relationship between this society and manufacturers. In suggesting that a movement of this kind be inaugurated, I am taking it for granted that the paramount motives of this organization are for the enlightenment of the public at large, and the advancement of science in general.

It is a fact that there is a certain amount of prejudice on the part of manufacturers against scientists, which I believe to be directly due to a lack of understanding and coöperation. There is, in fact, too much antagonism between manufacturers and our health officers. This is, perhaps, due, to some extent, to impractical and incompetent men being placed in these positions. It may, indeed, be laid in some cases to the fault of the laws they are trying to enforce. And, though I whisper it, it may be due to a desire on the part of some manufacturers to use fraudulent methods in the sale of their goods.

It is a belief too primary to question that science in the hands of men of genius has been directly responsible for nearly all great improvements in the production of pure foods. We have to but mention such names as Appert, Pasteur, Liebig, Hansen, Jorgensen and others and investigate their works to substantiate this assertion.

There have recently been some efforts made on the part of organized manufacturers of food products to utilize the services of some chemists and bacteriologists to solve certain scientific problems bearing on processes for canned goods. All such efforts have, however, been spasmodic and have been dropped; the results thus being minimized. I believe that what is needed to produce real results is quiet, persistent effort, and I think necessarily on the part of an organization.

There are three ways in which manufacturers have need of organized scientific aid: First, in the practical work of production; second, regulating our food laws; third, in educating the public to the use of pure foods, and to the fact that such goods can not be produced as cheaply as adulterated ones.

While it is necessary for the manufacturer to understand the mechanical details and general processes of his factory, it is impracticable for him to become an authority on the obscure scientific details. The ordinary farmer will not leave his work to investigate the mineral constituents of certain plant cells, however great the scientific value. The brewer does not care to know whether or not the bacteria which sours his product is spore forming, so he has a method of keeping clear of them. The baker does not care what particular variety of yeast he uses if he has the right one, and it is pure enough for practical uses. Yet, the foundation of his business depends upon the separation and purity of the yeast he employs. The canner will not investigate what action sulphite of soda will have on tin until it has cost him $60,000 in one year, as was experienced by a packer a few years ago. Thousands upon thousands of dollars have been lost because such facts as these have been unknown. In fact, the field is so broad that work in many departments of an organization would be necessary.

There is, and has been, great need in our States of a source of unprejudiced authority on the subject of foods which could be referred to in framing laws. Legislatures are fickle. Health officers are subject to political change, which makes the interpretation of the law subject to "change without notice." I am not presuming that it is the scope of this society to become a political factor, but had it been operating on the lines I have suggested it would only be a natural sequence for it to become an advisory authority for lawmakers as well as manufacturers.

In order to show some of the uncertainty the manufacturers have to deal with, I will read extracts from two different letters. One from the

Food Commissioner of Pennsylvania, the other from the Chief Chemist of the Agricultural Department, which is in answer to an inquiry made by a chemical house in New York. The following is from the Food Commissioner of Pennsylvania:

"A number of manufacturers of 'catsup' have represented that the strict enforcement, at this time, of rule No. 12, of the decisions published in Bulletin No. 30, by this department, so far as it relates to catsup, will seriously injure their business. They state that the catsup for next year's trade was manufactured before the rule referred to was issued and that the goods now contain a preservative, known as benzoate of soda, the use of which is prohibited under the law. Whilst rule No. 12 does not absolutely prohibit the use of preservatives in food, it does fix the responsibility upon the manufacturers of showing that a preservative is necessary, and in case of doubt as to its effect upon the health of the consumer, of showing that it is not injurious. Before strictly enforcing any new law, or new ruling, the Dairy and Food Commissioner has always given manufacturers and dealers reasonable time in which to be heard, and, if necessary, to get rid of adulterated goods already on the market, and this is in recognition of the fact that all reputable manufacturers and dealers desire to comply with every lawful regulation of trade for the protection of the public health, and only need to know what the law is, and be given reasonable time to adjust their business to its requirements. In order, therefore, to give time for the proper settlement of the points at issue, the enforcement of rule No. 12, so far as it relates to the use of a moderate quantity of benzoate of soda in catsup, is suspended until opportunity shall be given manufacturers to make clear the fact that its use is necessary and not injurious to health. A meeting will be arranged for in the near future, at which all who are interested can have opportunity to be heard."

It seems that the theory of the law has been reversed in this case by holding a thing wrong until it is proven right. This letter is practically a retraction, and it is very evident the law was passed without fair investigation.

The following is from a chemist, which was written in answer to a letter from a chemical house which manufactures carmine:

"I am in receipt of your letter of the 3d inst. relating to the classification of carmine. I appreciate the position in which you are placed, but do not consider that it would be permissible to class carmine with vegetable colors. Of course, it is not a coal tar derivative and has never been alleged to be injurious except when used in the form of a tin lake. Strictly speaking, however, as I said before, it is not a vegetable color and I should not be inclined to class it as such. It is unfortunate that there is so large an element who regard all vegetable colors as harmless and all others as objectionable."

You will notice from these letters that it is almost impossible for the manufacturer to get definite lines to work to.

To kill an evil we must get at its head. The greatest excuse for adulterated goods is that the public wants something that looks nice, and, above all, something that is cheap. As long as this demand exists, it will be satisfied. It is true we have laws requiring adulterated goods to be labeled as such, but they are juggled with to such an extent that they confuse the public all the more. While these requirements are in force concerning the labeling of adulterated goods, there is no stamp of approval provided for the pure food, and, the consuming public being unacquainted with the label requirement, has to take the manufacturer's word for it.

Laws regarding adulterated foods are necessarily technical. Technicalities can not reach the spirit of a manufacturer, though he may comply with their literal requirements. Foods may be and are prepared under the most filthy and unsanitary conditions, yet fill the technical requirements of the law.

How much greater the incentive to a manufacturer if he could have his goods and methods inspected and receive suggestions from an unprejudiced organization, which, by its researches, had become thoroughly competent.

I believe the State of Indiana could not make a greater move in favor of pure foods and benefit the public more than by delegating power to the Indiana Academy of Science, if it were willing, to place on goods which had passed its inspection, its stamp of approval. While the public should be protected, the manufacturer should be encouraged. In conclusion I wish to say that the needs which I have tried to present are real and not imaginary. While there would probably be considerable apathy on the part of some manufacturers in coöperating with this movement, those who are really interested in the quality of their products will greet a movement of this kind with their enthusiastic support.

Mounds and Burial Grounds of Bartholomew County, Indiana.

J. J. Edwards, M. D.

It has repeatedly been stated that there are no artificial earthworks or mounds within the county which may be ascribed to a prehistoric race. After investigation and numerous inquiries we sum up the data thus obtained and offer it for what it is worth to the student of archaeology:

1. A circular mound sixty feet in diameter and about three feet high, but by cultivation now almost level with the surface of the field, is situated on the farm of Henry Blessing, in Wayne township, section 1, township 8, north, range 5 east. Some years ago it was explored and five skeletons were found, besides numerous stone implements. Many articles of stone, together with fragments of bones, have since been obtained. A man named Sam. Clark found an entire skull, which he used as a "drinking gourd." This mound is one and a half miles northeast of Wailesboro.
2. There is a small circular mound on the Lloyd Moulridge farm, two miles west of Cox's Crossing, in Columbus township, in section 34, township 9, north, range 5 east. Mr. Oscar Lowe informs me that several skeletons and relics have been unearthed here. It has not been systematically explored.
3. There is a small circular mound just north of the Jackson and Bartholomew county line and south of the farm of Eli Marquette. It is situated in a strip of woodland east of the highway which runs southeast from Jonesville, and is in section 16, township 7, north, range 6, east. I do not know if it has been explored.
4. While opening the Wailesboro railroad gravel pit a large skeleton was exhumed. Beside him were buried several relics of stone, among which was a beautiful gorget of polished striped slate, now in my possession. It is different from, but more nearly resembles, the gorget figured as 130, page 118, of the thirteenth annual report of the Bureau of Ethnology (Washington, D. C., 1891-92, published 1896.) than any I have seen figured.
5. In 1901, on opening a gravel pit just north of Wailesboro, in section 12, in the angle formed by the pike and railroad and north of the crossing, a human skeleton was unearthed, but no relics were obtained. This was about one hundred yards north of the place where the large skeleton above referred to was exhumed.

6. There is a mound located on the Pence farm, on Flatrock River, Flatrock township, two miles northeast of Clifford; explored by Dr. Arwine in 1898. Bones, ashes and arrow-points were found.
7. There is a mound one and one-half miles east of the last mentioned (No. 6) on James Hagar's farm. Never explored.
8. Burial place on farm of James Remy, near Burnsville. See eleventh Geological Report, 1881, page 204.
9. Bones have been taken from the Remy gravel bed, near Burnsville. *Ibid.*
10. Bones have been taken from the Hacker burial place. *Ibid.*

Microscopical Organisms Found in the LaFayette (Ind.) Reservoir.

Severance Burrage.

The reservoir of the city of LaFayette is located in a park on Oakland Hill, the highest point of land east of the city, with an altitude of about two hundred feet above the level of the Wabash River. The reservoir itself is built up above the surrounding land level, and the survey head of the reservoir is given as two hundred and thirty-two feet. The reservoir is not quite two hundred feet square, has a depth of twenty-eight feet, and a capacity of four million two hundred thousand gallons. The water with which this reservoir is supplied is obtained from the regular city supply wells, which are driven forty or more feet into the bed of the Wabash River. The water from these wells is remarkably pure and free from organisms. A recent bacteriological analysis showed but one germ to a cubic centimeter, and a microscopical examination was a complete blank. Of course, this remarkable purity is at once lost when this water is pumped up to the reservoir and exposed to the air and sunlight.

It is the purpose of this paper to give a census of the micro-organisms, exclusive of the bacteria, found in this reservoir water, the figures being obtained from twenty microscopical analyses, covering a period of five years:

Diatoms—	Maximum number in any one sample.	Average in all samples.	Percentage of occurrence.
Asterionella	8,700	271.8	60
Cyclotella	2,500	129.5	50
Diatoma	600	10.9	30
Navicula	3,100	108.6	75
Synedra	135,400	18,766.6	100
Pinularia	200	3.8	25
Cocconeis	600	15.4	25
Gomphonema	100	0.9	5
Meridion	100	0.9	5
Cocconema	300	8.1	20
Melosira	4,200	47.2	10
Fragilaria	300	4.4	15
Nitzschia	50	0.4	5
Tabellaria	50	0.7	10
Algae—			
Chaetophora	100	5	5
Oedogonium	100	5	10
Raphidium	50	0.4	5
Protococcus	100	5	5
Scenedesmus	2,800	671.4	20
Fungi—			
Crenothrix	4,400	106.4	35
Beggiatoa	1,200	90	10
Infusoria—			
Dinobryon	64,000	6,546.6	90
Peridinium	28,900	1,031.8	50
Uroglena	800	75.3	25
Rotatoria—			
Anurea	500	126	25
Polyarthra	100	5	5
Crustacea—			
Cyclops	10	0.6	15

Total number of species represented, 27.

Particular attention is called to the three forms, Uroglena, Asterionella and Dinobryon.

The colony-building infusorial form *Uroglena* has appeared in the water of the LaFayette reservoir rather regularly in the summer months since 1896, and has been the cause of much annoyance to the water works officials. At such times it has imparted a very disagreeable odor and taste to the water, leading many consumers to complain that there were dead fish or eels in the pipes. In the summer of 1898 it became necessary to have the water completely drawn off from the reservoir in order to thoroughly cleanse it and get rid of the Uroglena. There has been no serious trouble since that time.

The star-shaped diatom *Asterionella*, although occurring in considerable numbers, has not, as far as known, caused any noticeable effect on the odor or taste of the water. Yet this is the organism which has so often given the characteristic geranium taste to many eastern water supplies.

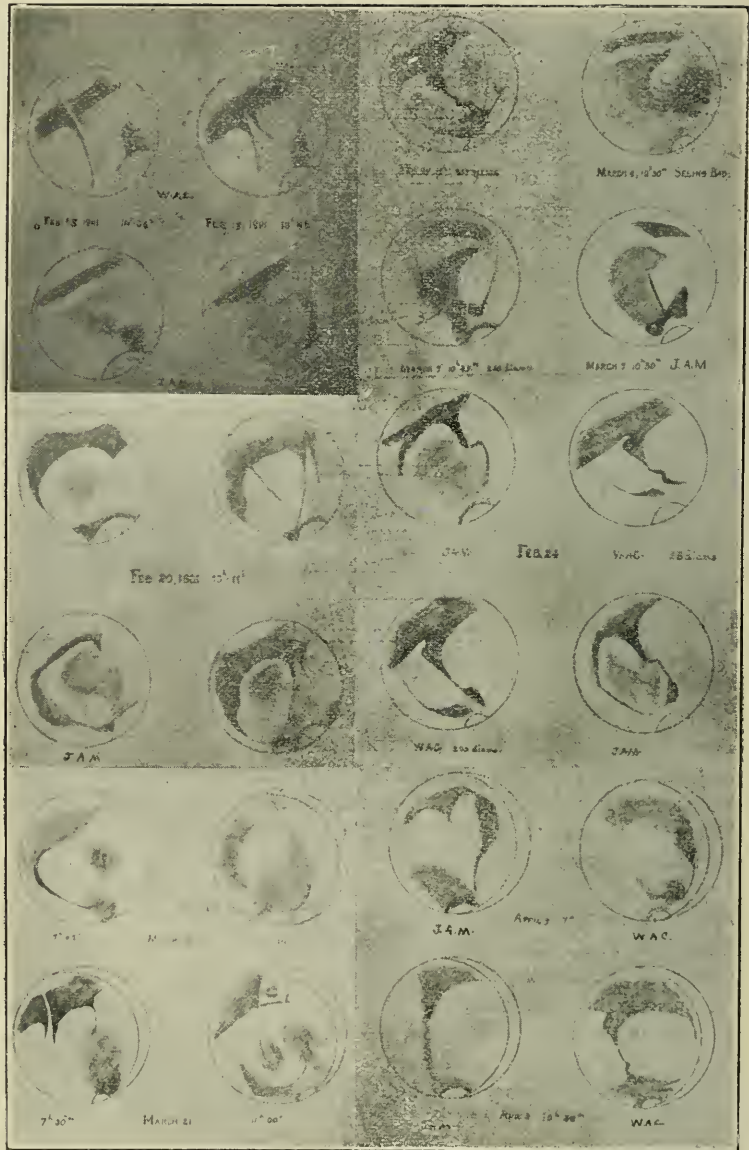
Another infusorial form, *Dinobryon*, is present in the water of the reservoir in large numbers at the present time. Should this number increase to any great extent, we may expect to have a fishy odor and taste imparted to the water.

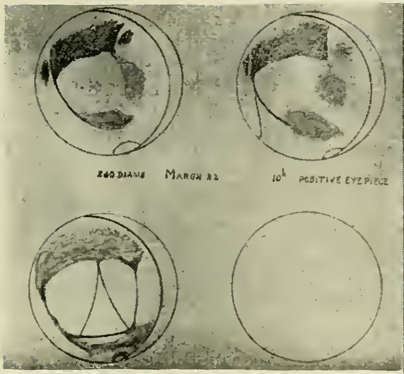
Aside from these three above mentioned forms, the organisms found in the reservoir have practically no effect on the odor or taste of the water.

Physical Observations of the Planet Mars at the Opposition of 1901.

W. A. Cogshall.

Observations of the last opposition of Mars were made at the Kirkwood Observatory of Indiana University from the time the twelve-inch telescope was in place, early in February, till late in May. The observations consisted mainly in drawing the surface markings and were carried on nearly every good night between the dates mentioned. The drawings submitted herewith were all made between February 15 and May 1. Drawings of two different observers are included in the series, part being by Professor J. A. Miller, and part by the writer. Where the drawings of both for the same night are placed together they are generally marked by the proper initials. In all this work the drawing was done as independently as possible, neither looking at the other's drawing until both were complete. It will be seen that in every case the markings drawn are essentially the same, although the drawings vary slightly both in detail and in the location of the dark areas, Dr. Miller almost always placing the dark regions of the southern hemisphere somewhat farther to the south than did the writer.




MARCH 22
10h POSITIVE EYEPIECE


J.A.M.


APR 13 8h 30m
APR 25 7h
APR 25 9h 35m
MAY 1. 8h

This opposition was not nearly so favorable to the observation of surface characteristics as some in the past, as Mars and the earth were so situated that at the time of opposition Mars was at his greatest distance from the sun, while the earth was at its least distance, thus making the distance between Mars and the earth almost a maximum. So great is the eccentricity of the planet's orbit that this distance at opposition may vary from thirty-five million miles to over sixty-two million miles. In this case it was near the latter limit, the nearest approach being on the 22d of February.

This opposition was also somewhat unfavorable if we compare results with those obtained in 1892 and 1894, in that the southern pole of the planet which was at that time turned toward us, at this opposition was turned away from us.

The large dark areas on the planet are mainly in the southern hemisphere and are the most easily seen of anything on the surface except the polar cap. It will be observed that there are also large dark areas in the northern hemisphere, but these, for the most part, are very changeable, both in size and shape and intensity, indicating probably that they are really water and that the change is purely seasonal in character. One of the most conspicuous markings on the planet at the time of opposition was the great polar ice cap. It will be observed that the early drawings all represent this feature as large, and the brilliant white color made it stand out in a very conspicuous manner against the yellow and red of the rest of the surface, while, toward the end of the series, the cap has diminished in size so as to be easily overlooked altogether. It will also be observed that the ice cap is represented with a dark fringe surrounding it, that this fringe follows the edge of the cap as it melts away, and that at the same time the dark areas near this pole become much enlarged and much more intense in contrast with the bright yellow of the disk. This tends to show that these dark patches are really water and as the polar snows melt, the water runs out over the comparatively level surface in great pools.

A few of the numerous so-called canals are shown. As to just the character and origin of these objects there has been a great deal of discussion. Their reality was even questioned for some time after their discovery, but of that there can now be no doubt at all. These canals were first seen by Schiaparelli in 1877, and from that time till the present they have been a constant source of perplexity. The same observer shortly afterward announced that at certain seasons these canals appeared to be doubled, and the same thing has been seen many times since, although as yet there is no really probable explanation offered. It has been supposed to be an optical effect by some, and due to atmospheric causes by others, and by some it is thought that the canal is really double. This doubling is shown in the drawing made on April 7.

As the rotation period of Mars is about thirty-nine minutes longer than our day, by looking at the planet at the same hour on successive nights we will see any particular marking shifted to the right from the center by about 10 degrees Martian longitude for each night. We are therefore able, in the course of about thirty-eight days, to view the whole surface by looking for a short time each night, and the rotation is sufficiently rapid so that even in the course of three or four hours the amount of new detail brought into view is large.

In the drawings of February 15 the most conspicuous part of the whole disk is the great northern ice cap with a large dark area bordering it. The dark band of color across the southern part of the planet is a portion of that great area, supposed at one time to be water, and near the center of the disk are two of the so-called canals, which, on this night, could be followed only for a short distance.

In all these drawings the contrast between the light and dark parts of the planet has been drawn greater than it really appears, so that the drawing would reproduce better. The outlines have been made distinct or hazy as they appeared, but the dark parts of the planet are not so dark generally as shown here.

By comparing the drawings of February 15 and those of February 20, the eastward drift of about ten degrees per day, mentioned above, has brought into view a very dark and conspicuous marking which will be found a number of times in the drawings of later date and which was always connected with the dark area about the pole by a well defined but irregular dark mark best shown in the drawings of the early part of April. This was the first real detail ever seen on the planet and was drawn by Huyghens in 1659. It has probably received more attention from observers than any other part of the planet. This dark line, with many more, from the polar seas leading toward the equator naturally suggests that the so-called canals do really carry away the water resulting from the melting snow. As they are about thirty miles wide, it has been suggested as more probable that they are really strips of vegetation bordering the canal proper, and it is also probable that much of the dark belt covering the greater part of the southern hemisphere is due mainly to vegetation. These areas deepen in color very decidedly at about the time the water would reach them if it were really conducted from the poles to the equatorial regions in the canals, and after the ice cap is all melted and no evidence of other water supply is visible, these areas again turn lighter in color as if the vegetation dried up or died.

Some of those who have done the most in the observation of the planet are of the opinion that the extreme regularity and geometric exactness of the canal system indicate that it is artificial in its origin and it is only fair to say that this is the appearance of the planet when seen to the best advantage. While this idea leads to the conclusion that there is or has been some sort of intelligent life on Mars, yet the canal system (be they real canals or something else) has as yet no other explanation which we can consider at all possible. If we assume the existence on the planet of some sort of intelligent life, a canal system such as we see would be essential, as we can see no storms and but very few clouds, the whole water supply being apparently the melting polar cap.

On the other hand, it is possible that the polar caps are not ice, but some other material which will vaporize in the Martian sunlight and solidify during the long polar night. Unless Mars has some source of heat which the earth has not, the temperature, even at the best, must be far below that experienced at the same latitude on the earth; and as the atmosphere is not more than one-half as dense as ours this difference in temperature is greatly intensified. It has been suggested that the caps are solidified carbon dioxide and we can not say that they are not. The most that can be said for this theory is that carbon dioxide will act that way at a low enough temperature, but it fails to explain in any degree the seasonal changes in color, and suggests no use or origin for the marks called canals. The ice theory accounts for everything but the temperature to melt it.

Consequently, the climatic conditions on Mars, the physical characteristics of its surface, its habitability and inhabitants are still open questions upon which much time and labor must be expended before we can say much about them with certainty.

A Problem in Geometry.

J. A. Cragwall.

TO CONSTRUCT A SQUARE THAT SHALL BE $\frac{M}{N}$ OF A GIVEN SQUARE.

The method given below can not be new, nor does it involve any new processes or discoveries; but in all the textbooks examined by the writer no mention has been made of such method.

It is here given because of its simplicity and directness, in the hope that some teacher will consent to lighten the work of the pupil in geometry to that extent. The construction is as follows:

Let ABCD be the given square. Lay off on one side of the square, as AD a distance DE equal to $\frac{M}{N}$ of AD. Then, CDEF is a rectangle with base equal to a side of the square and altitude $\frac{M}{N}$ of it. Then CDEF is $\frac{M}{N}$ of the square Now construct a square equivalent to this rectangle and we have a square that is $\frac{M}{N}$ of the given square.

Some Investigations in the Electro-Deposition of Platinum.

J. A. Cragwall.

When the work for this paper was begun, it was with no intention of making any study of the deposition of platinum, but to obtain a foil that could be used to separate an electrolyte into two compartments and at the same time to set up no barriers to the passage of a current of electricity; it was thought that in this way some new light might be thrown on the subject of the migration of ions. Not being able to secure platinum leaf thin enough for the purpose, an effort was made to make it by depositing platinum electrolytically on some metal that could afterwards be dissolved and leave the platinum intact. The work proved of greater proportions than was anticipated, so that the limited amount of time would only permit a partial investigation into the action of the electrolyte and the character of deposit. The available literature on the subject was very meager, the bibliography of the deposition of metals giving very little light.

Dr. William H. Wahl, of Philadelphia, has written a pamphlet which deals with the subject qualitatively and in a rather indefinite manner. In the investigation several problems presented themselves for solution, among them being the following:

I. The metal that shall be used for the cathode;

II. The solution of platinum to use for electrolyte;

III. The current density that gives the best character of deposit at the most rapid rate;

IV. The concentration of solution that gives best results;

V. The temperature that gives highest efficiency and best character of deposit;

VI. If the foil is porous or granular, the way to treat it so as to remedy the defect and get a dense, tough deposit;

VII. The liquid that will dissolve the metal of the cathode and leave the platinum foil intact.

Most of these problems are very closely related, so that results for several were sometimes obtained from the same set of experiments.

I.

On account of the smooth surface it will take, the ease with which it may be dissolved, that it will take a deposit of another metal so readily, and that it can be rolled into thin sheets, copper seems the best metal for the cathode. The anode, of course, should be platinum, carbon or other substance that will not be acted on by the nascent gas set free in the reaction.

II AND III.

The salt of platinum used must be such that it is easily dissolved and will start up no harmful secondary action during the passage of the current. Platinic chloride will not serve on account of this last restriction. Platinic hydrate, however, is almost ideal and was used in all experiments.

At first an effort was made to use platinic hydrate dissolved in oxalic acid, forming oxalate of platinum, the proportions used being—

1 oz. platinic hydrate,

4 oz. oxalic acid,

4000 c.c. distilled water.

Experiments gave the highest current density that could be used without the appearance of platinum black, as being about .0001 amperes per square centimeter, and even then there was a slight appearance of gas at the cathode. The liquid was of a clear straw color when warm, becoming purple on cooling; but, after allowing the current to run for about 15 minutes, a dark cloudy appearance was noticed at the anode that gradually spread to the whole liquid. No chemical analysis was made to determine the composition of this, though it is very likely that it was platinous hydrate. The liquid was then tightly stoppered and left for about two months, when it was found that all the platinum had been reduced to the form of spongy platinum. This was due to the fact that oxalic acid is an active reducing agent.

Taken as a whole, the experiments with oxalate of platinum were very unsatisfactory, the current being low, the solution unstable and the deposit dark, as if some of the dark precipitate was occluded in the deposit.

Mention is made of these trials for the reason that the results are contrary to the statements of Dr. Wahl.

The next solution tried was made by dissolving platinic hydrate in caustic potash in the proportions—

1 oz. platinic hydrate,
4 oz. caustic potash,
2000 c.c. distilled water.

It was possible to use a current density of .003 amperes per square centimeter and get a bright smooth deposit, when the liquid was held at a temperature of 65 F. When the deposit was made comparatively thick, however, there was some appearance of crystallization. Trial showed a current density of .002 to be about as high as it was best to go with this particular solution at the above temperature.

IV.

Tests were now made to determine the effect of varying the concentrations of the liquid. As above noted, when the proportions were—

1 oz. platinic hydrate,
4 oz. caustic potash,
2000 c.c. distilled water,

the maximum current density that could be used and get a clear, bright deposit was .0035 amperes per square centimeter.

With a solution in the proportions of

2 oz. platinic hydrate,
4 oz. caustic potash,
2000 c.c. distilled water,

it was found possible to run the current density up to .006 amperes.

With another solution in which the proportions were

5 oz. platinic hydrate,
8 oz. caustic potash,
4000 c.c. distilled water,

the current reached .012 amperes before the appearance of platinum black.

Increasing the platinic hydrate in the above so as to have 6 oz. platinic hydrate, increased the current density to .015 amperes per square centimeter. The amount of caustic potash was increased so as to make a solution having the proportions—

2 oz. platinic hydrate,
1 oz. caustic potash,
4000 c.c. distilled water,

when it was found that .002 amperes was as high as the current density could be carried. Increasing the amount of caustic potash still further decreased the amount of current that could be used.

From the results given it may be concluded that the greater the per cent. of platinum in the solution, the higher the current density that can be used. Any increase in the amount of caustic potash lessens the maximum current density.

V.

In regard to the temperature that gives the best results, the experiments showed that any increase in the temperature raised the maximum current density that could be used. Thus, at 65 F. .0035 amperes per square centimeter was the maximum, while a temperature of 100 F. permitted the use of a current as high as .008 amperes per square centimeter, with corresponding changes for intermediate points.

VI.

Burnishing the foil with a smooth bent glass rod, or with a piece of hard wood, made the platinum denser. Lightly beating the foil between chamois skins was of some assistance, though for the purpose in view great care had to be exercised to prevent getting the deposit of unequal thickness over the foil.

VII.

There are many liquids that will dissolve the copper—notably, nitric acid, but, on account of the formation of gas during the reaction and the consequent tearing of the foil, it and several others had to be discarded. Ammonium chloride was found to be the best, though its action is very slow. The result may be hastened, however, by first making this foil of copper, the anode in a copper sulphate electrolyte and dissolving away a large part of the copper before putting the foil in the bath of ammonium chloride.

There is one serious difficulty that is met in dissolving the copper. After all the copper has been dissolved, it is extremely difficult to remove the foil from the liquid on account of the cohesion being sufficient to add enough weight of water to the foil to tear it as it is taken from the liquid or roll it up so that it is useless.

This can only be overcome by placing the foil where it is to go when completed, and then dissolve away the copper.

Although some very fair foils were made in these experiments, it is hardly fair to say that they were wholly successful. But the work opens up another avenue that may lead to something very useful—the electroplating with platinum of delicate surgical instruments, etc., to take the place of nickel. It is well known that many efforts have been made to use platinum for such purposes, but, as far as the writer knows, with very indifferent success on account of the great trouble and consequent cost of the work. Using an electrolyte of platinate of potassium, it is possible to keep it constantly saturated by simply keeping a bag of platinic hydrate hanging in the solution; the process is comparatively rapid and needs little attention after once started. The plated article will stand considerable amount of usage, and, of course, will not tarnish under any ordinary circumstances.

Note on Some Experiments With a New Form of Pressure Regulator.

William Kendrick Hatt.

General.—The writer here records some experiments which were made under his direction in the Engineering Laboratory of Purdue University on a new apparatus by Mr. Will Hull, of the class of 1901, who developed the details of the apparatus from the suggestion of Mr. J. T. Wilkin, engineer for the Connersville Blower Company, Connersville, Ind.

The apparatus (Fig. 1) consists essentially of an expanding nozzle and a flat circular disc, against which the jet from the nozzle is directed, the disc being enclosed in a suitable chamber. The action is similar to that of the well-known ball nozzle, and the disc replaces the ball. In case of the ball nozzle the back pressure forcing the ball against the jet is the pressure of the atmosphere. In the apparatus here described the disc is enclosed in a chamber, and the back pressure is the pressure of the water in the chamber. This pressure is greater than that in the rapidly moving sheet of water on the up-stream face of the disc, so that the disc moves toward the nozzle until equilibrium is established. The disc thus automatically throttles the up-stream.

When this apparatus is inserted in a pipe line the pressure on the down-stream face of the disc is preserved fairly constant (within the limits of the experiments and for certain range of pressure in case of the apparatus used), while the up-stream pressure varies within wide limits. The principle of the apparatus will have an application whenever it is desired to deliver water at a constant pressure to a machine from a source of supply subject to fluctuations of pressure. Whether a design of disc and nozzle could be reached which would regulate the pressure in case of air or steam is not determined.

The experiments were initiated with the desire to obtain information which would serve as a basis for proportioning this apparatus to serve various conditions of pressure and delivery. The experiments were interrupted before that point was reached. The results obtained and the example are generally interesting and it seems worth while to record them.

Mr. Hull used various combinations of disc and nozzle until he found the proper combination which would regulate the pressure used in case of the apparatus available.

SECTIONAL VIEW.

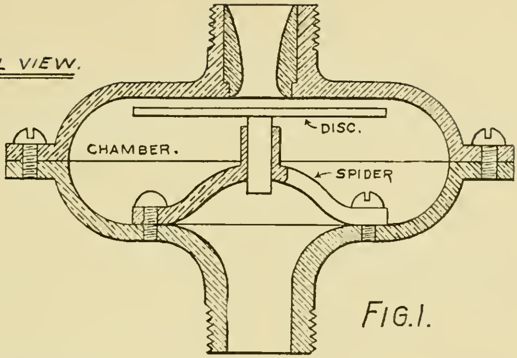
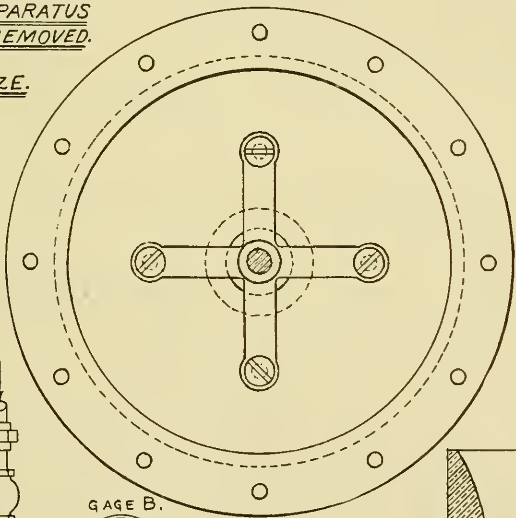


FIG. 1.

PLAN OF APPARATUS WITH TOP REMOVED.

$\frac{2}{3}$ FULL SIZE.

BRASS.



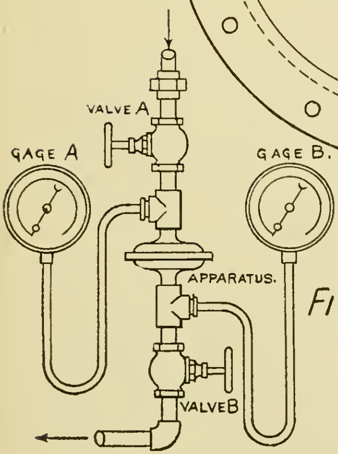


FIG 3

NOZZLE.

$\frac{4}{3}$ ACTUAL SIZE.

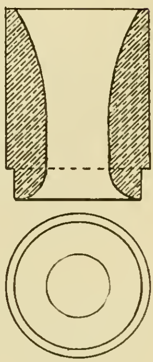
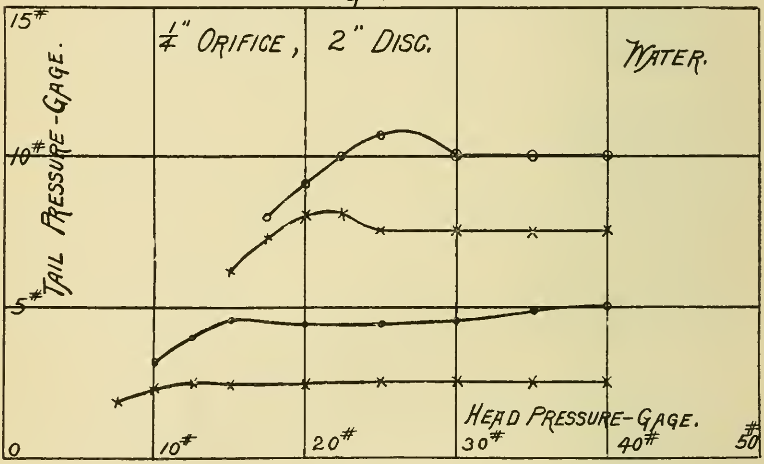


FIG 2

In brief, he found that a nozzle of form specified in Fig. 2 (called a ¼ inch nozzle), in combination with a 2 inch flat disc, would regulate the pressure in a ½ inch pipe to the following extent:

The pressure on the down-stream section of the pipe was preserved constant at 2½ pounds by the action of the disc while the pressure of the up-stream section varied between 10 to 40 pounds per square inch by gauge (as shown on Fig. 4).

FIG 4



APPARATUS.

Fig. 1 shows the construction of the apparatus with nozzle, disc, chamber and spider for supporting the disc. The fitting of the apparatus for experimental work is shown in Fig. 3. The two gauges for measuring the pressures were placed as close as possible to the chamber containing the disc. The fittings were made with great care. The valves shown were for controlling the pressures used in experimentation.

METHOD OF EXPERIMENT.

The apparatus was attached to the standpipe of the hydraulic laboratory, the pressure in which was controlled by a steam pump. Starting with a given standpipe pressure, say 40 pounds, the water was allowed to flow through the apparatus, being throttled by the lower valve to indicate a down-stream pressure of, say 2½ pounds per square inch on the lower gauge. This down-stream pressure was allowed to remain fixed during the test, the lower valve not being disturbed. The up-stream pressure was varied by the use of the upper valve, throttling the up-stream section. In this way up-stream pressures of from 40 pounds per square inch down by 5 five pounds per square inch steps to the lower limit were effected. The apparatus discharged into a weighing tank and the discharge was weighed. The temperature of the water was taken every minute because this temperature varied greatly throughout the tests, due to the fact that the standpipe tank was connected to the condenser of a Corliss engine. (With respect to the effect of the temperature on the results, it may be said that when the temperature of the discharge rose above the 100° F., the tail pressure gauge showed a very unsteady pressure, the needle vibrating with a range of as much as one-half pound. The disc was no doubt at this time subject to vibrations, which, when the temperature of the water rose to 110° F., were of such frequency as to cause a musical note. Under the latter condition the needle was too sluggish to respond and remained at a fixed position. The movement is probably connected with alternate periods of vaporization and condensation of the water on the upper side of the disc.)

Results.—The following combinations of nozzle and disc were used: One-eighth-inch nozzle, 1-inch disc; ⅛-inch nozzle, 1½-inch disc; ⅛-inch nozzle, 2-inch disc; 3-16-inch nozzle, 1-inch disc; 3-16-inch nozzle, 1½-inch disc; 3-16-inch nozzle, 2-inch disc; ¼-inch nozzle, 1-inch disc; ¼-inch nozzle, 1½-inch disc; ¼-inch nozzle, 2-inch disc.

Of these, the ¼-inch nozzle gave successful results; the ¼-inch nozzle, with the 2-inch disc, gave the best results. These are shown in Fig. 4. In working the head pressure down toward the tail pressure the former would approach a critical point at which the difference of pressure became so slight that the regulating effect ceased and both head and tail gauges suddenly moved to the same reading. The disc at this period, no doubt, dropped away from the jet. That is a certain difference of pressures is needed to enable the apparatus to work. This difference of pressure became greater as the tail pressure was increased, as is shown in Fig. 4.

In experiments with the other orifices mentioned the lines shown in Fig. 4 became straight lines inclined to the horizontal. The hump in Fig. 4 was characterized by an unsteady head pressure.

One disc was bevelled so as to give a constant area of passageway to the expanding ring of water, that is, it was dished with the deepest part next to the nozzle. This disc preserved a constant difference of pressure between the head and tail pressures.

Some experiments were carried on with air as the fluid passing through the pipes. With the nozzle and discs used there appeared to be no governing effect, in case of these air pressures.

In general it may be said that the shape of the nozzle has most to do with the action observed. A number of nozzles of different form were used; those most nearly like that shown on Fig. 2 gave the best governing effect.

The size of the disc affects the results obtained with any given nozzle. Two-inch disc gave better results than 1-inch or the 1½-inch disc.

The action desired could be obtained with water at a temperature of 75° F. as well as at the higher temperatures.

A very pretty cylindrical sheet of water could be obtained by removing the lower part of the casing. The disc acted like the well-known ball-nozzle. Under these conditions, with a head pressure of 40 pounds and a nozzle velocity (as figured from the discharge) of 14.6 feet per second, it was found necessary to exert a force of 9 pounds to pull the disc from the jet.

WATER.

¼-Inch Orifice.				2-Inch Disc.			
Gage Pressure.		Discharge Per Min. Cubic Ft.	Temperature of Water.	Gage Pressure.		Discharge Per Min. Cubic Ft.	Temperature of Water.
Head.	Tail.			Head.	Tail.		
40 lbs.	2.5 lbs.	0.301	105° F.	40 lbs.	7.5 lbs.	0.334	88° F.
35 "	2.5 "	0.304	105 "	35 "	7.4 "	0.337	92 "
30 "	2.5 "	0.304	108 "	30 "	7.5 "	0.342	93 "
25 "	2.5 "	0.304	109 "	25 "	7.5 "	0.342	93 "
20 "	2.4 "	0.300	112 "	22.5 "	8.2 "	0.342	95 "
15 "	2.4 "	0.300	112 "	20 "	8.0 "	0.350	96 "
12.5 "	2.5 "	0.304	111 "	17.5 "	7.25 "	0.323	95 "
10 "	2.3 "	0.282	106 "	15 "	6.2 "	0.314	94 "
7.5 "	1.9 "	0.267	112 "				
40 lbs.	5 lbs.	0.330	95° F.	40 lbs.	10 lbs.	0.377	82° F.
35 "	4.8 "	0.322	100 "	35 "	10 "	0.385	81 "
30 "	4.5 "	0.315	99 "	30 "	10.2 "	0.388	80 "
25 "	4.4 "	0.306	97 "	25 "	10.7 "	0.388	78 "
20 "	4.4 "	0.306	100 "	22.5 "	10 "	0.385	78 "
17.5 "	4.5 "	0.315	105 "	20 "	9 "	0.361	78 "
15 "	4.5 "	0.315	104 "	17.5 "	8 "	0.336	78 "
12.5 "	4.0 "	0.302	105 "				
10 "	3.2 "	0.270	108 "				

On Changes in the Proportional Elastic Limit of Nickel Steel, With a Note on Calibration of Testing Machines.

W. Kendrick Hatt.*

The variability of the proportional elastic limit of metal due to overstrain and its subsequent recovery after a period of rest, or proper annealing, have been studied by investigators, among whom may be named Bauschinger, Professor Gray and Mr. Muir.

The writer records here the results of experiments on a special nickel steel rolled for the purpose by the Bethlehem Steel Company. The experiments had two ends in view:

1. To calibrate the testing machines of Purdue University, in comparison with the testing machines of the government testing laboratory of the Watertown Arsenal, and those of the University of Illinois.

2. To study the variability of the proportional elastic limit and yield point of this special nickel steel.

The proportional limit here mentioned is that limit beyond which stress ceases to be proportional to strain. The yield point spoken of below is that limit at which a sudden increase in the elongation occurs without an increase in stress.

CALIBRATION.

A testing machine of ordinary screw type consists of a screw press and a large platform scale. It is necessary, of course, to ascertain if the load on the scale beam correctly indicates the pressure on the platform. This is often accomplished by loading the platform with a dead load of pig iron. For light loads the purpose might be served by a calibrated spring. The use of nickel steel bars of high elastic strength furnishes us with a spring of high capacity, whose deformation may be accurately measured. Calibration by means of these bars may be readily effected and relative errors in the machines detected. The absolute error may be known by comparison with a machine that has been calibrated by the dead weight method. The bars can be preserved and used from time to time to detect changes in the machine due to wear of knife edges. This is

*The main observations on which this note is based were carried out under the author's supervision by Messrs. R. Hitt and J. H. Jascha, senior students in Purdue University, 1901.

a more accurate method than that often used, involving the breaking of a half dozen steel bars from one rod at different laboratories and comparing the average breaking load.

In the work of examining the accuracy of the Purdue University testing machines, three nickel steel bars were used; two with a length between shoulders of 12 inches, and one with a similar length of 30 inches. In the case of the latter bar, it was possible to attach two extensometers to the bar *in tandem*, and by exchanging the position of the extensometers to compare the latter. The modulus of elasticity was measured in case of each bar on the machines of the three laboratories using the extensometers possessed by the three laboratories. One of these extensometers was sent from one laboratory to the other. If the extensometers are alike in their graduation and the modulus of elasticity of the bars is found to be equal on the various machines, the latter may be judged to have no relative errors. The observations at the University of Illinois were taken under the direction of Professor A. N. Talbot.

Taking the average of three bars tested at the three laboratories it appears (Table I) that the value of Young's Modulus at the Purdue laboratory is (in 100,000 pounds per square inch units) 29.22; at Illinois laboratory, 29.33; at Watertown laboratory, 28.66. Between the Purdue laboratory and the Illinois laboratory there is thus a relative difference of only about ⅓ of one per cent., an accuracy much in excess of that needed in any work for which these machines are used.

By interchanging the positions of two extensometers in case of the long bar, an opportunity existed of comparing the indications of two extensometers of different type—the Riehle extensometer (a screw micrometer) and the Johnson extensometer (a roller type). In Table II it is seen that the two extensometers yield identical results.

It is thus assuring to know the reliability of the ordinary type of testing machine and extensometer. If the Watertown machine is correct, the other machines yield results about two per cent. high. The Watertown extensometer, however, was not compared with the other extensometers.

ELASTIC CHANGES.

After the work of calibrating apparatus was complete, two of the bars were used in the study of the variability of the proportional and yield limit.

The results are shown in Table III. These results show that the behavior of nickel steel under overstrain is like to that of ordinary steel, namely:

Overstrain destroys the P-limit, and elevates the Y-limit.

The P-limit may be restored by annealing for a few moments in a bath above 212° F. The P-limit may be also restored by a period of rest. By a process of overstrain and subsequent annealing, the P-limit may be elevated to nearly the ultimate strength.

The decrease of diameter was also measured. The ratio of side contraction to longitudinal extension was found to be nearly ¼, which is the value of Poisson's ratio for this metal.

TABLE I.

Value of E. in 100,000 Units as Derived from Tests on Bars of Nickel Steel at Three Laboratories.

Bar.	Watertown.	Purdue.	Illinois.	Average.
1	28.71	29.29	29.40	29.23
2	28.59	29.32	29.14	29.14
3	28 66	29.36	29.20	29.20
Average	28 66	29.22	29.33	

TABLE II.

Comparison of Extensometers

Extensometer.	Illinois, 200,000 Olsen.		Purdue, 300,000 Riehle.	
	Roller.	Screw—1.	Screw—2.	Roller.
Position—				
On top	29.40	29 40	29.50	......
On bottom	29.00	29.00	......	29.10

TABLE III.

Showing Variability of P-Limit.

BAR No. 1.

Analysis	Carbon	0.27 %
	Manganese	0.58 %
	Silicon	0.214%
	Ph	0.024%
	Sulph	0.036%
	Copper	0.028%
	Nickel	4.552%

No. of Test.	Description of Test.	E. in Units of 100,000 lbs. to square inch.	P-Limit in Units of 1,000.	Y-Limit in Units of 1,000.	Maximum Stress.	Note Effect of Test.
1	Original	29.3	88.0	......	*96.0	Overstrain.
2	45 hours after	26.4	0.0	96.0	98.0	P-limit destroyed.
3	10 minutes after	24.8	0.0	94.0	*100.0	P-limit destroyed.
4	118 hours after and in 450° F. bath	29.0	100.0	116.0	116.0	P-limit restored by annealing.
5	22 hours after	28.2	112.0	117.0	*117.0	Overstrain.
6	After in bath at 218° F.	29.2	109.0	112.0	*114.0	Overstrain restored by annealing.
7	500 hours after	28.0	110.0	116.0	116.0	Overstrain restored by rest.
8	10 minutes after	26.0	110.0	116.0	116.0	Test to destruction 15% elongation, 42% contraction in 8″.

BAR No. 2.

No. of Test.	Description of Test.	E. in Units of 100,000 lbs. to square inch.	P-Limit in Units of 1,000.	Y-Limit in Units of 1,000.	Maximum Stress.	Note Effect of Test.
1	Original	29.7	92.0	95.0	*100.0	Overstrain.
2	15 hours after	26.1	70.0	100.0	*117.0	Overstrain.
3	2 weeks after	24.8	0.0	100.0	109.0	P-limit destroyed.
4	10 minutes after	24.6	0.0	108.0	......	P-limit destroyed.
5	After in bath at 190° F.	25.3	0.0	112.0	115.0	P-limit not restored.

*Indicates that the test overstrained the metal.
E. taken between limits of stress of 25,000 to 85,000.

The Kirkwood Observatory of Indiana University.

John A. Miller.

At its November meeting of 1900 the Board of Trustees of Indiana University appropriated a sum of money for the purchase of a telescope and some accessories, and for the erection of an Observatory. The Observatory is built of Indiana limestone and was completed in January of 1901. It contains six rooms—a library and computing room; a lecture room, which may be darkened at any time, equipped with a Colt electric lantern, lantern slides and other illustrative apparatus, a convenient dark room; a transit room; the dome room and a room similar to it and immediately below it.

The skeleton of the dome, which is twenty-six feet in diameter, is of white pine and is built according to plans furnished by Messrs. Warner & Swasey, who also furnished the running mechanism. It is covered with tin. The performance of both dome and shutter is entirely satisfactory.

The design of the Board of Trustees, that the equipment is to be used in a large part for instruction and in part for purposes of research, determined largely the character of the instruments which we afterwards purchased. In the dome-room is mounted a twelve-inch refractor. The objective is by Brashear, and is of high optical excellence, giving star-images which are free from fringes or distortion and on a black field. The mounting is by Warner & Swasey. It is provided with coarse and fine circles in both declination and right ascension, the fine ones being provided with reading microscopes and electric illumination. A star dial-dial located on the north side of the pier and driven by the driving clock, from which the right ascensions can be read directly, is of almost indispensable convenience. The driving clock drives regularly and the entire mounting is of the highest mechanical excellence.

The telescope has as accessories a micrometer by Warner & Swasey, provided with electric illumination; a polarizing helioscope; a battery of positive and negative eyepieces by Brashear, and two positive eyepieces by Steinheil und Söhne of Munich. The transit room contains a small universal instrument by Bamberg, a chronograph by Fauth & Co., a Bond sidereal chronometer, and a sidereal clock. A Howard sidereal clock, with contact that breaks an electric current each second except the fifty-ninth, and the last ten seconds at the end of every five minutes, will be put in place in a few weeks. Mr. O. L. Petitdidier, of Chicago, has kindly loaned the Observatory a parabolic mirror fifteen inches in diameter and with a focal length of 120 inches, which he constructed at his optical works. The mounting for this mirror has been designed by Mr. W. A. Cogshall and in large part constructed by him. The reflector will be in place by the first of March and will be used chiefly in photographing nebulæ.

These instruments, together with a portrait lens of five inches aperture and a Browning equatorial of four inches aperture, which for many years have been the property of the University, constitute a nucleus around which the University authorities hope to collect a more complete equipment.

The Observatory is located on the University campus, about 300 feet from the nearest building. With practically an unbroken horizon within 75 degrees of the zenith—as low as one can usually observe, and in most instances the view is entirely unobstructed.

We have found the seeing at the Observatory fair. On an average clear night a power of 300 can be used effectually; on about half the working nights we use a power of 480, while a night when a power of more than 600 can be used is comparatively rare.

The Observatory is essentially a Students' Observatory. Those who take courses in general astronomy are permitted to use the telescope a limited number of hours each week, and though this work is optional, few fail to avail themselves of an opportunity to use the telescope an hour. No accurate measurements or really scientific work is attempted by these students.

In addition to the work in spherical and practical astronomy and work carried on by the teaching force certain students are encouraged to undertake work in the nature of research. This generally consists of drawing planetary details or in making micrometical measures of double stars or of planetary disks. The observing lists are made out under the direction of the instructors and in general consist of stars that need measuring. We are engaged at present in measuring the double stars discovered in the process of making the catalogues of the Astronomische Gesellschaft. These as a rule are not difficult objects. Also search is being made for new pairs with a fair degree of success.

The Observatory bears the name of Dr. Daniel Kirkwood, the eminent astronomer, who, for nearly half a century, was a member of the faculty of Indiana University and who, by his manly qualities, won the lasting esteem of his students and his colleagues, and by his devotion to his science a lasting name among his contemporaries.

The Observatory was formally dedicated May 15, 1901. The dedicatory address was given by Astronomer W. J. Hussey, astronomer in the Lick Observatory. He spoke of "Astronomy and Modern Life." President Swain spoke of "Personal Recollections of Dr. Kirkwood."

Daylight Meteors.

JOHN A. MILLER.

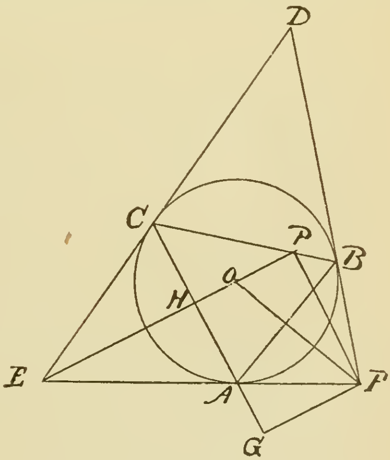
The Center of Population of the United States.

JOHN A. MILLER.

A Theorem in Geometry.

JOHN C. GREGG.

DEF is the triangle formed by the tangents at the vertices of a triangle ABC inscribed in the circle O. Draw EOP meeting BC in P and join PF. Show that EPF is a right angle.



Demonstration.

Draw FG perpendicular to CA produced, and join OF. Denote the angles of ABC by A, B, C, and the sides by a, b, c. Then

$$FG = AF \sin B$$

$$= \frac{c}{2} \sec C \sin B$$

$$= \frac{b}{2} \sin C \sec C$$

$$= \frac{b}{2} \tan C$$

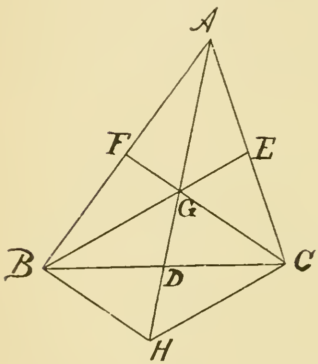
$= HP$, which is perpendicular to CG. Hence HPFG is a rectangle and EPF is a right angle.

A Simple Proof That the Medians of a Triangle Concur

John C. Gregg.

Theorem.—The three medians of a triangle are concurrent.

Demonstration.



Let AD and BE be two of the medians; they will meet in some point G. Join CG and extend it to meet AB in F. Extend AD to H, making DH = DG, and join HB and HC.

Since BC and GH bisect each other, BGCH is a parallelogram. In the triangle ACH, since GE is drawn through E, the middle point of AC and parallel to HC, G is the middle of AH. And in the triangle ABH, since G is the middle of AH and GF is parallel to BH, F is the middle of AB and CGF is the third median, and the theorem is established.

On the Density and Surface Tension of Liquid Air.

C. T. Knipp.

[Abstract. Published in the Physical Review, February, 1902.]

The variation of the density of liquid air with time was determined. The liquid was contained in a given Dewar bulb. The sinker method was used, and it was assumed that the coefficient of expansicn holds at the temperature of liquid air. A curve was platted which indicates that .933 is the density of liquid air when first made.

In the determination of the surface tension two methods were employed—the capillary tube method and the maximum weight method. Owing to the distortion due to the bulb, also to the agitation of the liquid surface, the first was not considered reliable. The second method, however, worked very well. The variation of the surface tension with time of the liquid contained in the above bulb was determined. A curve was platted. From the curve the surface tension of liquid air when first made was found to be 9.4 dynes.

A Few Experiments with Liquid Air.

C. T. Knipp.

[Abstract.]

Three experiments were given, using the liquid as a refrigerant. (1) The resistance of manganin wire at the temperature of liquid air; (2) the absorption of heat by conduction into the liquid; (3) the action of a Cu-Fe thermostat when placed in the liquid.

(1) The temperature coefficient of manganin wire was found to agree fairly well with that found by Dewar. Cooling the wire to the temperature of liquid air caused it to undergo no permanent change.

(2) By connecting a block of copper through a copper rod to a bath of liquid air the temperature of the block of copper can be reduced to nearly that of the refrigerant. This principle enables any intermediate temperature to be maintained. By this method a connecting rod of copper about ½ sq. cm. in area and 20 cm. long froze a cu. cm. of mercury placed in the block of copper in 6¼ minutes.

(3) A Cu-Fe. thermostat was found to be very sensitive, and it was also noticed that the same coefficients hold at the temperature of liquid air.

The Bitangential of the Quintic.

U. S. Hanna.

Note on an Attempted Angle Trisection.

R. J. Aley.

The Zoölogical Survey of Minnesota.

Ulysses O. Cox.

With the establishment of the Geological and Natural History Survey in Minnesota provision was thereby made for collecting and describing the various faunal forms of the State. For a number of years after the survey was established work was done only along geological lines. In 1886 there appeared a list of the Aphidæ of Minnesota, by Mr. O. W. Oestlund. and in the following year a synopsis of the same group by the same author. In 1890 there was published a report on the Mammals, by Professor C. L. Herrick. This report can not, however, be considered anything but preliminary, since it was written before any great amount of investigation had been done and it will, no doubt, be superseded later by an enlarged and up-to-date report. In 1892 there appeared a preliminary report on the Birds, by Dr. P. L. Hatch; in 1895, a report on the Copepoda, Cladocera and Ostracoda, by Prof. C. L. Herrick, which is probably final; and in 1897 a preliminary report on the Fishes, by the writer. The first three reports mentioned were issued under the direction of Prof. N. H. Winchell, State Geologist, but the others have been published under the direction of Prof. H. F. Nachtrieb, State Zoölogist, who for the past eleven years has had entire charge of the work of the survey. Every summer for ten years parties have been at work in the various portions of the State collecting material and data for the final reports. During the past three seasons the work has been especially active. In May, 1899, a house-boat, christened the Megalops, was built and launched at Mankato, on the Minnesota River, and very successfully floated to Red Wing, on the Mississippi, before the close of the season. A description of the Megalops and an account of the first season's trip appears in the Proceedings of the Indiana Academy of Science for 1899. In the summer of 1900, in early June, the Megalops was restocked and started from Red Wing on its second season's journey, down the Mississippi. Considerable time was spent on Lake Pepin, as the conditions and fauna there varied greatly from that of the Mississippi River proper. The territory along the Mississippi was quite carefully explored and material collected as far as Brownsville, Minn., which is within a few miles of the southern boundary of the State. Attention was given primarily to the fishes, but much other material was also collected, especially insects, batrachians and reptiles. Near the close of August the Megalops was again anchored for the winter, this time at Brownsville.

Early last spring Prof. Nachtrieb purchased for the survey a gasoline launch, and with it towed the Megalops back to the head of Lake Pepin, where it was beached and served as a station during the summer. This region is especially rich on account of the variety of conditions. On the one hand there is Lake Pepin, which is about two miles wide and nearly forty miles long. In many places it has fine sandy and gravelly shores and in others there are marshes. It is hemmed in by high bluffs, which are from two hundred to three hundred feet above the water level, but in places there are low points which extend out from the bluffs into the lake for one-fourth of a mile or more, and on these numerous fishermen are located. Seining, also other forms of netting, is allowed in the lake, so an abundance of material for study can readily be obtained. The water is usually clear and varies in depth from ten to thirty feet.

As is well known, Lake Pepin is simply a remnant of what was once the large glacial Mississippi River. At the lower end of the lake the Chippewa River empties from the Wisconsin side and carries with it a great

amount of sediment, chiefly sand. This deposit has filled up the bed of the original stream at that point, and consequently dammed it and produced a lake. At all other places along its course what was once the magnificent Mississippi, two to four miles in width, is now narrowed down to one, or at most two or three, small channels and a few bayous. At the upper end of the lake the delta is exceedingly well marked. There are three main channels of the river, several lakes and numerous bayous, some with water connection and others without, during the dry season.

There is water of various depths, marshes, clear pools and all the chief forms of aquatic vegetation that this region of Minnesota affords—in fact, all the conditions that could be desired for an inland laboratory. The region abounds in breeding places for fishes, batrachians and reptiles; many species of mollusks are found in the lake, and the lower forms of aquatic life are everywhere abundant.

Thus it would seem that an ideal spot had been found for a lake laboratory for the University of Minnesota, which it is hoped the authorities may see their way clear to establish there in the near future.

During the past summer Prof. Nachtrieb kept a small party at the head of Lake Pepin in the beached Megalops, with which he spent the greater portion of his own time. Large collections were made, among which were many insects, numerous fish stomachs and a quantity of histological material.

During the past summer Prof. Nachtrieb, with an assistant, spent a few weeks on the Lake of the Woods, studying the lake sturgeon, and the writer, with three assistants, put in the entire summer on Lake Vermilion, at Tower, Minn. Lake Vermilion is some forty miles long in one direction, much narrower in the other, but it is not one open body of water, but rather a number of small lakes connected by numerous channels. It is in the heart of what was once an evergreen forest region, and its shores, which are chiefly rocky, border on the granite on the one hand and the very early stratified forms on the other. The water is clear and pure except for the floating forms of aquatic life in midsummer, and it varies in depth from five to forty feet, with possibly a few small areas that are deeper.

We established our camp on Pine Island, about seven miles from Tower. There was no one living within six miles of the place and no facilities for camping except numerous beautiful locations among the pines and the outfit which we carried with us. We erected two tents and from the dilapidated roof of a former homesteader's cabin secured enough boards to make some tables. We also made an excavation in the bank, lined it with slabs split from cottonwood poles, roofed it over with boards and tar paper from the dilapidated cabin, and thus had a very efficient dark room, in which we successfully developed more than three hundred negatives. Our outfit, in addition to the culinary department, consisted of seines, gill-nets, other smaller nets, a canvas boat, microscopes, books, cameras, guns, preserving jars and fluids, and other minor articles. One member of the party, Mr. J. E. Guthrie, devoted nearly all his time to insects, of which he secured a large collection. Another member of the party gave special attention to leeches, and a third collected and studied the mammals. The writer devoted nearly all his time to a study of the fishes. Collections were made of the species found in the lake and the inflowing streams, and many of the species were dissected and photographed. Attention was also given to a study of the habits of these fishes. From the main camp expeditions were made to all parts of the lake.

We were on the lake about two months and a half, and found the camping method a very satisfactory and pleasant one. The limit of this paper will not permit me to state any of the results of our work, but they will appear later in the forthcoming reports of the survey, some of which are now under way.

Culture of Amoeba.

A. J. Bigney.

Several years ago I presented a paper before this Academy on a new method of obtaining amoeba. This method was as follows: Take some of the green scum from the surface of some ponds and place it aside for a few weeks, during which time great numbers of amoeba will have developed. This scum must be composed mostly of euglena in the resting stage. I have never known this method to fail.

During the past season I have had unusual success with this method of securing them. About the first of September I obtained some of these euglenae and placed them in a wide-mouthed two-ounce bottle and left them on my desk for about two months, at which time I needed them for class use. When I first took this material from the pond there were a few amoeba in the midst of the euglena. When I needed a supply I found them by the hundreds on almost every slide. Frequently there would be so many that they would literally fill the field of the microscope. They were large specimens. It was the largest supply that I have seen reported in this country. It may be that others have had equal success with some other method. We used them for some time and then nearly all the remaining ones went into the resting stage.

Protective Coloring in Terns.

A. J. Bigney.

Protective coloring in birds has been and still is a subject of great interest to the ornithologist. Since ecological factors are receiving so much attention now on the part of biologists, every item bearing upon variations due to environment is of interest, since it throws some light upon the question of evolution.

One of the most remarkable instances of protective coloring came under my observation during the past summer on the island of Penikese, made famous by Louis Agassiz's first marine laboratory. This island is occupied by only one family. Nothing is raised except a few garden plants and sheep. There are other inhabitants of the island, however, that are more important than sheep—at least to the biologist. These are the terns. Long before one reaches the island he can hear the shrill voices of myriads of these birds as they fly about the island almost constantly from daylight to dark. These terns are protected by law and hence have become very numerous. Almost countless thousands are to be found. The sounds of their shrill voices make a lasting impression upon a person. The island is entirely made up of glacial material, here and there covered with grass. The beaches around the entire island are quite wide and covered with granite pebbles of various colors, mostly of a white, gray or slate color, giving them a mottled appearance. The grass and the soil is very much the same in color. The dead grass furnishes a fine place for nesting and also for hiding-places for the young birds. In the breeding season the nests and young birds are so numerous that one has to pick his way carefully, lest he step on some of them. They are so nearly the color of the ground and grass that you can hardly see either bird or nest. If the parent bird is on the nest the deception is almost perfect.

The most deceptive coloring is in the young birds when they lie out on the pebbles to warm themselves in the sunlight. The imitation is so perfect that you have to look for some time before you can see the birds. The eggs are mottled in the same way as the sticks, grass and earth that compose the nests. The adult birds are not mottled as are the young birds or the eggs, thus showing that this is truly a protective coloring.

Experiments on Developing Eggs.

A. J. Bigney.

The greatest mysteries in the biological world are undoubtedly locked up in the egg. If we can understand the intricate changes that go on in a developing egg we have accomplished much. Considerable light has been thrown upon this subject during the past few years. Eminent biologists all over the world are spending their lives trying to solve the mysteries. Various experiments have been devised to try to throw light upon these early changes in the egg.

These experiments which I performed were under the direction of Dr. Lillie, of the Chicago University, at the Woods Holl Marine Laboratory.

Experiment 1.—The egg of a common sea minnow, the Fundulus, was used. When the egg was in the two-celled stage one of the blastomeres was punctured with a needle and pressed out of the vitelline membrane. The other blastomere went on developing. Its development, however, was slower. It went through all the regular changes and became an embryo. The only difference that could be discerned was in size. It was considerably smaller than the normal embryo. I succeeded in keeping it alive seven days. I have not studied the embryo any more to see whether there are internal changes that are different from the normal embryo. The significance of this ability of one blastomere to develop into a complete embryo is not fully understood. In this egg it seems to indicate that the developing power is equally distributed throughout the egg.

Experiment 2.—In this experiment the eggs of the sea-urchin Arbacia were used. The eggs just fertilized were placed under a long cover-glass with a thin piece of cover-glass under one end, thus giving a graded pressure upon them. In the segmentation of these eggs the first and second cleavage planes were natural, but the third was parallel to the first, the same as in the Fundulus. The blastoderm in the eight-celled and sixteen-celled stages were almost identical with corresponding stages of Fundulus. The eggs did not develop further than thirty-two cells where the pressure was greatest.

Experiment 3.—Arbacia eggs five minutes after fertilization were shaken violently for about a minute. The membranes surrounding the eggs were thereby broken; the eggs were then placed in artificial sea water in which there was no calcium. Eggs were thus treated at two-celled, four-celled and eight-celled, with the following results:

Those separated at the two-celled stage lived to form plutei.

Those separated at the four-celled stage formed regular blastulae in most cases.

Those separated at the eight-celled stage also formed regular blastulae.

Experiment 4.—This is an experiment in artificial parthenogenesis in arbacia. Plutei six days old were reared by Dr. H. J. Hunter, of Kansas University. He carried on the work longer and he has specially reported on this, hence only this reference.

These experiments are very interesting and may be of considerable importance when we learn how to perfectly interpret them.

The Eye of Palæmonetes Antrorum.

Edwin Manson Neher.

Contributions from the Zoölogical Laboratory of the Indiana University, under the direction of C. H. Eigenmann. No. 47.

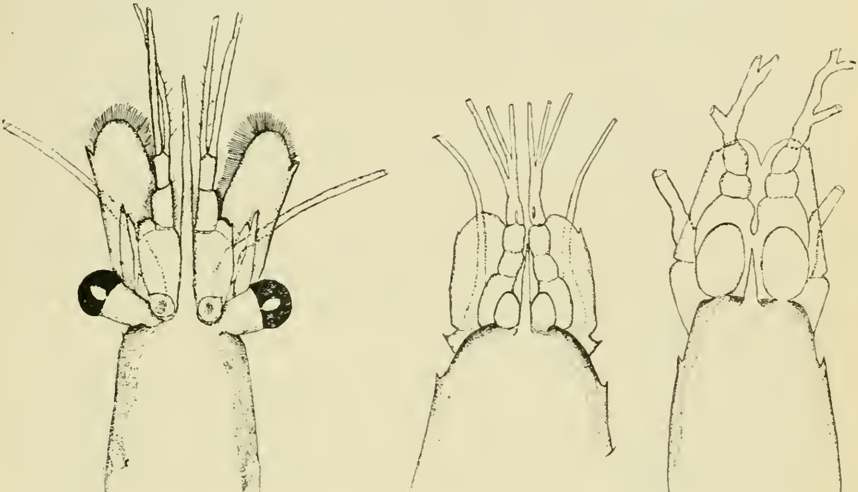
A blind shrimp, Palæmonetes antrorum, evidently occurs in abundance in the subterranean streams about San Marcos, Texas. It comes out of the artesian well of the United States Fish Commission at that place in large numbers. The well is about one hundred and ninety feet deep and has a yield of about one thousand gallons per minute.

A brief description of Palæmonetes was published by Benedict, 1896.

The material examined consists of young specimens, 5 to 5.5 mm. long from tip of rostrum to tip of telson and adult specimens measuring 15 mm. along the same line. Most of them were collected by Dr. C. H. Eigenmann at the San Marcos well in September, 1899. Others have since been sent by Mr. J. L. Leary, Superintendent of the United States Hatchery at that place.

The material at my disposal was preserved in 4 per cent. formalin. The anterior end of the cephalo thorax was dehydrated and imbedded in paraffin by the chloroform method. Sections were floated out on warm water and fixed to the slide with glycerin-albumen and stained with Mayer's haemalum, followed by eosine. Specimens of P. exilipes, which were used for comparison, were treated with Perenyi's fluid for forty-eight hours before imbedding and the sections were depigmented in 10 per cent. nitric acid for ten hours. The cuticle of the blind shrimp was found to section readily without softening in Perenyi's fluid.

According to Chilton, '94, the degeneration of the eyes of crustaceans may follow one of three lines. We may have—



1 2 3

4 5 6

1. Total atrophy of optic lobes and optic nerves, with or without the persistence in part of the pigment or retina and the crystalline lens.

2. Persistence of optic lobes and optic nerves, but total atrophy of the rods and cones, retina (pigment), and facets, or,

3. Total atrophy of the optic lobes, optic nerves, and all the optic elements.

The degeneration of the eye of the species under consideration has evidently followed the second of these lines. The optic stalk has suffered a foreshortening, and as a consequence the optic ganglia have become telescoped. The greatest reduction has taken place in the ecto-dermal portions of the eye, which are reduced to a group of cells not exceeding and probably fewer than 350. Inasmuch as a single normal ommatidium contains sixteen cells, the degree of degeneration reached is readily seen to be very great.

The extent of the modification of the eyes can perhaps be most readily described by a comparison of the eyes and optic stalk of this species with those of Palæmonetes exilipes, taken in the San Marcos River, but a short distance from the artesian well.

The eye and optic stalk of P. exilipes presents the general appearance of the crustacean eye. The stalk is a truncate cone (Fig. 1), attached by its smaller end. On the distal end is the large, dark, conspicuous, hemispherical eye. It is wider than the widest part of the stalk.

In P. antrorum the eye stalk is much smaller (Fig. 2), as may be seen from the following table:

	exilipes.	antrorum.
Length of specimen	17 mm.	15 mm.
Length of stalk to retina	787 μ	525 μ
Width of stalk at retina	700 μ	175 μ
Width of stalk at base	387 μ	387 μ
Width of retina	962.5 μ	0

Nothing appears to remain of the eyes except the short, colorless, delicate stalks. The stalks are conical, being attached by their larger end. The axis of the stalk is parallel with that of the body.

The distal end of the optic stalk of P. antrorum is covered with a single layer of indifferent hypoderm with nuclei 7.2 μ by 3.6 μ, except at a short distance from the distal end of the outer lower quarter of the stalk, where a group of slightly modified hypodermal cells, three deep, replace the single series of outer parts. The nuclei in this group of cells are rounded, measuring about 6 to 8 μ in diameter. This group of cells measures about 50 μ by 70 μ. There is no indication of an arrangement of these cells into anything resembling the arrangement of the cells in an ommatidium.

The following data gives the number of retinal cells found in each of a series of cross sections. Sections are $6\frac{2}{3}$ μ thick and counted from in front:

No. of Sections.	No. of Cells in Retina.
1 to 8	0
8	11
9	19
10	20
11	27
12	33
13	33
14	28
15	27
16	26
17	7
18	7
19	5
20	6
21	11
22	13
23	10
24	10
25	5
26	6
27	6
28	8
29	4
30	2
31	0
32	0
Total	327

In P. exilipes there is a space between the basement membrane of the hypoderm and the membrana propria of the optic ganglia, which is occupied by the fine fibers which connect the ommatidia and optic ganglia. In P. antrorum this space is filled with coagulated haemolymph (Fig. V). This haemolymph is in circular or angular blocks. These blocks begin about 40 μ from tip of eye and extend back through a space of about 60 or 70 μ to the cells of the optic ganglia. Small particles of coagulated haemolymph also extend down the outside of the eye for about half of its length.

Only a very few specimens of the young shrimp, P. antrorum, could be obtained. These were from 5 to 5.5 mm. long. The optic stalk and eye are much larger in proportion to the size of specimen (Fig. III) than in the adult antrorum, but they are actually not as large as in the adult. The internal structure showed no greater differentiation than in the eye of adult.

I am very grateful to G. H. Parker for assistance in the interpretation of the structure of this eye.

EXPLANATION OF FIGURES.

Figure 1. Dorsal view of the front end of P. exilipes.

Figure 2. Dorsal view of the front end of P. antrorum, showing the small eyes.

Figure 3. Dorsal view of the front end of a young P. antrorum about 5 mm. long.

Figure 4. Photograph of a cross section through the optic stalk of P. antrorum, showing the group of retinal hypodermal cells of the right eye.

Figure 5. Photograph of a longitudinal section through the optic stalk of P. antrorum, showing the group of retinal hypodermal cells.

Figure 6. Enlarged view (photograph) of group of retinal hypodermal cells shown in Fig. 5.

Figure 7. Photograph of another group of retinal hypodermal cells. Horizontal section.

BIBLIOGRAPHY.

Benedict, James E., '96.—Preliminary description of a new genus and three new species of crustaceans from an artesian well at San Marcos, Texas.
Proc. U. S. Nat. Mus. Advance sheet. April 14, 1896.
Proceedings xviii. pp. 615-617. August 12, 1896.

Chilton, Charles, '94.—The Subterranean Crustacea of New Zealand; with some general remarks on the fauna of caves and wells.
Trans. Linn. Soc. Lond., vi, pt. 2, 1894.

Parker, '90.—The eyes in blind crayfish.
Bull. Mus. Comp. Zool., xx, pp. 153-162, plate i.
Parker, '91.—The Compound eyes in crustaceans.
Bull. Mus. Comp. Zool., xxi, pp. 45-140, plates i-x.

The History of the Eye of Amblyopsis.

C. H. Eigenmann.

[Abstract.]

A. DEVELOPMENT.

The eye of Amblyopsis appears at the same stage of growth that it appears in fishes developing normal eyes.

The eye grows but little after its appearance.

All the developmental processes are retarded and some of them give out prematurely. The most important of the latter is the cell division and the accompanying growth that provides the material for the eye.

The lens appears at the normal time and in the normal way, but its cells never divide and never lose their embryonic character.

The lens is the first part of the eye to show degenerative steps and it disappears entirely before the fish has reached a length of 1 mm.

The optic nerve appears shortly before the fish reaches 5 mm. in length. It does not increase in size with the growth of the fish and possibly never develops normal nerve fibers.

The nerve does not increase in size with growth of the fish.

The optic nerve gradually loses its compact form, becomes flocculent, dwindles and can not be followed by the time the fish has reached 50 mm. in length. In the eye it retains its compact form for a much longer time, but disappears here also in old age.

The scleral cartilages appear when the fish is 10 mm. long; they grow very slowly—possibly till old age. They do not degenerate at the same rate as other parts of the eye if they degenerate at all.

B. HISTORY.

The history of the eye may be divided into four periods:

(a) The first period extends from the appearance of the eye till the embryo reaches 4.5 mm. in length. This period is characterized by a normal palingenic development except that cell division is retarded and there is very little growth.

(b) The second period extends from the first till the fish is 10 mm. long. It is characterized by the direct development of the eye from the normal embryonic stage reached in the first period to the highest stage reached by the Amblyopsis eye.

(c) The third period extends from the second period to the beginning of senescent degeneration, from a length of 10 mm. to about 80 or 100 mm. It is characterized by a number of changes, which, while not improving the eye as an organ of vision, are positive as contrasted with degenerative. There are also distinct degenerative processes taking place during this period.

(d) The fourth period begins with the beginning of senescent degeneration and ends with death. It is characterized by degenerative processes only, which tend to gradually disintegrate and eliminate the eye entirely.

C. SUMMARIAL TABLE OF THE ORIGIN, DEVELOPMENT AND DEGENERATION OF THE EYE AND ITS PARTS.

	Earliest Appearance or Differentiation.	End of Cell Division.	End of Morphogenesis.	End of Histogenesis.	Beginning of Degeneration.	Disappearance.
Eye	1.5 mm.	5-7 mm.	10 mm.	Before 25 mm.	25 mm.	Beyond 130 mm.
Choroid fissure	2.5 mm.	—	—	—	—	10-130 mm.
Pigmented layer	2 mm.	?	2.5 mm.	10 mm.	100 mm. or before.	Beyond 130 mm.
Cones	Rarely and then after 10.	—	?	?	?	?
Outer nuclear	4.4-5 mm.	5-7 mm.	—	10 mm.	Before 25 mm.	Beyond 130 mm.
Outer reticular	Never.	—	—	—	—	—
Horizontal cells	Never.	—	—	—	—	—
Inner nuclear	4.4-5 mm.	—	—	10 mm.	Before 25 mm.	130 mm. and beyond.
Ganglionic	4.4-5 mm.	—	—	10 mm.	Before 25 mm.	130 mm. and beyond.
Optic fiber layer or nerve	4.4-5 mm.	—	—	5 mm.	25 mm.	100 mm.
Scleral cartilages	9-10 mm.	?	?	75 mm.	—	—
Lens	2.5 mm.	5 mm.	5 mm.	—	3 mm.	6-10 mm.
Corneal epithelium	5 mm.	?	—	—	7 mm.	10 mm.

? I do not know.
— Does not take place.

D. CONCLUSIONS OF GENERAL BIOLOGICAL INTEREST.

Some late stages of development are omitted by the giving out of developmental processes. Some of the processes giving out are cell division, resulting in the minuteness of the eye and the histogenic changes which differentiate the cones and the outer reticular layer.

There being no causes operative or inhibitive either within the fish or in the environment that are not also operative or inhibitive in Chologaster agassizii, which lives in caves and develops well-formed eyes, it is evident that the causes controlling the development are hereditarily established in the egg by an accumulation of such degenerative changes as are still notable in the later history of the eye of the adult.

The foundations of the eye are normally laid, but the superstructure, instead of continuing the plan with additional material, completes it out of the material provided for the foundations. The development of the foundation of the eye is phylogenic, the stages beyond the foundations are direct.

E. TABLE OF MEASUREMENTS OF EYES OF EMBRYOS OF DIFFERENT SIZES.

Condition of Embryo Living or Direction of Sections.	Length of Embryos.	No. of Embryos Measur'd.	Longitudinal Diameter.	Vertical Diameter.	Axial Diameter of Eye from Cornea to Optic Nerve.
	1.6 mm	1	80 μ.	....	36 μ.
	1.76	....	100	....	48
	2	3	135	....	....
	2.5	2	190	....	100
	2.8	1	170	....	....
Alive	4	1	200	150	100
Alive	5	7	144	134	....
Sagittal	6	1	136	88	....
Cross	6	1	....	70	100
Horizontal	6	1	136	....	80 and 108
Mounted entire	6.5–7	1	160	160	....
Cross	5.5–7	3	....	126	99
Horizontal	6.5–7	3	152	....	115
Sagittal	9–9.5	1	108	....	88
Cross	9–9.5	1	....	106	90
Horizontal	9–9.5	1	114	....	98
Sagittal	10	1	120	112	....
Cross	10	2	....	108	109
Entire	10	1	135	130	....
Horizontal	25	1	120	....	128
Cross	25	1	....	160	160
Horizontal	35	1	192	....	144

The Eye of Rhineura Floridana.

C. H. Eigenmann.

[Abstract.]

Rhineura floridana is a legless, burrowing, amphisbaenian lizard, found in Florida. My attention was called to it by Mr. W. S. Blatchley, and I secured specimens through dealers and through Dr. W. B. Fletcher, of Indianapolis, who kindly forwarded a number of living specimens to me.

A study of the eye of this lizard has led to the following conclusions:

1. The eye of Rhineura has reached its present stage as the result of a process of degeneration that probably began in the early miocene.

2. The dermis and epidermis pass over the eye without any modification. The conjunctival pocket has vanished.

3. Harder's gland is many times as large as the eye and pours its secretion into the tear duct and thus into the nasal cavity.

4. The eye muscles have disappeared.

5. A cornea is not differentiated.

6. The lens is absent in half the eyes examined and varies greatly in those in which it was found.

7. The vitreous body has practically disappeared.

8. The pigment epithelium is variously pigmented. It is of greater extent than is sufficient to cover the retina and has been variously invaginated or puckered over the proximal and posterior faces of the eye.

9. An uveal part of the iris is not found.

10. The eye of Rhineura does not represent a phylogenetically primitive stage; it is an end product of evolution as truly as the most highly developed eye.

11. The adult eye shows few indications that there has been a cessation of development at any definite ontogenic stage. It does not resemble as a whole any ontogenic stage.

12. An arrest in the ontogenic development has taken place in so far as the number of cell multiplications concerned in forming the anlage of the various parts of the eye have decreased in number, and in the lack of union of the lips of the choroid fissure.

13. It is possible that the absence of cones or rods is due to an arrest in the histogenesis of the retina, but since these structures are normally formed in the young of Typhlotriton and disappear with age, it is possible

that their absence in the adult eye of Rhineura is also due to ontogenic degeneration.

14. The irregularity in the structure and existence of the lens and the great reduction of the vitreous body offer evidence in favor of the idea of the ontogenically and phylogenically earlier disappearance of the ontogenically and phylogenically newer structures.

15. Horizontal nuclei found between the pigment epithelium and the outer limiting membrane are probably derived from the proximal layer of the optic cup.

16. The different layers of the retina have reached a degree of differentiation out of proportion to the great reduction of the dioptric apparatus and general structure of the eye.

Zoölogical Miscellany.

C. H. Eigenmann.

1. Portions of a mastodon were found on a sand-bar in the Ohio River, near Rockport, Ind. They have been presented to Indiana University by Karl Cramer.

2. The bones of Megalonyx jeffersoni, from the Owen collection, have been mounted in their relative positions and are now on exhibition in Owen Hall.

3. The Museum of the Indiana University finds itself in possession of a collection of birds, made by President Roosevelt at St. Regis Bay and at Oyster Bay, between 1872 and 1877. Most of the specimens bear the original labels written by Mr. Roosevelt, which are examples of explicitness and fulness in labeling. The earliest specimen was collected February 12, 1872, and bears the serial number 4 of his collection. Mr. Roosevelt published a small paper upon the birds of the Adirondacks and another on those of Long Island, based in part on these specimens. The trustees of the University have ordered a dust-proof case to be made, in which they are to be preserved for the future.

There are forty-six birds in all, forty-two species, fifteen less than the number sent here by the National Museum.

The labels read as follows:

Roosevelt Number.	Name.	Date.	Habitat.	Reverse.	I. U. Number.
4A.	Larus.	2–12–1872.	Peninzeah.		860
4A 37.	Mimus rufus ad. ♂.	9–10–1872.	Piermont, N. Y.		1061
2C 5.	Tinnunculus alaudarus ad. ♂.	2–24–1873.	Ramleh, Syria.		586
319.	Corvus americanus ♀.	7–10–1874.	Oyster Bay, L. I.	16.5 34.2 11.6 7.4 1.9 2.3 2.0 1.6. Iris, brown. Bill, black. Legs, black.	1045
354.	Ceryle alcyon ♀.	8–21–1874.	St. Regis L., N. Y.	13.6 22.3. Iris, brown. Bill, black. Legs, slate.	1038
490.	Plotis anhinga.	3–10–1875.	Gainesville, Fla.	27.0 39.0. Bill, yellow. Feet, black.	1047
525.	Pipilio erythropthalmus ♀.	6– 5–*1875.*	*Oyster Bay, L. I.*	7.4 10.5. Iris, red. Bill, brown. Legs, yellow.	1054
540.	Icterus spurius ♀.	6–23 –*1875.*	*Oyster Bay, L. I.*	6.5 9.8. Iris, brown. Bill, black and slate. Legs, slate.	1046
551.	Cyanospiza cyanea ♂.	7–17–*1875.*	*Oyster Bay, L. I.*	5.0 8.5. Iris, brown. Bill, black and white. Legs, brown.	1055

578.	Dendroica maculosa ♂.	8– 7–1875.	St. Regis L., N.Y.	4.5 7.8 Iris, brown. Bill, brown. Legs, brown.	1059
590.	Empidonax Trailli.	8–25–1875.	Oyster Bay, L. I.	5.0 8.0. Iris, brown. Bill, brown and yellow. Legs, brown.	1044
594.	Picus pubescens ♀.	8–28–1875.	Oyster Bay, L. I.	6.6 12.9. Iris, brown. Bill, slate. Legs, slate.	1042
599.	Icterus Baltimore.	9– 3–1875.	Oyster Bay, L. I.	7.2 12.2. Iris, brown. Bill, brown and whitish. Legs, slate.	1050
622.	Zonotrochia melodia ♀.	10–23–1875.	Oyster Bay, L. I.	6.3 7.8. Iris, brown. Bill, brown. Legs, ——. Cont. crop, seeds and insects.	1053
641.	Parus atriccillus ♀.	3–24–1876.	Oyster Bay, L. I.	5.2 8.2. Iris, brown. Bill, black. Legs, slate. Cont. crop, insects.	1062

Roosevelt Number.	Name.	Date.	Habitat.	Reverse.	I. U. Number.
666.	Helminthophaga ruficapilla ♀.	5–20–1876.	Garrisons, N. Y.	4.6 7.9. Iris, brown. Bill, brown. Legs, brown.	....
669.	Dendroica Blackburniae ♂.	5–20–1876.	Garrisons, N. Y.	5.2 8.9. Iris, brown. Bill, brown. Legs, brown.	1060
704.	Tringoides macularius ♀.	7–25–1876.	Oyster Bay, L. I.	7.8 13.8. Iris, brown. Bill, brown and light. Legs, greenish.	1037
708.	Chaetura pelagica ♂.	7–26–1876.	Oyster Bay, L. I.	5.2 12.5. Iris, brown. Bill, brown. Legs, brown. Cont. crop, gnats and flies.	1041
712.	Empidonax acadicus ♂.	7–27–1876.	Oyster Bay, L. I.	6.0 9.8. Iris, brown. Bill, brown, lower mand. yellow. Legs, brown.	1043
741.	Dafila acuta ♂.	3– 5–1877.	New Jersey.	25.6 37.8. Iris, chestnut. Bill, brown. Legs, brown. Cont. crop, veg. substance, gravel.	776

757.	Turdus Pallasi ♀.	6–23–1877.	St. Regis L., N. Y.	7.0 11.2. Iris, brown. Bill, brown and yellow. Legs, yellowish. Cont. crop.	11
758.	Picus villosus ♀.	6–23–1877.	St. Regis L., N. Y.	9.0 15.0. Iris, brown. Bill, slate. Legs, slate.	1039
761.	Vireo solitarius ♂.	6–25–1877.	St. Regis L., N. Y.	5.4 9.3. Iris, brown. Bill, brown. Legs, slate. Cont. crop, small beetles.	1056
770.	Sphyrapicus varius ♂.	6–20–1877.	St. Regis L., N. Y.	8.4 15.2. Iris, brown. Bill, brown. Legs, slate.	1040
820.	Spizella pusilla.	4–17–1878.	Oyster Bay, L. I.	5.7 7.8. Iris, brown. Bill, pink. Legs, yellow-brown. Cont. crop, beetles, ants and gravel.	1052

The original labels of the following birds are not with the specimens:

I. U. Number.	Name.	Date.	Habitat.
702.	Vanellus cristatus ad. ♂.	2–10–1873.	Beni Hassan.
166.	Vireo noveboracensis ♀.	5–30–1874.	Oyster Bay, Long Island.
57.	Certhia familiaris rufa ♀.	12–30–1874.	Oyster Bay, Long Island.
118.	Dendrœca virens ♀.	5–11–1875.	Oyster Bay, Long Island.
709.	Calidris arenaria.	6–11–1875.	Oyster Bay, Long Island.
426.	Empidonax minimus ♂.	7–19–1875.	Oyster Bay, Long Island.
264.	Poœcetes gramineus ♂.	8– 2–1875.	St. Regis, New York.
187.	Tachycineta bicolor ♂.	9– 2–1875.	Oyster Bay, Long Island.
418.	Contopus virens.	6–27–1877.	St. Regis Lake, New York.
124.	Dendrœca discolor.	6–11–1878.	Oyster Bay, Long Island.
121.	Dendrœca pinus ♂.	6–12–1878.	Oyster Bay, Long Island.

The following are undated and arranged according to I. U. number:

I. U. Number.	Name.	Habitat.
243.	Spinis tristis ♂.	Oyster Bay, Long Island.
314.	Passerina cyanea ♀.	Oyster Bay, Long Island.
455.	Picus villosus ♂.	
792.	Fulix marila ad. ♂.	Northeastern United States.
1036.	Tringoides macularius ♂.	Oyster Bay, Long Island.
1048.	Aluco flammeus, ad.	
1049.	Icterus spurius, juv. ♂.	Oyster Bay, Long Island.
1051.	Aegiothus linaria.	
1057.	Helminthophaga pinus, ad. ♂.	Long Island.

Variation Notes.

C. H. Eigenmann and Clarence Kennedy.

The Spinning of the Egg–Sac in Lycosa.

W. J. Moenkhaus.

The habit of the female spinning a round, ball-like egg-sac and carrying this suspended from the spinners during the period of incubation, is, so far as I can determine, characteristic of the entire family of ground spiders, the *Lycosidae*, with the exception of the single genus *Dolomedes*. The process of the construction of the cocoon has been seldom observed, so far as I can determine from the literature. This is due to the difficulty attending such observation, since all of the species either tunnel more or less deeply into the ground or live in retreats under stones, boards, and the like. I had tried for a long time, without satisfactory results, to observe this until I finally hit upon a species *Lycosa sp.* that permitted me to make the observation very completely. The plan had been to place gravid females in glass jars half-filled with earth, and by moistening this next to the glass induce her to construct her burrow there and thus enable me to watch her actions through the glass. While I got several females thus to construct their burrows and spin their egg-sacs, I was not able to see sufficiently well through the glass, which always became pretty well besmeared with earth during the excavation. In the case under consideration, however, the whole process occurred above ground, so that I could see it step by step. This, briefly, ran as follows:

She first excavated a shallow hole in the middle of the jar about one-third greater in diameter than the length of her body. This she did with her mandibles and palpi, piling the excavated ground in a crescentic heap around one side of the hole. Then she spun a thin sheet over the hole, extending from the top of the crescentic heap to the opposite side, completely covering the hole. This sheet, thus, was not horizontal, but inclined, and in the instance observed about 25 degrees, the inclination, of course, being determined by the height of the crescentic embankment. Upon the center of this sheet a crescent-shaped pocket was constructed with the broad and open side directed toward the higher end of the incline. Into this the eggs were deposited immediately after its completion. The eggs filled the pocket heaped full. The exposed surface of the eggs was then closely spun over so that they were completely enclosed in a slightly compressed spherical cocoon, suspended in the center of the sheet. The edges of the sheet were then cut loose from the ground, carefully rolled up with the mandibles and palpi and tucked up against the cocoon, being spun fast as the work proceeded. This appeared as a rather prominent equatorial band around the cocoon at the line of attachment of the sheet. The whole cocoon was strengthened by further spinning, and, when finished, was fastened to the spinners and carried away. The whole was completed in a little more than one-half hour.

I have examined the cocoons of over fifty different species of *Lycosidae* and all show their equatorial band more or less prominently, so that it would seem that all the species adopt in general this same plan of constructing their egg-sac.

Experiments in the Hybridization of Fishes.

W. J. Moenkhaus.

[Abstract.]

During the past three years thirty-three different crosses were made among fishes. Most of these were between marine species; several were between fresh-water species, and three between marine and fresh-water species. In no combination was there a failure of impregnation. The per cent. of eggs impregnated was usually large—50 to 100 per cent.; in a few instances as low as 1 per cent. This per cent. bore no relation to the blood relationship of the species. In most of the cases there was either no polyspermy or the per cent. of polyspermy was small. In two crosses this was as great as 50 per cent. of the impregnated eggs. The degree of polyspermy bore no relation to the nearness of relationship.

In all cases of normal impregnation the earlier phases of development were passed through normally. All crosses except where *Batrachus tau* was used as the female, the development went beyond the segmentation stages, the embryonic shield being apparently perfectly formed. Many crosses went beyond this to the closure of the blastopore, but in these cases the embryo was varyingly shorter than the normals. Seven crosses developed into healthy fry. Some of these, however, showed abnormalities, usually in the caudal peduncle and the anal fin. These latter crosses were either between species of the same genus or nearly related genera.

An Aberrant Etheostoma.

W. J. Moenkhaus.

While seining in Tippecanoe Lake during the summer of 1896, there was taken among a great many Etheostoma caprodes a single very aberrant specimen of darter. I have been unable to identify it with any described species. Its close affinity to Etheostoma caprodes and to Etheostoma aspro at once strikes one, and a closer study shows it to be in many respects intermediate between these two species.

The specimen is rather large, although not too large for an Etheostoma aspro, measuring 78 mm. in length. The form of the head and body is very much like Etheostoma aspro. The snout is evidently longer and the interorbital space broader. The cheeks, opercle and nape are scaled. The color pattern, on the whole, also resembles more closely that of Etheostoma aspro. The barred character of Etheostoma caprodes in the upper half plainly shows itself. Along the side is a series of nine large dark blotches, more or less confluent with intermediate smaller ones. The dorsal, pectoral and caudal fins are barred. The ventral and anal fins, plain.

In the table are given measurements and counts of the aberrant specimen and the two most nearly related species:

	Etheostoma caprodes.	Etheostoma sp.?	Etheostoma aspro.
Dorsal fins	XIV-16 (average)	XVI-14	XIII-13
Anal fin	II-11 (average)	II-11	II-9
Lateral line	88 (average)	80	69
Head in body	4.27	4.21	4.00

Three possibilities present themselves: (1) The specimen may be merely an unusually aberrant form of Etheostoma caprodes or of Etheostoma aspro; (2) it may be a new species; (3) it may be a hybrid.

In regard to the first, it may be said that, considering all the characters, it is scarcely within the range of normal local variability of either species. If we consider the spines and rays, the scales and the proportions as set forth in the above table. it would seem easiest to consider it a variation of Etheostoma caprodes. In the form of the body and the coloration it could more easily fall within the range of variation of Etheostoma aspro. Indeed, this affinity is so strong that if it is merely a variation it can only have come from Etheostoma aspro.

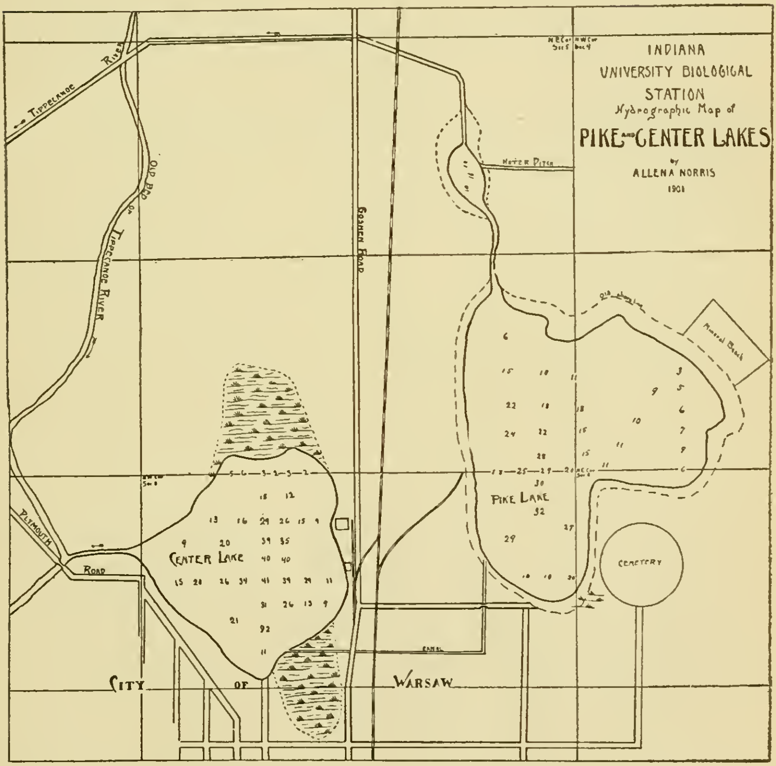
Both in coloration and in structural characters it can readily be distinguished from either of the two most closely related species, so that it would be easy enough to characterize it as a new species. The reasons against this are the usual ones, namely, that we have only a single specimen and that if it represented a species that is even only poorly established more specimens should have been obtained in the enormous amount of seining that was done during the same, previous and subsequent summers.

It is entirely possible that we have here a hybrid. There are characters that show a strong affinity for each of the supposed parent species, as well as characters (scales) that are intermediate. Both parent species occur in the lake, Etheostoma caprodes abundantly, Etheostoma aspro sparingly. The most serious objections against considering this a hybrid is the large number of dorsal spines—sixteen—in the dorsal, larger than in either parent species. About 2 per cent., however, of Etheostoma caprodes have sixteen spines in this lake and an occasional specimen is found with seventeen. It should be stated in this connection that I have experimentally obtained healthy fry between *Etheostoma coeruleum* and *Etheostoma nigrum*, two species much more distinct than the assumed parent species. There seems, therefore, to be considerable evidence in favor of the assumption that this is a hybrid.

REPORTS FROM THE BIOLOGICAL STATION.

I. MAPS OF WINONA, PIKE AND CENTER LAKES.*

ALLEN A. NORRIS.



---

*Contributions from the Zoölogical Laboratory of the Indiana University, under the direction of C. H. Eigenmann, No. 48.

II. FAUNA AND FLORA OF WINONA LAKE, PARTS A, B, C, D.*

A. A List of the Mollusca of Eagle, Center and Pike Lakes, Kosciusko County, Indiana.

A. A. Norris.

The mollusks mentioned below were collected during the summer of 1901. In the preparation of the list I have been under obligations to Dr. Call, of the Children's Museum, Brooklyn, and to Chas. T. Simpson, of the Smithsonian Institution, each of whom examined and named a part of the collection.

UNIVALVES.

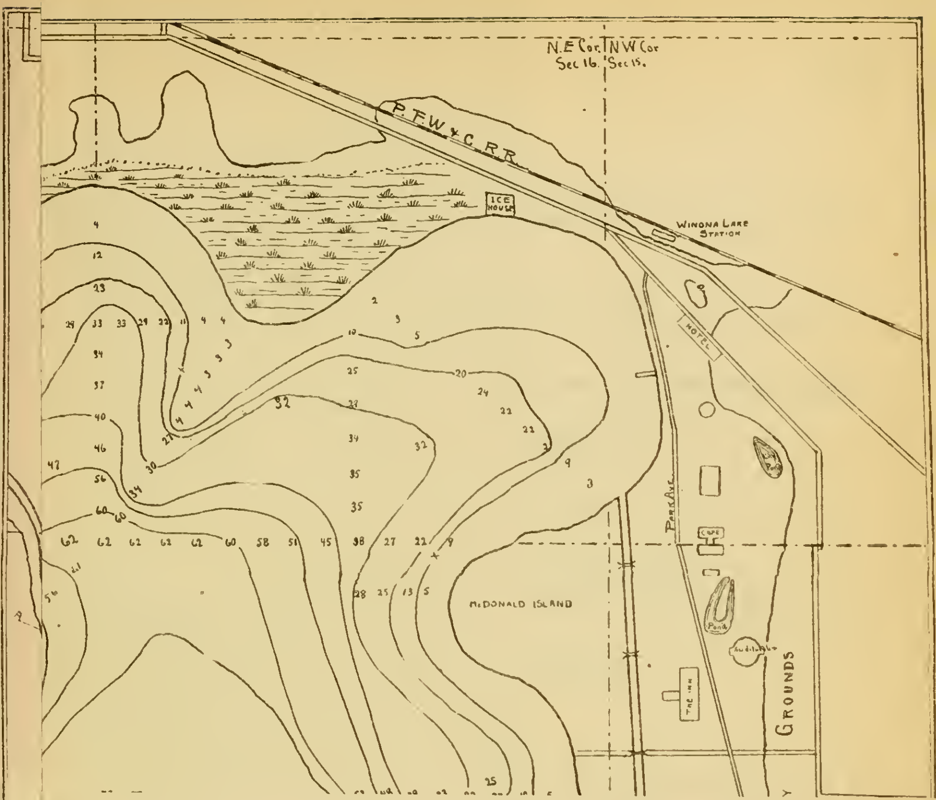
1. *Selenites concava* Say. Common on the marsh shores of Pike Lake.
2. *Mesodon multilineatus* Say. Abundant.
3. *Mesodon mitchellianus* Lea. Common.
4. *Limnophysa caperata* Say. Common.
5. *Limnophysa humilis* Say.
6. *Physa gyrina* Say. Common.
7. *Helisoma campanulata* Say. Abundant.
8. *Helisoma trivolvis* Say. Abundant.
9. *Helisoma bicarinata* Say. Common.
10. *Gyraulus parvus* Say. Common.
11. *Amnicola limosa* Say. Common.
12. *Amnicola parata* Say. Common.
13. *Valvata tricarinata* Say. Common
14. *Campeloma subsolidum* Anthony. Found in outlet of Eagle Lake.
15. *Campeloma rufum* Haldeman. Abundant in the outlet of Eagle Lake.
16. *Pleurocera subulare* Lea. Very abundant in Pike Lake and Eagle Lake.
17. *Pleurocera elevatum* Say. Outlet of Pike Lake.
18. *Sphaerium transversum* Say. Frequent in the outlet of Eagle Lake.

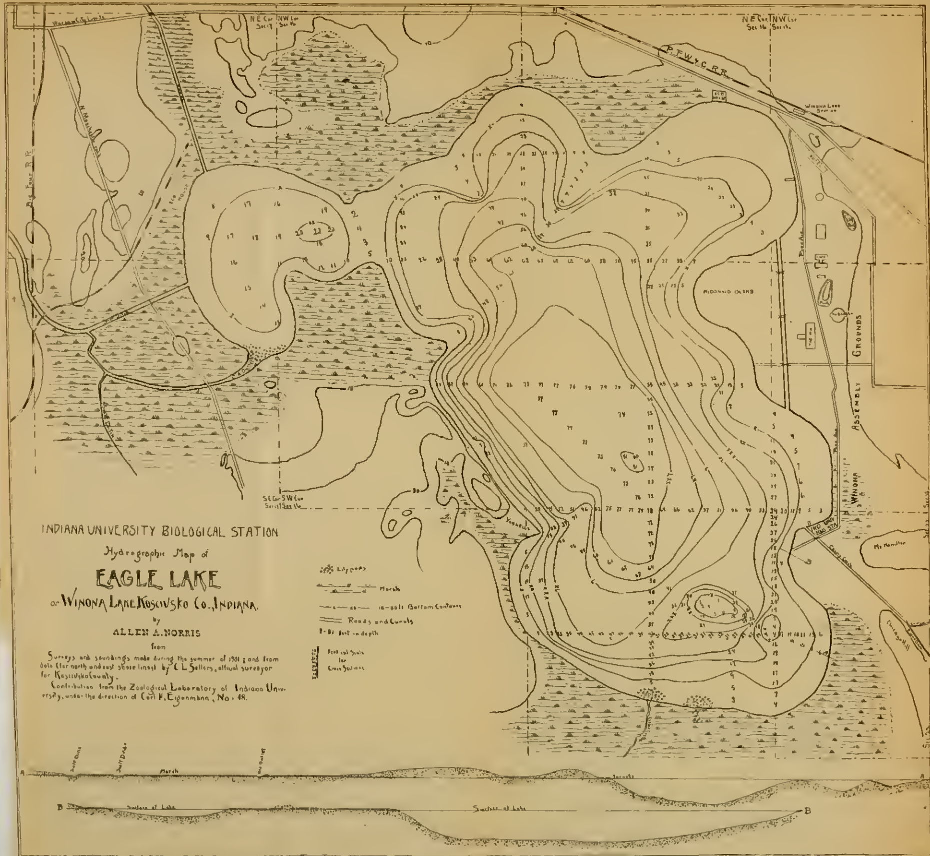
BIVALVES.

19. *Unio undulatus* Barnes. Abundant in the outlet of Pike Lake, rare in the other outlets, not found in the lakes.
20. *Unio gibbosus* Barnes. Three specimens were taken in the outlet of Eagle Lake.

---

*Contributions from the Zoölogical Laboratory of the Indiana University, under the direction of C. H. Eigenmann, No. 49.


N.E Cor. Sec 16.
N W Cor Sec 15.
P. F. W. & C. R.R.
ICE HOUSE
WINONA LAKE STATION
HOTEL
Park Ave
McDONALD ISLAND
Pond
The Inn
GROUNDS


INDIANA UNIVERSITY BIOLOGICAL STATION
Hydrographic Map of
EAGLE LAKE
or WINONA LAKE KOSCIUSKO CO., INDIANA.
by
ALLEN A. NORRIS
from
Surveys and soundings made during the summer of 1901; and from data (for north and east shore lines) by C. L. Sellers, official surveyor for Kosciusko County.
Contribution from the Zoological Laboratory of Indiana University, under the direction of Carl H. Eigenmann, No. 48.
Lily pads
Marsh
Bottom Contours
Roads and Canals
Feet in depth
Vertical Scale for Cross Sections
P. F. W. & C. R.R.
McDONALD ISLAND
ASSEMBLY GROUNDS
WINONA
Surface of Lake
Marsh

21. *Unio iris* Lea. Frequent.
22. *Unio subrostratus* Say. Abundant.
23. *Unio fabalis* Lea. Eagle Lake and Pike Lake.
24. *Unio cylindricus* Say. A single specimen was taken in the outlet of Eagle Lake.
25. *Unio luteolus* Lamarck. Abundant.
26. *Unio ventricosus* Barnes. A single specimen (dead) was found in the outlet of Pike Lake.
27. *Unio rubiginosus* Lea. Common in Eagle Lake and in the outlet of Eagle Lake. None taken from other waters.
28. *Unio clavus* Lamarck. Rare in outlet of Eagle Lake.
29. *Unio glans* Lea. Common.
30. *Margaritana rugosa* Barnes. Outlet of Eagle Lake.
31. *Anodonta edentula* Say. Six.
32. *Anodonta grandis* Say. Common in Eagle and Pike Lakes.
33. *Anodonta footiana* Lea. Abundant in Pike Lake, rare in Center Lake, not found in the streams.
34. *Anodonta ferrusaciana* Lea. Abundant in Pike Lake.

B. Additions to the Indiana List of Dragonflies, with a Few Notes.—No. II.*

E. B. Williamson.

ADDITIONS.

1. *Enallagma aspersum* Hagen. A single female was taken June 27, 1901, in the woods on Chapman Hill, near Winona Lake. The female of this species of *Enallagma* is so distinctively colored that I do not hesitate to record the species for the State on such scanty material. I think this species will be found to be extremely local in distribution.

2. *Dromogomphus spoliatus* Hagen. Old canal feeder along the St. Joseph River, and St. Joseph River, Robison Park, Ft. Wayne, July 19 and August 11, 1901. Abundant; both sexes taken; several exuviae gathered from piles at boat landings in Robison Park; observed feeding on adult imagoes of the following insects: *Pieris rapae*, white cabbage butterfly, and the two dragonflies, *Hetaerina americana* and *Argia putrida*. An active, inquisitive species, relentless in love

* No. I was published in last year's proceedings (1900), pp. 173–178.

and war, more wary than *D. spinosus*, and most numerous about the water from 9 a. m. to 4 p. m., where they are conspicuous by reason of the yellow or reddish-yellow seventh to ninth abdominal segments.

3. *Gomphus villosipes* Selys. Tippecanoe River, near Warsaw, June 23, 1901, 3 males. Holliday and Williamson.

4. *Gomphus dilatatus* Rambur. Tippecanoe River, near Warsaw, June 23, 1901, 5 males, 1 female. Williamson and Holliday. This species was found only near the P., Ft. W. & C. R. R. bridge over Tippecanoe River, and only on this one date. The bridge was being repaired, and the dragonflies were taken resting on some of the timbers, usually near the water, which flowed swiftly here. Possibly half the number seen were captured. They did not patrol the river, apparently, and, when frightened, they usually left the river, disappearing over the fields on either side.

5. *Gomphus spiniceps* Walsh. Old canal feeder along the St. Joseph River, near Ft. Wayne, July 19, 1901, one teneral female taken, another teneral seen, and two exuviae found in grass clumps two or three feet from the water.

6. *Sympetrum corruptum* Hagen. Near Winona Lake, August 10, 1901, 1 male. Miss N. O. Harrah.

Ninety-seven species of dragonflies are now recorded for Indiana. If *semiaquea* (or the form usually known by this name) and *assimilatum* should be regarded as distinct from *Tetragoneuria cynosura* and *Sympetrum rubicundulum* respectively, then the Indiana list numbers 99 species.

NOTES AND CORRECTIONS.

1. *Argia translata* Hagen. Pl. I, Fig. 1. Ab., male 30, female 28; h. w., male 22, female 23. A dark colored species; post-ocular spots small, not connected; thorax nearly to first lateral suture black, narrow antehumeral and posthumeral pale stripes, the latter only above; these stripes wider and the posthumeral longer in the female; sides of thorax pale, second lateral suture with a black stripe. Abdomen black; pale, narrow, interrupted basal rings on 3–7; male with a blue basal spot on 8 and 9, spot apically three-pointed, one point on either side (half the length of the segment on 8, nearly the entire length on 9), and the middle one on the dorsum; female with a pale lateral stripe the length of the abdomen, interrupted at bases and apices of segments, and placed lower on 6 and 7. The distribution of this species, as now known, is such as to make its discovery in Indiana possible.

2. *Nehalennia irene* Hagen. Winona Lake, June 22, 1901; Wooden Lake, July 4, 1901. Clarence Kennedy.

3. In plate I are figured the male abdominal appendages, lateral and dorsal views, of four species of *Enallagmas*. Two of these, *calverti* and *aspersum*, have been taken in the State, and the occurrence here of *cyathigerum* and *doubledayi* is probable. The species here designated as *cyathigerum* is the same as *annexum*. I believe that *annexum* (North American) and *cyathigerum* (European) are identical. *Hageni* and *cyathigerum* are very closely related—much more closely than *calverti* and *cyathigerum*. *Doubledayi* finds its closest allies in *carunculatum* and *civile*

4. In the report of the State Geologist for 1897, p. 404, I have recorded *Enallagma laterale* Morse for Shriner Lake. This is a mistake in determination; the single male is *carunculatum*.

5. The seasonal range of *Enallagma traviatum* is possibly not so short. I have records of it at Winona Lake from June 24 to July 13, 1901. It is much less conspicuous than any other *Enallagma* with which I am acquainted.

6. On and about July 6, 1901, Mr. Kennedy and myself noticed on several occasions the increased activity of *Enallagma pollutum* and *signatum* as twilight came on. In the spatter-dock beds, where, during the mid-day hours only an occasional wandering male would be seen, just before sundown many pairs clung to the broad leaves or flitted in couple far out over the lake.

7. On August 25, 1901, at Cedar Lake, Whitley County, Mr. Kennedy and myself took, in two or three hours' time, 65 specimens of *Ischnura kellicotti* about water-lily beds at the southwestern end of the lake.

8. The distribution of *Herpetogomphus designatus* as now known is such that this species may be looked for in southwestern Indiana. In the key to genera, *Dragonflies of Indiana*, it will run out to *Ophiogomphus*. Professor Needham has pointed out that the two genera, *Ophiogomphus* and *Herpetogomphus*, may be distinguished by the form of the post anal cells. This character is indicated in figs. 2 and 3, pl. I. In the case of *Ophiogomphus* the two branches of the anal vein form a distinct loop. *Ophiogomphus rupinsulensis* was taken, June 23 and 30, 1901, along the Tippecanoe River, near Warsaw.

9. *Dromogomphus spinosus* has been observed during 1901, as follows: Tippecanoe River, June 23 and 30; Chapman Lake, June 30; and Ft. Wayne, along the old canal feeder, July 18. During July the species was taken several times at Winona Lake.

10. *Lanthus albistylus* Selys has been taken in Maine, Pennsylvania and Tennessee; and its occurrence in Indiana is very probable. In the *Dragonflies of Indiana* this species will run out to the genus *Gomphus*. *Lanthus* and *Gomphus* may be separated by the form of the post-anal cells (see figs. 4, 5, 6 and 7, pl. I). In *Lanthus* the portion of the second branch of the anal vein bounding the

first anal cell on its outer side (M) is longer than that portion of the anal vein bounding the outer side of the same cell (S). In *Gomphus* M is always shorter than S, unless a vein between post-anal cells meets S, as in fig. 4. The *Gomphi* occurring in Indiana can be readily separated into three groups on characters of the post-anal cells.

I. Second branch of anal vein not angled where the first cross vein between post-anal cells meets it (at point T); normally two post-anal cells in the first series (fig. 4). (North American and European.)

II. Second branch of anal vein angled at point T; normally one post-anal cell in first series, two in second (fig. 5). (North American.)

III. Second branch of anal vein angled at point T; normally one post-anal cell in first two series, followed by two (fig. 6). (North American.)

Lanthus is similar to this Group III of the genus *Gomphus*. It may be separated by the character indicated above.

The species of *Gomphi* known to occur or possibly occurring in Indiana may be arranged in these three groups, as follows:

I.	II.	III.
brevis.	(?) pallidus.	externus.
viridifrons.	villosipes.	fraternus.
quadricolor.	(?) cornutus.	crassus.
exilis.		ventricosus.
sordidus.		vastus.
spicatus.		dilatatus.
graslinellus.		amnicola.
furcifer.		plagiatus.
(?) pallidus.		notatus.
		spiniceps.

Prof. Hine and Mr. Tough have studied *G. cornutus* and *G. pallidus* for me. From their sketches I believe both species will come in Group II, but the material is so scanty I can not be sure of this.

11. *Gomphus viridifrons* Hine. Pl. I, figs. 16 and 17. Described in the *Ohio Naturalist*, Vol. I, No. 4, p. 60, Feb., 1901. The color description is quoted below:

"Length of the abdomen, about 33 mm..; hind wing about 27 mm.; black, face and occiput green; prothorax with anterior margin and three spots, green or yellow; thorax green with spaces at base of wings, lateral suture and six bands before, black; the two middle bands are abbreviated anteriorly and separated by the mid-dorsal carina, which is very feebly green. Abdomen black, a dorsal band and sides of first two or three segments yellowish; a yellow spot at base of each of segments, four to seven; and sides of 8 and 9, usually yellowish. * * * This is *Gomphus sp.* Williamson, Dragonflies of Indiana, p. 294." This species is most closely related to *abbreviatus*, which species, however, is not known west of the mountains. From *brevis*, another close relative, which has been taken in western Pennsylvania, it may be separated at sight by the green face, the face in *brevis* being sharply marked with black.

12. *Gomphus descriptus* Banks should be dropped from the Indiana hypothetical list. It was recorded from Illinois on an erroneous determination. The species has not been recorded west of the mountains.

13. Mr. Tough, in a recent letter kindly calls my attention to an error in the description of *Gomphus dilatatus*, p. 286, *Dragonflies of Indiana.* Second line from bottom, for *apical* read *basal.* Mr. Tough reports taking two males of this species in Illinois, and one of these has a small but distinct yellow basal spot on the eighth abdominal segment. The few specimens I have seen of *dilatatus* have had eight immaculate above.

14. *Gomphus segregans* Needham is a synonym of *Gomphus spiniceps* Walsh.

15 On June 17, 1901, at a ripple near the Clover Leaf railroad bridge over the Wabash River at Bluffton, I took *Gomphus fraternus*, *G. crassus*, and *Progomphus obscurus*. *P. obscurus* was the most abundant and *G. crassus* the rarest. The next day at the same ripple, at the same time of day, under conditions which to me seemed the same as the day before, I took *G. graslinellus*, *G. crassus* and *P. obscurus.* But *G. fraternus* was not seen, and *G. graslinellus*, not seen on the 17th, was the commonest species of the three on the 18th. Specimens of the four species were all bright and clean, not at all worn. The why, whence and whither of imago *Gomphi* is a puzzle. On both these dates in the crowded willow herbs at the ripple *Argia putrida, apicalis, tibialis, sedula* and *violacea*—the five *Argias* known for the State—were pairing.

16. During the season of 1901 *Progomphus obscurus* was observed at Bluffton, June 17 and 18; Tippecanoe River, near Warsaw, June 23 and 30; Chapman Lake, June 30, where half a dozen exuviae were gathered on the sand beaches near the water's edge; old canal feeder and St. Joseph River near Ft. Wayne, July 19.

17. An exuvia of *Hagenius brevistylus* was collected from a pile in Tippecanoe River, June 23, 1901. On June 30 Mr. Kennedy took an imago along the river, and on the same date several were seen in a second growth brush lot, flying leisurely about—if no insect collector was in striking distance—and frequently alighting on twigs, stumps or an old rail fence.

18 During the summer of 1901 *Boyeria vinosa* was not rare in the low woods about the Biological Station at Winona Lake. Students collected a large number of nymphs of all sizes at Turkey Lake, July 19, 1901.

19. A single exuvia of *Basiaeschna janata* was found along the Tippecanoe River near Warsaw, June 23, 1901, identified by Professor Needham.

20. On August 24 and 25, 1901, Mr. Kennedy and myself collected several males of *Aeschna clepsydra* at Shriner Lake, Whitley County. This makes the Shriner-Round Lake list number 47 species. As observed on these two days, *clepsydra*, as his brighter color pattern would indicate, is a more dashing fellow than his common congener *constricta.*

21. *Macromia illinoiensis* Walsh. Wabash River, Bluffton, June 20, 1901; Tippecanoe River, near Warsaw, June 23, 1901; old canal feeder and St. Joseph River, near Ft. Wayne, July 19 and August 11, 1901. *Macromia taeniolata* Rambur. Old canal feeder and St. Joseph River, near Ft. Wayne, July 19 and August 11, 1901; associated with *illinoiensis*, *taeniolata* being the most numerous. This large dragonfly, floating idly or cutting through the air without apparent effort, always flashing the sunlight like darts from glimmering wings and metallic body, can not fail to draw the interest and admiration of any idle observer who may wander along its haunts. Its alertness usually brings dismay to the collector who has waited patiently in waist-deep mud and water for its coming, and whose deep and fervent reproaches follow the beautiful form as it sails away, first treetop high, then skimming the water with its strong front wings, in pure derision of the impotent wretch who plotted so clumsily against its life.

22. During the whole of July, 1901, and possibly later, *Epicordulia princeps* was on the wing along the reed-grown shores of Winona Lake. This species spends more hours per day on the wing than any other species in Indiana. In the gray twilight, before sunrise, while the black bass were noisily gathering their breakfasts in the shallow water, as we sat in the boat casting to right and left with an indigestible, hook-enshrouded minnow, *princeps*, misty and indistinct, floated by. After sunset, when we went to the shore with the shotgun to snapshot at bats, there he was again, out over the water, hurrying along in the gathering dusk as though his day were not yet completed.

23. On September 3, 1901, at an old gravel pit near Bluffton, I observed *Sympetrum vicinum* ovipositing. The male held the female by the head as they hovered a minute in front of a curtain of algae, formed by a mass of the plant clinging to the edge of an old plank as the water had become lower in the pit. This curtain was about nine inches high, the lower edge of it trailing in the water. The dragonflies moved swiftly forward and the abdomen of the female

was tapped quickly against the curtain. At once they moved backward and downward, and the female struck the water with her abdomen. Then they rose again, hovered a moment a few inches in front of the curtain, and repeated the performance. After some time they separated and alighted among some cat-tails growing near. Oviposition was not interrupted by copulation. Part of this curtain of algae was collected. Portions of it were literally piled up with the dragonflies' eggs. Doubtless some of the eggs were washed from the abdomen into the water, but the majority were placed on the algae. Eggs had been placed at the top of the curtain, but this had become thoroughly dry. Females, which I saw ovipositing were placing the eggs two or three inches above the water where the curtain was very damp. The hatching of the egg, and possibly the first moult of the nymph, takes place on this curtain.

24. Though the subject of Odonate copulation has been considered by many authors with "presque toujours une description detailée et souvent poetique," I have been unable to find any statement concerning the filling of the seminal vesicle of the male dragonfly, other than that this takes place before copulation. In the case of *Calopteryx*, *Argia* and *Enallagma*, where I have been able to make positive observations, the male fills the seminal vesicle at once after he has captured the female. It seems probable that during the wild flight of mating *Aeschnas* and some of the gomphines (I have noticed especially *Dromogomphus spoliatus*) the seminal vesicle is being filled, and, this accomplished, the pair come to rest in tree-top, on the ground, or where not, and copulation takes place. The Anisoptera, which I have observed, do not copulate while flying, if they are undisturbed.

EXPLANATION OF PLATE.

1. *Argia translata* Hagen. Ohio Pyle, Pa., September 8, 1901, J. L. Graf. Lateral view of ♂ abdominal appendages.
2. *Herpetogomphus designatus* Hagen. Portion of right wing; *t*, triangle; *i*, internal triangle; *a*, anal vein (or postcosta); b, first branch of anal vein; c, second branch of anal vein; p, post-anal cells (middle post costal space).
3. *Ophiogomphus rupinsulensis* Walsh. Portion of right wing. Lettering same as for fig. 2.
4. *Gomphus spicatus* Hagen. Portion of right wing. Lettering same as for fig. 2.
5. *Gomphus villosipes* Selys. Portion of right wing. Lettering same as for fig. 2.
6. *Gomphus scudderi* Selys. Portion of right wing. Lettering same as for fig. 2.
7. *Lanthus albistylus* Selys. Portion of right wing. Lettering same as for fig. 2.

8 and 9. *Enallagma doubledayi* Selys. Provincetown, Mass., August 4, 1899, J. E. Benedict. Lateral and dorsal views of ♂ abdominal appendages.

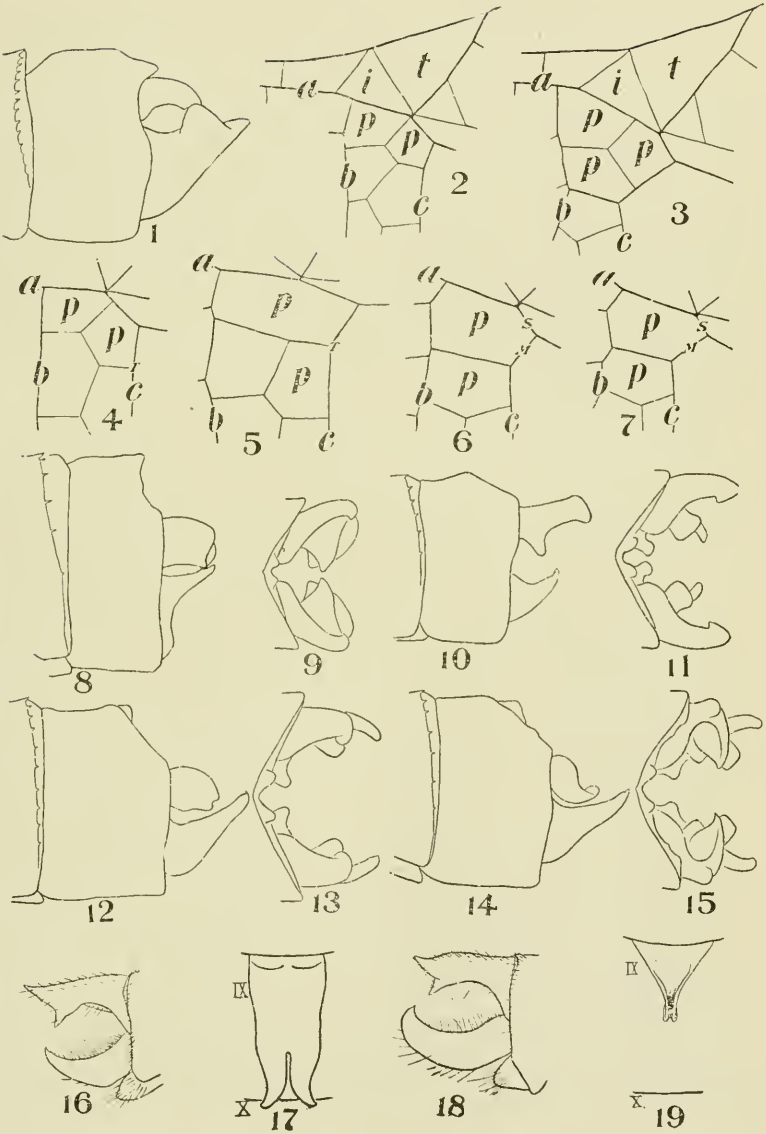
10 and 11. *Enallagma aspersum* Hagen. Conneaut Lake, Pa., August 18, 1899, D. A. Atkinson. Lateral and dorsal views of ♂ abdominal appendages.

12 and 13. *Enallagma calverti* Morse. Sheep Creek, Wyoming, August 6, 1899, E. B. Williamson. Lateral and dorsal views of ♂ abdominal appendages.

14 and 15. *Enallagma cyathigerum* Charpentier. Sheep Creek, Wyoming, August 6, 1899, E. B. Williamson. Lateral and dorsal views of ♂ abdominal appendages.

16. *Gomphus viridifrons* Hine. Ohio Pyle, Pa., June 25, 1900, E. B. Williamson. Lateral view of ♂ abdominal appendages.
17. *Gomphus viridifrons* Hine. Ohio Pyle, Pa., June, 1900, E. B. Williamson. Vulvar lamina.
18. *Gomphus brevis* Selys. Ohio Pyle, Pa., June 24, 1900, E. B. Williamson. Lateral view of ♂ abdominal appendages.
19. *Gomphus brevis* Selys. Ohio Pyle, Pa., June 28, 1900, E. B. Williamson. Vulvar lamina.

PLATE I.



C. Flora of Eagle Lake and Vicinity.

H. Walton Clark.

The work embodied in the following report was accomplished by the writer, assisted by Mr. Charles M. Ek, during the summers of 1899 and 1900, under the auspices of the Indiana University Biological Station. The purpose of the work is to present a study of Eagle Lake as a unit of environment as regards plant life, and the special line of investigation was that of the various plant aggregates of the lake, including their relations to each other and to that body of water. Many thanks are due to Dr. C. H. Eigenmann, Director of the Station, and to Dr. Mottier, Head of Department of Botany of the the Station, for assistance in suggesting and mapping out lines of work.

As regards the plan of the work, it will be helpful to the reader to bear in mind that the survey of the area studied was made in a series of concentric rings, beginning at the northeast corner of the region described, that is, at the laboratories, and starting southward. All descriptions have this beginning and sequence, and the sides of the lake are described in the following order: (1) east side, (2) south side, (3) west side, (4) north side.

Eagle Lake is one of the many small lakes of northern Indiana which occupy depressions in the surface of the glacial drift. It is somewhat irregular in outline, and consists of a large main body, a somewhat narrow neck or channel, and a large bay at the west end. According to Mr. Large, who made a survey of the lake several years ago (Proceedings Ind. Acad. Sci., 1896), the area of the lake is about 0.897 square mile.

Before entering into a detailed description of the lake and its flora, however, it may be well to consider briefly the surrounding country. This description of the region surrounding the lake is not intended to be exhaustive; it is simply presented as a sort of frame for the picture of the lake itself. The whole region from the lake shore to and including characteristic portions of the high ground beyond the limits of the lake plain, moreover, not only represents a sort of unit area in itself, but at the same time includes an interesting variety of conditions and furnishes interesting bits of well marked biological areas that are to be found on a large scale elsewhere, but which here in their limited size offer very favorable opportunities for study.

Eagle Lake and its plain are nearly surrounded by a rather abrupt terrace of yellow sand, which rises at varying distances from the lake shore and beyond which extends the undulating upland, forming the characteristic topography of the region in general. In only three rather narrow points does the terrace approach very near to the water's edge. These places are (1) along the northern part of the lake, near the northern end of the Assembly grounds, (2) at the place known locally as Yarnelle's landing, or Yarnelle's point, and (3) near the outlet. At all other places it recedes from the lake, leaving a large, level, lake plain. The rampart of hills, or terrace, is cut through in three places: (1) Cherry Creek valley, (2) the valley of Clear Creek, and (3) at the outlet. In the direction of Warsaw there is a long stretch of low ground, the exact natural limits of which it is impossible to define on account of many artificial changes, but which contains Market-street pond, an interesting body of water, and extends farther on toward the lakes on the other side of Warsaw, such as Pike Lake, Center Lake and others.

Along the southeast and south shore is a high, narrow ice ridge between the lake and the lake plain. The ice ridge is present elsewhere also, but is nowhere else so plainly marked. Fig. 1 shows a bit of old tolerably well marked ice ridge in this region.

In the discussion the regions about and including the lake will be noted in the following order: (1) The terrace and upland, along with the gullies through them. (2) The lowland between the terrace and the lake, consisting of lake plain and lowland forest. (3) The lake shore and belt of shore plants. (4) The ponds and bayous belonging to the lake plain. (5) The belt of marsh plants (plants with emersed leaves), and of short-stemmed aquatics. (6) The belt of long-stemmed aquatics. In the general discussion, simply typical species will be mentioned. The lake plants proper will be discussed more thoroughly later.

The terrace is composed of a yellow sand with an admixture of some clay. The slope from the lake plain is occasionally gradual; always, however, there is finally a rather steep and bluffy ascent. At Yarnelle's point there is no gradual slope at all, but the bank rises sheer from the water's edge.

THE UPLAND.—In the state of nature the upland is covered with a forest of such trees as the various oaks and hickories, some walnuts, a few tulip trees, wild cherry, ash and elm. In some cases there is no undergrowth of shrubs, and very little grass or herbs, as the forest floor is covered with a thick carpet of dried leaves. At other places, especially near the sides of gullies, there is an undergrowth of such shrubs as prickly

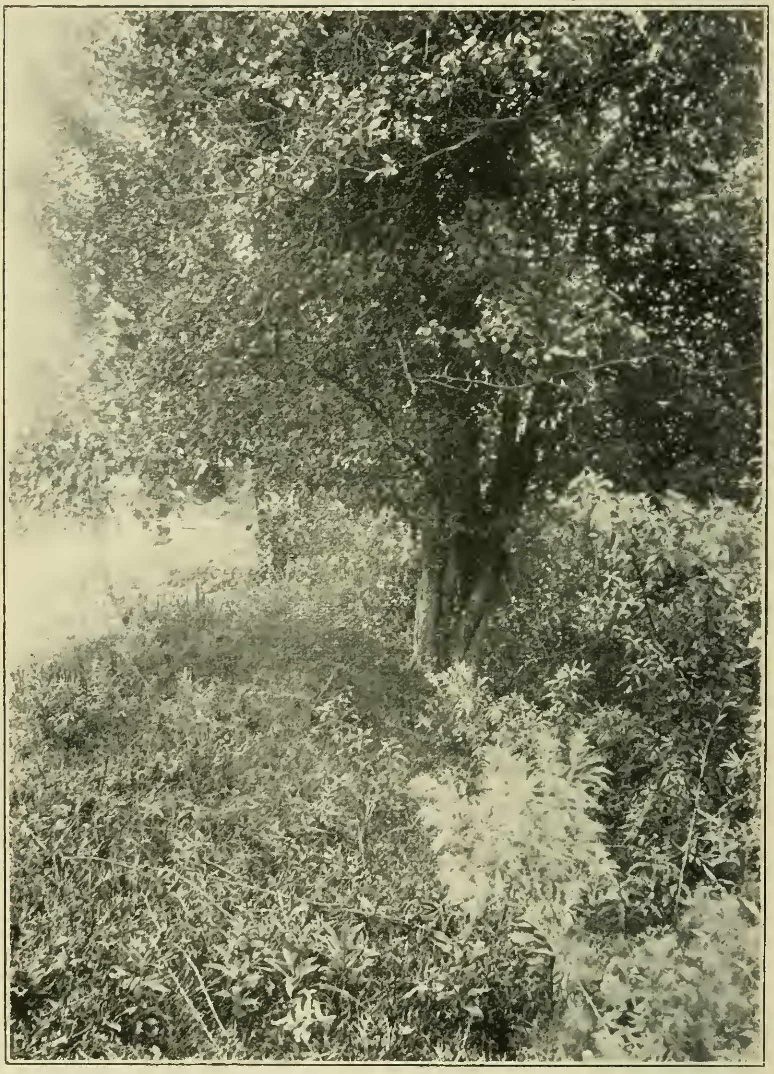


Fig. 1.

ash, raspberry and blackberry, some hoptree *(Ptelea)* and witch hazel, while the forest floor is covered with a carpet of common bladder fern, *Cystopteris fragilis*, some maiden-hair fern (not very common), Indian turnips, wood rush, various galiums, pinks, may-apples, hawkweeds, wood sunflowers, tick trefoils, and so on. *Anychia* is abundant in some places. In other places are a few scattered patches of *Sabbatia angularis*, frostweed, pinweed and *Hepatica hepatica*, the round-lobed liver leaf. This is the predominant species of the genus here; in fact, the only species the writer has seen at all, while in other parts of the State, except in Marshall County, the only species the writer has seen was *H. acuta*. In a hasty trip to Chapman's Lake, not far from Eagle Lake, plenty of *Hepatica acuta* was seen and no *H. hepatica*. (At Chapman's Lake, too, *Impatatiens pallida* was the only species seen. At Eagle Lake I have seen only *I. fulva*.)

Syndesmon thalictroides, which is usually regarded an early spring bloomer, flowers occasionally in late summer in various forests near the lake. During the summer of 1899 a specimen was found in the woods south of Cherry Creek, about one-half mile from the lake, in flower in August. In 1900 a plant was found in full bloom June 29, over near the Pennsylvania railroad, and another on July 30, up Clear Creek ravine.

Toward the foot of some of the hills, and in rather open spaces, is found an abundance of such plants as the black huckleberry (*Gaylussacia resinosa*), mullein foxglove, downy false foxglove, wild flax, frostweed, and in some places *Frasera*. Here, too, is an abundance of dense tufts of various mosses, while a small cup lichen, *Cladonia*, covers the earth with a continuous gray mantle. Toward the outer edge of the forest and at the foot of the hills is a sparse growth of wild oat grass and *Fimbristylis*.

The heavy forest southeast of the lake contains about the same species of trees as those mentioned above as characteristic of the hill forest. Here is a large number of introduced plants, as motherwort, burdock, and sweet briar rose. The forest near Yarnelle's point contains a basin where pin oak is almost the only species, while in the forest near the outlet there is coral root in considerable abundance. There is an abundance of fungi in all the forests, of Myxomycetes, Boleti and various Agarics.

In certain places the forests have been removed from the hills, where it has been left to grow up again without apparently having ever been cultivated much; we have a growth peculiar to such places everywhere. In one such region sassafras, not frequently to be met with in the native forest, has taken the place and grows so thickly as to shade out all undergrowth except a few spindly, discouraged-looking plants of red sorrel, *Rumex acetosella*. The lower leaves of this copse of sassafras took on beautiful autumnal coloration quite early in 1900. It was quite noticeable toward the end of July. Other parts of this once cleared place are covered with a thick sod of Kentucky blue grass.

There is also in the region just described (east of the lake) a sparse growth of scrubby oaks with clumps of raspberry and blackberry and wild grapes here and there.

The Russian mulberry has established itself here and forms an abundant sprinkling through the copse. The trees have in all probability sprung from seed scattered by birds. A peculiarity of this place is the tendency of plants of one species to form continuous patches to the exclusion of almost everything else. The sassafras has been cited as an example of this. One finds here and there a large bright green spot where dewberry vines have crowded out everything else. In other spots large patches of common five-finger (*Potentilla canadense*), in others *Steironema ciliatum*, and in others of prostrate tick trefoil cover the ground exclusively.

Where the ground has been wholly cleared, and cultivated, and then abandoned, we have, besides the ever present ragweed and *Chenopodium*, such rosette plants as mullein, pasture thistle, and canada thistle. Pepper grass is abundant, shepherd's purse scarce. There is also an abundance of such mat plants as purslane, carpetweed, and spreading spurges. Species of *Eragrostis* spread out in the form of mats. Crabgrass is abundant, and where the ground is cultivated, one of the most persistent and annoying weeds. *Euphorbia corrolata* is particularly abundant and conspicuous.

The gullies and immediately adjacent forests have a flora of their own somewhat different from the rest. The gully of Cherry Creek is a broad, level, swampy tract of country, covered with willows, sedges, skunk cabbages and various other marsh plants. It has a mucky soil, and resembles an extension of the lake plain.

Along the sides of this gully is considerable underbrush in the forest. There are plenty of such small trees as juneberry, flowering dogwood, ironwood, water-beech and haws, and such shrubs as hop-trees (*Ptelea*), witch hazel, bladdernut, and so on. Far up the gully is a specimen of the laurel-leaved oak, *Quercus imbricaria*, and one of alternate-leaved dogwood, neither of which are particularly common in the region. At the foot of the hills are a few ferns, lady-fern, maiden-hair and brittle bladder fern (*C. fragilis*). In general, however, the delicate wood ferns are not abundant in this region. *Mitella diphylla* fringes the slope of the hills here and there. Both in this gully and at places in the lake plain, as the southern end of the Assembly grounds, are soggy hills covered with a growth of sedges, shrubby five-finger, grass of parnassus, and so on. Numerous springs issue from these hills. In the bottom of the gully, and near the creek itself, is an abundance of swampy ground, with *Sagittarias* and other marsh plants. Here is an abundance of the liverwort, *Conocephalus*.

One dry hillside along this gully is completely covered with hounds-tongue. The hillsides from which springs issue bear in places large patches of horse-mint (*Monarda fistulosa*) and are made purple in August by masses of iron-weed in bloom.

The upper part of the gully of Clear Creek is different both in appearance and flora from that of Cherry Creek. Here the creek cuts its way through hills of sand and gravel. The bottom of the tolerably wide gully is mostly sandy soil, and the creek bottom is solid and often contains sand-bars and gravel-banks. The different slopes have a somewhat different flora. There are a few large basswood trees, and some beech and a few box-elder on the east side. On the slope on this side are found rock cress, *Blephilia*, nettles, beech-drops, and so on. On the west side of the gully were found spice bushes, *Celastrus scandens*, or climbing bitter-sweet, hedge hyssop, tall scouring rushes, blood-root, celandine poppies, remains of trillium, wood anemones, dutchman's breeches, and the like.

The sides of the outlet, where there is a broad marshy region without any pronounced gully, showed no plants different from those common to the region, except there was an especial abundance of the reindeer lichen, *Cladonia rangiferina*. There is here a broad, densely overgrown, swampy tract, full of willows.

At different places between the sand hills and the lake are the *low ground forests*, the bottoms of which seem to be slightly higher than the surface of the lake plain itself. One of these forests is to be found in the vicinity of the laboratories and another down along Clear Creek. This forest differs considerably from the high-ground forest in both soil and vegetation. The soil is a rich, black, sandy loam. The trees are burr oak, ash, aspen, willow, elm, plum, and so on. At the junction between the low-ground and high-ground forests we have at one place, near Chicago

Hill, a clump of red-bud trees. At another, on the border line between the upland and lowland forest, the ground is thickly covered with ground ivy, *Nepeta gleichoma.*

Here in the low-ground forest we have, especially in the first forest mentioned (that near the laboratories), a dense undergrowth of hazel-nut, prickly ash, hop tree and many other shrubs, so that the wood was somewhat difficult to pass through. The forest floor is also thickly covered with a quite dense growth of vines and tall weeds of numerous species, among which may be mentioned virgin's bower (*Clematis virginiana*), grape, hop, spotted touch-me-not, false nettle, American bell flower, great blue lobelia and cardinal flower, rice cut-grass, and many other such plants.

The low-ground forest in the vicinity of the laboratories was much modified during the summer of 1900, as a good deal of the underbrush was removed. In all cases it goes entirely down to the fringe of willows which grows at the edge of the lake.

The second low-ground forest, at the southern or west of southern side of the lake, not far from the region of Clear Creek mouth, consists of nearly the same sort of trees as the other, but the ground is rather more marshy, black and level, and the vegetation of the forest floor is of a somewhat different sort. There are more soft maples and large willows here, and lizard's tail is a characteristic plant. A small part of the shore is sandy here, and there is, between the lake shore and the low ground, back from the lake, a high, narrow ice ridge, four or five feet wide and breast high, and quite steep on each side. There are tolerable good ice ridges in other places, as south of Chicago Hill pier a little way, shown in Figure 2 (Fig. 2 shows lake plain on the left with willows on the ice ridge on the right), and over by Yarnelle's point, but these are not nearly so well marked.

The greater part of the country between the lake and the hills is a flat, level, meadow-like tract, forming the *Lake plain.* The soil of this plain is generally of a black or brown muck, with plenty of marl in places. Ditches dug through it reveal an abundance of gasteropod shells, many of them yet entire but very fragile, and many of them broken. These attest the former existence of the lake over the lake plain.

Traditions of old settlers refer to a time when the lake shore came up, in places at least, to the foot of the hills. One such tradition refers to the lake reaching the base of the hill known as Hamilton Mound, and the date assigned is about 1836. It is not reported whether this was simply the result of a temporary flood or a constant condition. The area of the surface is subject to quite marked variation at present, possibly more so than before the removal of much of the surrounding forest. The Government Survey shore line of 1834 lies at places considerably outside present maps of the lake. Mr. Large expresses his opinion that it perhaps marked the limit of the swampy ground.

In appearance and vegetation the various parts of the lake plain differ considerably from each other. In some places the soil is a reddish or brownish muck, in other places it is a blackish soil. In some parts it is a

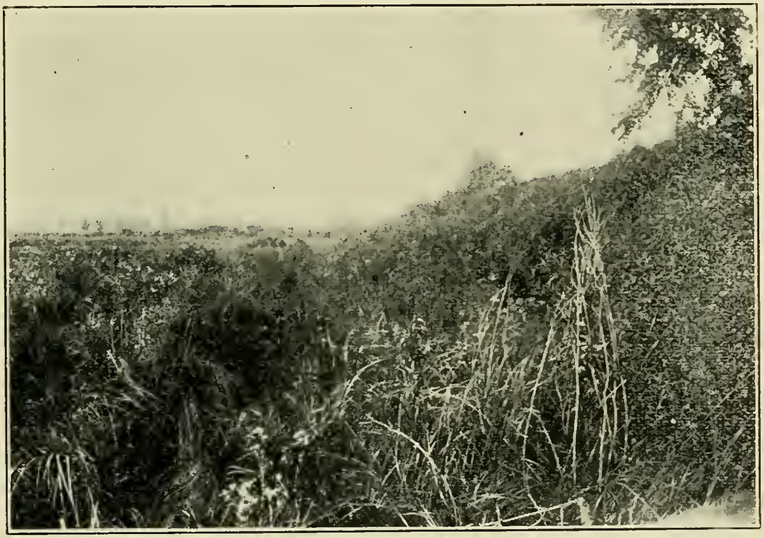


Fig. 2.

sedgy, ferny meadow, in others it is covered with a dense growth of bushes, as clumps of willow, *Cephalanthus* and *Cornus*. There seem to be indications, however, that it was once nearly alike in vegetation, and that the sedgy, ferny meadow has been cleared off by artificial means. One indication of this is that we have wholly different regions on different sides of fences, one side of the fence being bushy, and the other covered with sedges, grasses and ferns only. In one place where there was such a level meadow, a few dead willow sprouts were noticed. Examination revealed that they were charred about the roots and had probably been killed by fire, which had passed through and left the ground rough and tussocky. Between this meadow just described and the lake, near the lake shore, were plenty of low bushes, which had probably been saved by the proximity of the lake and possible resulting saturation of the ground, or more probably by the amount of sand in the low ice ridge upon which they grew. A few characteristic portions of the lake plain will be described in order:

(1) At the Assembly grounds, where the lake plain was once quite broad, it has been modified by filling in, and by the construction of base ball grounds and race track. This portion is now a level field overgrown with grass.

(2) The portion of the lake plain bordering on the southern end of the Assembly grounds was once brushy like the portion next to be described now is, but the brush has been cleared off. At present it is a level tract, covered thickly with sedges and ferns. Toward midsummer it is made purple in patches by the blossoms of loosestrife, *Lythrum alatum*. Later in the year there is a zone of blue about the height of one's head from the many blossoms of tall blue vervain, while later still the ground is yellow in places with blossoms of the cone-flower or black-eyed susan, which grows in great abundance here, and blossoms quite late in the season.

Farther on down, near the Biological Station, the lake plain is more in its natural condition. Here, at the foot of the hills, is a belt of sensitive fern extending for a good way along the edge of the plain. The whole plain is pretty densely covered with low clumps of *Cornus*, willows, Carolina rose, and button-bush. An examination of this region shows three distinct formations of vegetation. Upon a casual glance one sees very little but bushes. A close examination, lower down toward the ground, will show a thickish growth of tall sedges and a few coarse grasses, while an examination still nearer the surface of the ground will reveal a growth of slender prairie fern. These formations are shown to particularly good advantage where artificial agencies have been at work. Where the bushes only are removed, one sees for the most part simply a level stretch of tall, narrow-leaved sedge, with a few stalks of tall grass here and there. Where the grass has been mown one sees an unbroken patch of fern.

In the vicinity of the laboratories a low-ground forest, already described, comes down entirely to the water's edge. South of this is another stretch of lake plain. This plain is mostly devoid of bushes, except a narrow fringe along on the low ice ridge. It is covered with sedges, tall grasses and an under-formation of marsh fern. The distribution of plants in this region is somewhat patchy in places. There are several areas covered with the royal fern, *Osmunda regalis*, at the outer edge, near the hills. This fern grows so thickly here that at certain times the ripened sporangia give the whole landscape a brownish cast. Toward the lake is a pond of considerable size fringed with cat-tails and a whitish sedge, along with *Eleocharis* and *Sagittaria*. Near the lake shore, as has been said, is a fringe of willows. In this portion of the plain, during the month of August, the wand-like stems of blazing star, *Lacinaria spicata*, with long spikes of violet purple flowers, rise here and there and give a peculiar effect.

The portion of the lake plain south of the lake is continuous with that just mentioned and extends to Clear Creek. Along its outer margins it is much like the portion just described—a sedgy, flat stretch of country. To this during the late summer an abundance of swamp milk-weed and joe pye weed tint the whole landscape a light purple. Near the lake is a large pond or marsh where grows in one place great patches of *Sagittaria*. Here are the most extensive patches of bulrush, cat-tail, *Sparganium* and *Calamus* in the vicinity. Beside growing by themselves in places, these plants also grow together in other spots, forming a mixed flora. The soil is more than saturated with water, and is very miry. There are not many willows here, but just a little distance west, near Clear Creek, the large marsh extends back a long distance, and consists of an almost impenetrable willow thicket. Back of this willow thicket is a low-ground forest, already mentioned. At the extreme west end of this marsh it becomes more open and prairie-like, and has the appearance of having been burned over. Among the tall sedges of this place is an abundance of such plants as prairie fern, prairie dock and a tick trefoil (*Meiboma canadense*), very showy when in bloom. Some of the ground is mossy. One large tamarack with several smaller ones, probably its seedlings, are growing here isolated from others of the kind. The ground is not like that generally found in tamarack swamps.

At the termination of this marsh, a hill, part of it under cultivation and part of it upland forest, comes down near to the lake. From this place the hill and high-ground forest extend along the lake shore to some distance beyond Yarnelle's point, and for a space the lake plain and low ground wholly disappear.

Beyond Yarnelle's landing, and near the neck of the lake, the lake plain begins again and broadens considerably. Part of the plain has been cleared and pastured and mown so that little is left but the sedges. Part of it is covered densely with willows. It is not different in appearance from other portions of the lake plain, and is different in vegetation only in that in the wet portion adjacent to the lake two *Utricularias* are found among the sedges, one, *U. vulgaris* sparsely, and probably left by the lake as it retreated after a flood, and the other, *U. intermedia*, forming a dense and continuous mat over the ground. Here, too, is a large cat-tail and bur-reed marsh, and the bottom of the ground among these plants is thickly covered with moss, a long, bright green species. Wild senna is abundant in this place. The open plain continues until near the outlet, where it has never been cleared, and consists of a dense willow thicket. The plain on the western side of the lake is cleared, and at one place extends through a narrow neck between the hills for a considerable distance from the lake.

The lake plain along the northern shore is so much like that of the other part that no detailed description need be given, except to say that that portion along the neck of the lake, that is, the western end, is still a willow thicket, while the remainder is cleared. In the direction of Warsaw, along the middle part of the north shore of the lake, the hills make a large loop, so that the lake plain spreads out into a large round bay, with a narrow neck or channel. Here is one large and many small tamarack trees and many alders. The ground, however, is tolerably dry and there is no marsh in this region. One bunch of *Sphagnum* was found growing high and dry at the foot of the hills in the sandy ground, forming a tussock around the base of a tree. The plain narrows as one goes eastward until the hills nearly reach the lake near the railroad station at Winona.

From Eagle Lake, toward Warsaw, extends an interesting stretch of level ground. The surface is higher than that of the plain, but it is swampy and mucky. Part of this was once an old tamarack marsh; and, although no tamarack trees remain, it still abounds in *Sphagnum*, choke berries, chain fern, hispid dewberries and huckleberries. It has probably once been the home of many of those interesting plants generally found in tamarack marshes—pitcher plants, orchids of various species, cranberries, and perhaps droseras.

At this place the railroad intersecting the region brings in its interesting accompaniment of introduced plants. Among these are *Lupinus perennis*, squirrel-tail grass, *Salsola kali*, and so on.

Along the lake shore there is in many places a narrow fringe of willows and dogwoods. These probably once formed a continuous stretch, but have been removed by artificial means. Just edging the lake, too, was found, during the summer of 1899, an abundance of creeping *Selaginella*, but it was not nearly so abundant in 1900.

PONDS.—Just as the lake occupies a large hollow in the surface of the drift, so are lesser hollows in the surface of the lake plain, and in the region surrounding the lake, occupied by *ponds*. In some of the shallower ponds, and these remote from the lake, the supply of water is temporary and they are dry basins during the drier parts of the year. The ponds are exceedingly varied in appearance and flora, and are interesting objects to study. They are really lakes in miniature, and may represent future stages of the lake itself. Lack of space, however, will prevent the discussion of this interesting feature of the region, except to say that their quiet waters contain in abundance many interesting aquatic forms which are not to be found in the lake, or which occur there only in limited quantity. Among these plants are the various duckweeds, *Lemna minor*, *L. trisulca*, *Spirodella polyrhiza*, *Wolffia columbiana* and *W. braziliensis*, which are to be found in the ponds and lagoons on the eastern side of the lake. Other ponds contain an abundance of liverwort, two species, *Ricciocarpus natans* and *Riccia fluitans*, being abundantly represented. Some of the ponds containing foul water have *Utricularia vulgaris* in abundance. Here the bladders are black and full of dark, solid dirt, and the plants blossom profusely. This plant is found only scantily in the lake itself, and in this situation the bladders are empty and more or less transparent. The whole plant is bright green and I have not seen it in blossom at all. One of the ponds (Market street) contained *Brasenia* in abundance, and it blossoms profusely. A small patch was found in the southwestern part of Eagle Lake, but I have never seen it in bloom there. One of the ponds east of the lake contained large balls of nostoc in great abundance.

THE LAKE PROPER.—Preparatory to the task of mapping the various plant aggregates of the lake, it was found necessary to measure along the shore line, and so become acquainted with the relative distance of various objects. This work was done quite carefully and lengthy notes taken concerning the nature of the shore. Stations were established and full descriptions written of neighboring objects, so as to make their recognition possible. This was the most laborious and tedious part of the work, and not particularly fruitful of direct results, for of the great mass of notes taken the greater number would be tedious and uninstructive to the reader. The value of this work was evident, however, during every succeeding stage of the work; for during all the subsequent observations of the lake, every detail of the shore was familiar as nothing else could have made it, and objects could be oriented at a glance from any position in the lake.

Of the many things that might be said in detail concerning the physiography of the lake only a few of the most important and striking, as character of soil along shore, etc., can be noted.

SOIL OF SHORE.—Various parts of the shore, as along the Assembly grounds, at the Biological Station, and south of Chicago Hill pier, are sandy beach. This sand is not like that of the sand hills; it is a solid, whitish sand, with small banks or streaks of quite reddish sand here and there. Other parts of the shore are of a tough, blackish or brownish muck; the greater portion of the shore is of this nature. The shore about Yarnelle's point is rather coarse gravel.

Some parts of the shore are suffering wave erosion. Particular examples of this are the region just south of the mouth of Cherry Creek, and again at the cape just beyond the neck of the lake, and on the southern side. At these places the lake has encroached a good deal on the land in spite of the protection afforded by the roots of bushes, etc. Trees and bushes are undermined and fall over, and there are stumps in the lake bottom for some way out. At other places, as at the south end of the lake and along parts of the north end, the treeless, mucky shore is being worn away. Here the waves act as a "horizontal saw" (to use Le Conte's illustration), leaving a solid, mucky platform in the bottom and a steep, almost vertical step off at the water's edge from the level plain to the bottom. The waves often cut between tussocks of grass and leave minute fiords. At other places the sod or turf is undermined, and moves up and down with the waves. The muck is in places very tough and resisting. Large chunks of the fibrous soil are torn loose from the shore or bottom and rolled by the waves into a peculiar rounded form, much like a rounded rock in shape, and yet not torn apart. The work of erosion along these mucky stretches of shore is hastened and assisted very materially by holes, presumably water-dog burrows, which honeycomb the soil and render it susceptible of being broken up into pieces.

Elsewhere, especially between the patches of *Scirpus lacustris* to be described later, sedimentation is going on quite rapidly, and banks of soft, black mud are in the progress of formation. The waves throw up the mud in the form of loops and bands, and so form small irregularities in the coast line. An examination of the mud thrown up or built up in these situations shows it to be composed of small pieces of *Scirpus* in various stages of decay. Thus the *Scirpus* furnishes a large amount of material for the building up of new shores. Besides the comminuted and decayed *Scirpus* there are occasional banks of broken *Scirpus* stems, not yet decayed nor much broken up, piled like windrows up beyond the summer water line. These banks are probably piled up during the high water of spring or shoved up by the ice. Upon the soft, black mud banks mentioned above, there springs a dense growth of annual weeds which forms the advance guard of land vegetation in these regions.

It may be that the lake plain has for its foundation decayed *Scirpus* stems, to which is added turf from the sedges that today so thickly clothe its surface.

As has been said, long stretches of shore are made up of a firm, whitish sand. Such stretches are to be found along the Assembly grounds, north of Chicago Hill pier, and in the vicinity of the mouth of Clear Creek. This sand is often found floating in films on the surface of the water near shore. At the mouths of the creeks, banks or deltas of white sand are built up and these project above the surface of the water when the lake is low, and form islands. At other places it can not be said definitely that either erosion or sedimentation is taking place. Gently lapping waves will pile up a narrow ridge of sand just at the edge of the water, but high, strong waves will wash them down again. During active wave motion the advance of the waves will move particles of sand shoreward, while the back flow will move them back about the same distance.

Frequently on the sandy banks, perhaps everywhere in such places where not interfered with, the three-cornered rush *Scirpus americanus*, grows out and forms the advance guard of vegetation.

THE FLORA OF THE LAKE SHORE is not essentially different in species from that of the shallow ponds adjacent to the lake, especially the large pond on the southern shore. The only difference is that the plants in that pond (bulrush, cat-tail, spatterdock, pickerel-weed and arrowhead) form large patches, as they have here a broad region of shallow water and congenial soil. Along the lake shore the plants, all except the bulrush, form comparatively narrow belts. Most of the bulrushes (*Scirpus lacustris*) in the ponds outside of the lake are light in color and soft in texture (there are only a few found of the dark green firm form), while the reverse is true of the bulrushes in the lake.

THE FLORA OF THE LAKE PROPER now comes up for consideration. In the beginning it may be well to state that many of the plants growing in the neighborhood of the shore exhibit decided variations in general appearance. They have two extreme forms, one found growing in shallow water and the other in deep water. Among such plants may be mentioned the following:

(1) *Scirpus lacustris* (light green, apparently glaucescent — easily crushed—form already noted) grows in rich muck in shallow water. This appears to continue in blossom longer than the other, and but one patch is found in the lake proper, though it is abundant in the ponds. The dark-green, firm form, growing in the marl and in deeper water, generally has the umbel more contracted. At a few places these forms seem to intergrade, although there is no gradual shading-off at the place in the lake where they grow side by side.

(2) *Nymphaea advena*, or spatterdock, exhibits a variation in habit really very slight but quite conspicuous, and readily noticed by the most superficial observer. In rich soil and shallow water it is stout and erect, the large petioles holding the leaves high out of the water. In deep water all, or nearly all, the leaves float, and the petioles are lax.

(3) White water lily—the same general change, only more marked. The shallow water form has stout petioles, holding the leaves far above the surface of the water and at an angle, and the leaves show a radical ribbing or faint fluting, not coincident with the veins, but in direction like that of a palm-leaf fan—deep water form, with slender, weak, often coiled petioles and leaves floating on the surface of the water. On sandy bottom the plant is much smaller in leaf and flower, giving the form (Var. *minor* Simms).

(4) Water plantain, leaves exceedingly variable in shape, those under water resembling eelgrass; those floating are much like leaves of some of the *Potamogetons*, while the aerial leaves resemble the ordinary plantain.

The following brief synopsis will suffice to give a general idea of the centripetal sequence of the various plants of the lake. (1) On shore, out of water: *Scirpus americanus*, *Sagittarias*, *Eleocharis acicularis* and cat-tails. Here, too, may be reckoned *Polygonium amphibium*, with its roots on shore and its prostrate stem floating. It strikingly resembles a *Potamogeton*. (2) On shore and extending away into the water; *Scirpus* *lacustris*, *Potamogeton fluitans*, *Nymphaea advena.* (3) Confined to shallow water: *Pontederia cordata*, *Naias flexilis*, *Nitella* (a small moniliform species), *Eleocharis interstincta*, *Eleocharis palustris*, *E. mutata*, *Cladium mariscoides*, *Vallisneria spiralis* and *Potamogeton natans.* (4) Deep-water plants: *Ceratophyllum*, *Myriophyllum*, *Potamogeton lucens*, *P. amplifolins* and *P. pectinatus.* Beyond this last group belongs mostly the floating confervoid algae of the lake.

A consideration of the habits of the plants just mentioned will show at once how their forms correspond to their position. Each group mentioned have certain common characteristics, and may be placed in the same ecological group. (1) The shore plants already mentioned generally have stiff, stout petioles and stiff, generally rather thick. leaves. (In the *Scirpi* and *Eleochari* the culms function as leaves.) They all have large air tubes leading to the roots. This applies to all the lake-dwelling species.

Growing near the shore in places are the aquatics with short stems and the plant wholly submersed. *Naias* is a good type. They form a band in the center of a group which forms a wider belt, the emersed leaved lake plants.

These *lake plants with emersed leaves* extend from the shore out to where the water is about 6½ feet deep. Among these are reckoned the *Scirpi* and *Eleochari* (with the explanation above). These plants form the broadest belt in the lake, and one reason for the breadth of their distribution is to be found in the variability of the species which compose it, as has been dwelt upon somewhat fully above. This belt may, on this account, be divided into two strips; one including the shallow water forms and the other the deep water forms. *Castalia* and *Nymphaea*, which belong here, grow out to a depth of about five feet eight inches. *Scirpus lacustris* grows out farther, that is, to a depth of 6½ feet, and it here projects up out of the water about 5 feet, making the total length of some of the longest culms 11½ feet. Where Scirpus grows out into deep water it seems to exhaust itself in the effort to reach light and air, and so they are generally few-fruited or wholly sterile, with deadish brown tips. They progress out into the lake by means of rhizomes, and at the outer edges of the belt one can frequently note their arrangement in straight lines, corresponding to the position of the root stock.

The Aquatics with Submersed Leaves.—It is difficult to fix the exact limits of these plants with certainty, especially so that they could be represented on a map, for they do not form visible patches at the surface. It is convenient, as said above, to divide them into two groups—the short-stemmed aquatics—for length of stem seems to be the chief factor in determining the habitat. It should be borne in mind, however, that the long-stemmed are quite variable in length, depending on depth in which they grow. In general the influences which determine the habitat of wholly submersed aquatics, aside from the kind of soil at the bottom, is the amount of light (and probably dissolved gases) available. The amount of light and dissolved gases is determined by the nearness to the surface. The former is also determined by the clearness of the water; and in case the clearness of the water is disturbed by organisms characterized by holophytic nutrition, the amount of gaseous plant food, as well as the light, would be decreased with the increase of amount of suspended organic material. This feature of the case will be touched upon later.

The short-stemmed aquatics (*Naias*, *Chara* and the like) grow only in shallow water. They were found out to a depth of six feet of water, rarely more.

Among the *long stemmed aquatics* Potamogeton *lucens* is generally found in isolated patches, while *Myriophyllum*, *Ceratophyllum*, and *Potamogeton pectinatus* grew together, making long belts. These form the extreme central belt of (phanerogamic) lake plants. They are to be found from 100 or 150 to 600 feet from shore, according to depth of water. By means of dredging it was ascertained that these plants rarely or never grow out much deeper than can be seen from a boat with favorable light. Twelve feet was the greatest depth at which any were found. As they grew to be about six feet long, the distance from their tops to the surface of the lake varies from about six feet, at the deepest, to nothing at the shallowest places where they grew. During the latter part of August, 1899, when the lake surface was quite low, due to a protracted drouth, some of the plants of *Myriophyllum* projected up to the surface and the tops floated, but they did not seem to be thriving well.

Toward the south-central part of the lake is a large bar, and its position is marked on the water surface by the presence of Potamogetons and other deep-water plants.

It is seen, therefore, that the greater part of the lake bottom is devoid of coarse vegetation, the plants making only a rather narrow belt around near the shore. The plants seem limited, moreover, to depths much shallower than might be expected. Records of these species growing to considerably greater depths are common. This limit in depth may perhaps be partly explained by the large amount of diffused matter to be found in Eagle Lake. This material is so abundant that it gives the lake water a decided amber color, and the rays of the sun penetrating into the water make streaks much like those formed by sunlight entering into a very dusty room, or dusty atmosphere, as in the phenomenon commonly spoken of as the "sun drawing water." It is very certain that this material cuts off a great deal of light, and perhaps absorbs considerable of plant food. At any rate, there seems to be an interference of some sort between the larger plants and the plankton—a fact generally observed. (See a reference to this relation, part 5, page 257, of Science, Vol. XI, No. 268.)

THE LAKE ALGAE.—No particular attention was paid to the Algae except where they formed conspicuous masses. Most of the work in this group was left to the investigators in plankton. *Oedogonium*, *Cladophera* and *Spirogyra* could be found almost any time in the ditches and along the edges of the lake.

Throughout both summers of the work, 1899 and 1900, *Mongeotia* was very abundant in the lake, especially in the head bay. Much of it formed immense cloudy patches among the water weeds, and much of it was in the shape of large, floating, yellowish green patches. There was a good deal of *Rivularia* in the lake. All I saw here was attached. It grew in a semi-globular form, fastened to water weeds and rushes. Upon rich, muddy bottom, where there is an abundance of dead bits of Scirpus, there is a good deal of *Chaetophora*, which assumes the form of a narrow, elongated, dichotomously branching thallus, which resembles some of the narrow *Riccias* in outward aspect. The water is full of fine granular masses of *Clathrocystis*, and short, stout, rigid filaments of *Oscillaria*, which resemble hair clippings. *Hydrodictyon* is very peculiar in its occurrence in the lake. It suddenly appears in great masses at the mouth of Cherry Creek, and then, after remaining a few days, it is washed in great masses upon the shore and suddenly disappears, generally after reproduction, so that after the large plants have disappeared the water is full of very tiny ones. The date of appearance of this plant in 1900 was July 13. By July 27 all the older *Hydrodictyon* had disappeared as a mass and the water was full of young plants.

Many large *Nostoc*-like jelly masses of an unicellular alga, probably *Aphanothece*, were found along the northern shore of the West bay. Among other algae noted in considerable masses was *Microthamnion*. There was also a few plants of a small momiliform species of *Nitella* found in the south part of the lake, quite near shore, in 1899. None was seen in 1900.

The water is quite full of minute algae, which is generally kept well mixed up with the water by the constant churning of the waves. In quiet places, however, as near the shore in sheltered places, or among the rushes, these algae, mainly *Clathrocystes*, form a surface scum. On one day during the latter part of the summer of 1899, when the lake was tolerably low, and after a very calm night, these algae formed an unbroken film or scum over the surface of the lake, except where broken up by the jumping of fishes, etc. The track of the boat and every oar-stroke could be noted across the lake as far as could be seen clearly at all, and, as said above, every place where a fish had splashed up was left as a break on the surface. Some phenomenon similar to this is briefly noted in an article by C. D. Marsh, and various names given for it, as "breaking of the meres," or "working of the lakes." (See Science, Vol. XI, No. 268, first column, page 379.)

DETAILS OF DISTRIBUTION.—In the preceding discussion the only determining condition of plant distribution taken into consideration was the amount of water present in the soil or about the plant; and the various plant groups have been spoken of as if they occurred in regular concentric belts or circles.

The amount of water has indeed been the most conspicuous influence, and the most easily measured, here as everywhere, and it has been this fact that has determined the conception of the ecological groups, xerophytes, mesophytes, and hydrophytes. It is needless to say, however, that there are multitudes of other influences, such as soil, temperature, and many obscure and perhaps undiscovered influences which operate to make the distribution of the various species tolerably irregular.

Some of the most noteworthy irregularities will now be discussed more in detail. Only lake plants will be noted.

SCIRPUS AMERICANUS (three-cornered bulrush) is found in scattered patches at almost any bit of sandy shore. Along the east and south shores it grows rather thinly and covers only small areas. Its general absence or scarcity along the eastern side of the lake is due in some cases (as in front of the Assembly grounds) to artificial removal. Beginning at the southeastern bend of the lake, however, it extends in large and frequent patches almost to the bend which forms the neck of the lake. At places where it is thickest, as at the gravelly shore at Yarnelle's landing, it is the predominant form, here growing very dense and close. There are also dense strips of considerable length on the shore along the northern end of the lake. Its distribution seems to be determined by the presence of solid sand-beds or bars where it delights to grow. It generally grows wholly on shore or in only quite shallow water, and does not seem to like the beating of waves so well as does *S. lacustris*. Fig. 3 shows a characteristic set of relations (south of Chicago Hill pier). Willows on ice ridge at the left. *Scirpus americanus* on sandy bank. *S. lacustris* in water with stems on shore. A patch of *Pontederia cordata* in water in foreground.

Fig. 3.

PONTEDERIA CORDATA occurs in small or isolated patches all around the lake, but by far the largest and most continuous stretch is at the south end, not a great way from the mouth of Clear Creek. This plant is generally associated with *Nymphaea advena* and is closely similar to it in structure and habit. It generally forms a belt between the main mass of *Nymphaea* and the shore. The *Pontederia* farthest from shore grows in among the *Nymphaea* nearest the water's edge. *Sagittaria*, in so far as it grows along the shore, occupies nearly the same position, except that it grows at the water's edge. *Pontederia* and *Nymphaea* grow in considerable abundance in the pond south of the lake, and *Sagittaria* has its best development here, forming an immense patch intermixed with other plants. Among other plants which frequently come down to the water's edge, but which are most abundant on the lake plain or in its ponds, are cat-tails, Calamus, and some *Phragmites.*

The chief representatives of the short-stemmed aquatics are *Naias flexilis* and *Chara.* *Naias* grows in scanty patches nearly everywhere in the shallow water near the shore. There are occasionally very dense patches. Such were found in 1900, midway between the Biological Station and Willow point, near the mouth of Clear Creek, and out in front of the laboratories. There was also considerable on the west side of the lake near the shore.

CHARA begins at the southwest corner of the lake and covers a considerable area there. Then it stops until near the neck of the channel which lies between the lake and West Bay. It covers nearly all the bottom of this channel, and extends in a good way, about 300 or 400 feet nearly all around the bay, except for a distance along the western side, where it is mucky. Another patch of Chara occurs, mixed in with Naias, in front of the Assembly grounds. The specimens of Chara found in this latter place were much larger and longer than those found elsewhere, and were fuller of fruit.

SCIRPUS LACUSTRIS is the most abundant and conspicuous of the lake plants. One belt begins about 200 feet north of Chicago Hill pier. From this place it extends, with the exception of a few very narrow interruptions, almost to Yarnelle's point, where it thins out and wholly disappears for a little way, its place being occupied, as before noted, by *S. americanus.* Not far north of the landing, however, it begins again and extends up to the channel, and runs far out into a sharp cape at this point. There is another small patch in the middle of the channel, which is cut in two by the steamboat track. This plant fringes the outlet bay quite thickly, and then occurs again at the mouth of the canal which leads from the lake to Warsaw. Another strip begins at the channel and extends up to the red ice-house. There is a broad region bare of any *Scirpus* all along the Assembly grounds; its absence here is in all probability due to artificial removal, for the conditions of growth are in every way favorable. The last patch begins along Willow Cape and extends far out into the lake, and grows along the shore until a little north of the laboratories. This leaves a large gap until nearly to Chicago Hill pier. This plant seems to delight in a soft, marly soil, and does best in rather shallow water. Its absence at Yarnelle's landing may probably be accounted for by the sudden slope at that shore and by the gravelly beach. Whenever long bars run out into the lake, *S. lacustris* marks the place by projecting out into long capes. Fig. 4 represents a characteristic patch of *S. lacustris* (south of Chicago Hill pier), along with other relations. On the left, shore with willows, and mud bar with *Scirpus stems*. Between the shore and Scirpus are patches of *Pontederia cordata*.

Fig. 4.

Potamogeton pectinatus forms a wide belt extending from rather shallow water (four feet) to seven or eight feet. It occurs in scattered patches all round the lake. *P. amplifolius* grows in somewhat deeper water than the preceding. It forms several large patches, one in front of the laboratories and one near the mouth of Clear Creek. Other smaller patches are distributed quite generally. *Myriophyllum* and *Ceratophyllum* generally grow in the same depth of water and often form mixed patches. The latter is found almost all round the lake in considerable quantities. These two plants form their thickest patches in the mud near the outlet.

Potamogeton lucens, though abundant, is rather scattered. *P. zost raefolius* and *Heteranthera dubia* grow intermixed in about five feet of water, and resemble each other somewhat, except *Heteranthera* has a round stem. Bits of *Heteranthera*, broken off by the waves and washed ashore, take root and grow and blossom, forming mats of short, bright green plants with yellow blossoms.

The spatterdock (*Nymphaea*) and water lily (*Castalia*) are to a cons'derable extent found growing together. *Nymphaea* forms a tolerable large patch in the pond in southern lake plain. It is not found in the lake along any part of the northwestern shore at all. It covers a very large area at the southern end of the lake near the mouth of Clear Creek (see Fig. 5), and runs its greatest distance out from shore on a bar formed at the

Fig 5.

mouth of the creek. It begins again at the extreme end of the West Bay, near the outlet, and forms a broad marginal belt around this part of the shore. There is a third patch at the mouth of the steamboat canal. It extends for some distance beyond the canal mouth to the north side. Nymphaea seems to prefer a muddy bottom. It seems to be fond of a gentle current, and extends from the lake for some distance up Clear Creek, and down the outlet. Its greatest development in the southern part of the lake is due to the protection it has there from lashing winds, as this is the sheltered side of the lake. Fig. 6 shows a patch of spatterdock, with intermixed bulrushes, near the outlet.

Castalia odorata, or white water lily, has a somewhat more general distribution, as scattered plants occur nearly all round the shore. There is a number of stout plants growing in the bayou in front of the laboratories, then there is none whatever until about 700 feet south of Chicago Hill pier. From this place occurs occasional patches of the small form until the large stretch of *Nymphaea* at the mouth of Clear Creek, is reached. Here there is a wide, dense growth of the ordinary floating-leaved form. There is a second large patch, similar to this one, in the bend at the south-

Fig. 6.

west corner of the lake. It is here nearly free from spatterdock. The broad bay leading to the outlet has two belts, the outer belt of the stout form growing almost out of the water in the rich muck at the edge of the shore, and the ordinary form out in the water. (These are shown in Fig. 7.) There are scattered small patches all along the west coast of the West Bay. In 1899 a good-sized patch grew about the region of the mouth of the steamer canal. It was not noted in 1900. Here the species ends except for occasional plants.

Many other plants are found in the lake, but not in quantities sufficient to call for more than passing notice. Only a few plants of *Philotria* were seen here, although it grows abundantly in bayous. *Vallisneria* grows most plentifully just south of the mouth of Cherry Creek, about Chicago Hill pier, about 700 feet south of this, near Clear Creek mouth, at the western end of West Bay, near the pier by the ice-houses, and off the Assembly grounds. Bladderwort, *Utricularia vulgaris*, fringes the edges of the channel, but it is not particularly abundant here. It was really found in much greater quantities in the lake plain just beside the channel. The

Fig. 7.

plants in the lake are bright green, with empty bladders and no blossoms, while those in the foul water of Willow Point bayou and elsewhere were very different in appearance, the bladders black with contents, and the stems bearing abundant flowers.

Water-shield (*Brasenia purpurea*) covers rather thinly only one small area at the south side of the lake. The plants are small and unthrifty, and I have never seen them in blossom at this place. In a pond not far away (Market-street pond) they blossomed abundantly during the summer of 1899.

Cladium mariscoides grows in several small patches at the edge of the lake, mixed in with the *Scirpus*. *Eleocharis palustris* grows in the lake rather scantily in two places, one just a little north of Chicago Hill pier, at the beginning of the *Scirpus* patch, and the other a little south of Yarnelle's landing. *Eleocharis interstincta* and E. *mutata* form each two small patches along the southwestern shore of the lake and at Yarnelle's landing. There were only a few duckweeds *(Spirodela)* found in the lake proper. This was along the southern edge, where it was shady and calm.

GENERAL RELATIONS.—The plants on the shore, especially those which grow out upon newly-made soil, probably have a good deal of influence in binding the shore together, and assist in the encroachments of the land upon the lake. This influence, however, is difficult to measure or express in definite terms, for it seems irregular and uncertain, as erosion goes on quite rapidly even where there are forests on shore, wherever the wind has full sweep. Small trees are uprooted and fall, and in some places stumps are found in the bottom of the lake near shore.

THE PLANTS IN THE WATER, especially the *Scirpus*, form a large amount of material for the building up of new shore. They also break the influence of the waves against the shore. At times, when the surface of the lake was quite rough, the water above a large patch of water weeds, particularly *Potamogeton amplifolius*, was often noted to be perfectly calm. The large submersed leaves of the latter plant are very effective in catching the moving molecules of water, retarding their motion, and so preventing waves.

The larger plants in the lake bear certain relations to the plankton. Among the *Scirpi*, the *Clathrocystis* scum is abundant almost any time during the latter part of the summer. Here we have a marked influence on the vertical distribution of the plankton. On the afternoon of August 21, 1900, a thickish coating of clathrocystis was noted among the bulrushes near the shore, and during the night the lapping waves piled it up in a narrow streak along the water line.

The stems of the water plants furnish lodgment for many aquatic plants and animals. Fresh water sponges grow abundantly upon the *Scirpus* stems.

A peculiarity of a species of *Rivularia* may be noted in this connection. It frequently grows quite abundantly attached in small hemispheric masses to stems and leaves of water plants. I have never seen it floating in Eagle Lake at all, and Dr. Howe, who has worked particularly with the plankton, has found it floating but once. At Turkey Lake it is said to float in great quantities, the whole lake appearing crowded full of dark green spheres the size of a large pinhead, and on a short visit to Tippecanoe Lake I noticed the same phenomenon. I have not had opportunity to compare the richness of vegetation of Turkey and Tippecanoe Lakes with that of Eagle Lake. It is possible that the condition *Rivularia* assumes depends upon the abundance or scarcity of plants which will serve as places of attachment. In assuming this attached position it escapes the plankton nets, and so its abundance is liable to be underestimated; for as there is difficulty in manipulating the net among the water weeds, direct comparison of its abundance would be impossible to obtain.

As an agent in the dissemination of seeds the lake acts only to a limited extent, as a floating seed would need sufficient surface projecting above the water in order to be wafted far. Many such seeds as acorns, hazel nuts and butternuts were floating in the water, but all of them were decayed. In the case of winged seeds, however, it was different. A number of small seedlings of the soft maple were found growing along the shore about high-water line, and the seeds had evidently been deposited there by the waves. The year of 1899 was somewhat noteworthy for the very heavy crop of elm seed, especially white elm. In the early summer of that year, in the vicinity of Fort Wayne, the writer noted woodland ponds, the surfaces of which were entirely covered with the seeds of this species. In the same summer, but later, there was found at the high-water line of the lake just north of the laboratories a row of small seedling elms growing as thickly as they could stand. There was another long, thick row in a corresponding position along the southeast shore of the lake. In the summer of 1900 quite a number of the elms were found. They had increased well in size and looked quite thrifty. If undisturbed they may form the beginning of a forest, much like the present low-ground forest along the lake shore. There was no elm seedlings of 1900 noted; the crop of seed in the forests was not by any means so large during that summer.

Below is appended a list of plants noted in the vicinity of Eagle Lake. The list of plants occurring in the neighboring forests, or at any distance from the lake, is not intended to be complete, as observations were made here only incidentally as time could be taken from the lake work. It is believed that all the phanerogams of the lake have been noted. The order and synonymy is that of Britton and Brown's Illustrated Flora. Wherever these names differ from those of the sixth edition of Gray's Manual the latter are given also. In arranging this list I have availed myself of the labors of Dr. Stanley Coulter in his list of the flowering plants and ferns of Indiana in the State Geological Report of 1899. Much botanical survey work has been done in the county (Koscinsko) in which Eagle Lake is situated by various botanists, among them chiefly Dr. Stanley Coulter and Mr. W. W. Chipman.

LIST OF PLANTS NOTED AT EAGLE LAKE AND VICINITY.

1. Botrychium virginianum (L.) S. W. Virginia Grape Fern.
   In upland forests; not common.
2. Osmunda regalis L. Royal Fern.
   Very common in the southeastern portion of the lake plain, near Chicago Hill. Frequent in tamarack swamps.
3. O. cinnamonea L. Cinnamon Fern.
   Not rare in swamps. Quite abundant in a tamarack swamp a few miles southeast of Warsaw.
4. O. claytonia. Clayton's Fern.
   Not rare along Clear Creek mouth.
5. Onoclea sensibilis L. Sensitive Fern.
   Very common at edges of lake plain in places, especially on the eastern side. Common in low, flat swales.
6. Cystopteris fragilis (L.) Bernh. Brittle Fern.
   Not common. Found in moist, but not wet woods.
7. Dryopteris acrostichoides (Michx.) Kuntze. Christmas Fern. (*Aspidium achrosticoides* S. W.)
   Not abundant; found on a bank along Clear Creek.
8. D. thelypteris (L.) Gray. Marsh shield Fern. (*Aspidium thelypteris* S. W.)
   The most common fern, growing in the flat plains in great abundance, making a distinct strata in places.
9. D. cristata (L.) A. Gray. Crested Shield Fern. (*Aspidium cristatum* S. W.)
   Not very common; found scattered in low, flat woods.
10. Phegopteris hexagonoptera (Michx.). Fee. Broad Beech Fern.
    Not very common; found in dry woods.

11. Woodwardia virginica (L.) J. E. Smith. Virginia Chain Fern.
Abundant in old tamarack swamps, especially along the steamboat canal to near Warsaw, and a tamarack about one mile east of the lake.

12. Asplenium angustifolium Michx. Narrow-leaved Spleenwort.
Some found in the county, but not very near Eagle Lake.

13. A. filix foemina (L.) Bernh. Lady Fern.
Scattered in low, moist woods.

14. Adiantum pedatum L. Maiden-hair Fern.
Not common near the lake; a few plants found at the foot of a hill about a quarter of a mile east of the lake.

15. Pteris aquilina L. Brake.
Found pretty abundantly on sandy hills, especially along the railroad.

16. Equisetum arvense L. Field Horse-tail.
Common along the railroad and on side base of a hill about one-quarter mile east of the lake.

17. E. fluviatile L. Swamp Horse-tail.
In the margins of the ponds adjacent to the lake, in shallow water.

18. E. hyemale L. Common Scouring Rush.
Abundant on hillsides and along the railroad; a good deal of variation in size and general appearance.

19. Lycopodium lucidulum Michx. Shining Club Moss.
In a tamarack east of Eagle Lake.

20. Selaginella apus. (L.) Spring Creeping Selagenella.
In flat, moist plains, among the grass. Abundant in various portions of the lake plain.

21. Larix laricina (Du Roi) Koch. Tamarack. (L. Americana Michx.).
There are several tamarack swamps in the vicinity of Eagle Lake. Most of them aro dying.

22. Juniperus virginana L. Red Cedar.
Plants found in the county, but not very near the lake.

23. Typha latifolia L. Broad-leaved Cat-tail.
Abundant in marshes and occasionally at the lake shore. Great patches on the southern lake plain.

24. Sparganium eurycarpum Engelm.
Common in swamps.

25. S. simplex Huds.

Not rare in a few swamps, quite local, however.

26. Potamogeton natans L. Common Floating Pondweed.

Abundant in shallow water, Eagle Lake.

27. P. amplifolius Tuckerm. Long-leaved Pondweed.

In patches, common. Eagle Lake.

28. P. lonchites. (P. fluitans Roth.)

Common in the lake, especially near outlets and inlets.

29. P. lucens L. Shining Pondweed.

Abundant in the lake.

30. P. perfoliatus.

Quite plentiful in Eagle Lake.

31. P. zosteraefolius Schum. Eel Grass Pondweed.

Abundant.

32. P. pusillus L. Small Pondweed.

Only a few specimens seen.

33. P. pectinatus L. Fennel-leaved Pondweed.

One of the most common and widely distributed.

34. Naias flexilis (Willd.) Rost and Schmidt.

Quite abundant in shallow water, sometimes forming extensive carpets.

35. Triglochin palustris L. Marsh Arrow Grass.

In a swamp south of the lake about a half mile.

36. Alisma plantago aquatica L. Water Plantain.

Abundant in moist places.

37. Sagittaria engelmanniana J. G. Smith. (S. variabilis gracilis Engelm.)

A few plants along the shore of Eagle Lake in lagoons.

38. S. latifolia Willd. Broad-leaved Arrowhead. (S. variabilis Engelm.)

Quite abundant, especially on the southern lake plain.

39. S. rigida Pursh. (S. heterophylla pursh.)

A few plants noted in shallow water.

40. S. graminea Michx. Grass-leaved Arrowhead.

At the Laboratory bayou.

41. Philotria canadensis (Michx.) Britton. Ditch Moss. (Elodea canadensis Michx.)

In bayous and cut-offs; very little found in the lake itself.

42. Vallisneria spiralis L. Tape-grass. Eelgrass.

In patches, scattered, not abundant in Eagle Lake.

43. Andropogon scoparius Michx. Brown Beard Grass.
Some along the railroad.

44. A. furcatus. Forked Beard Grass.
Some in the southeast lake plain, and occasional elsewhere.

45. Chrysopogon avenaceus (Michx.) Benth. Indian Grass. (C. Nutans Benth.)
Common, especially along the Pennsylvania Railroad.

46. Syntherisma sanguinalis (L.) Nash. Crab Grass. (Panicum sanguinale L.)
Abundant in cultivated places and a troublesome weed.

47. Panicum crus-galli L. Barnyard Grass.
Abundant in moist places.

48. P. walteri. Salt Marsh Cockspur Grass.
Some along the southeast shore of the lake.

49. P. porterianum Nash. (*P. latifolium* Walt.)
In dry woodlands.

50. P. pubescens Lam. Hairy Panicum.
Common in open woodlands.

51. P. capillare L. Old Witch Grass.
Found abundant in Winona Park.

52. Ixophorus glaucus (L.) Nash. Yellow Fox-tail. (*Setaria glauca* Beauv.)
Abundant in waste places.

53. I. viridis (L.) Nash. Green Fox-tail Grass. (*Setaria viridis* Beauv.)
Quite common.

54. I. italicus (L.) Nash. Hungarian Grass. (*Setaria italica* Kunth.)
Escaped cultivation in various places.

55. Cenchrus tribuloides L. Burr Grass. Sandbur.
Found in dry sandy soil.

56. Zizania aquatica L. Wild Rice.
Some found in a tamarack not far from the lake.

57. Homalocenchrus virginicus (Willd.) Britton. White Grass. (*Leersia virginica* Willd.)
Grows sparsely in damp woods near the lake.

58. H. oryzoides (L.) Poll. Rice and Cut-grass. (*Leersia oryzoids* Swartz.)
Forming tangled, scratchy masses in places along the lake shore.

59. Phalaris arundinacea L. Reed Canary Grass.
Some found on the lake plain.

60. Muhlenbergia diffusa.
Some growing in dry, sparsely wooded places.

61. Phleum pratense L. Timothy.
Abundant.

62. Cinna arundinacea L. Wood Reed Grass.
Found in moist places, especially where shaded.

63. Agrostis alba L. Red Top.
Found along Cherry Creek.

64. Agrostis pernnans (Walt.) Tuckerm. Thin Grass.
Some found along Cherry Creek.

65. Calamagrostis canadensis (Michx.) Beauv. Blue-joint Grass.
Scattered among other grasses on the lake plain.

66. Danthonia spicata (L.) Beauv. Wild Oat Grass.
Grows thinly at edges of dry hills.

67. Spartina cynosuroides (L.) Willd. Fresh-water Cord Grass.
Tolerably common in swamps and along the railroad.

68. Bouteloua curtipendula (Michx.) Torr. (*B. racemosa* Lag.)
One patch on a hill toward the southern end of the Assembly grounds.

69. Eleusine indica (L.) Gaertn. Yard Grass.
Found along streets at Warsaw.

70. Phragmites phragmites (L.) Karst. Reed. (*P. communis* Trin.)
Some grows along the lake shore. Abundant in a tamarack swamp northeast of Eagle Lake.

71. Eragrostis purshii Schrad.
Not rare, along roadsides and old fields.

72. E. major Host.
Abundant in old fields and along roadsides.

73. Dactylis glomerata L. Orchard Grass.
A little found growing along roadsides.

74. Poa annua L. Low Spear Grass.
Found in a dooryard east of Eagle Lake.

75. Poa compressa L. Wire Grass.
Not rare in old fields.

76. Poa pratensis L. June Grass. Kentucky Blue Grass.
Scattered everywhere.

77. Panicularia nervata (Willd.) Kuntze. (*Glyceria nervata* Trin.)
Common at the edges of various ponds.

78. Panicularia fluitans (L.) Kuntze. Floating Manna Grass.
Not uncommon in ponds.

79. Festuca eliator L. Fall Fescue Grass.
Scattered, principally along the railroad.

80. Bromus ciliatus L. Wood Chess.
Tolerably common, scattered in thin forests.

81. B. secalinus L. Cheat. Chess.
In old wheat fields.

82. Agropyron violaceum (Hornem) Vasey. Purplish Wheat Grass.
Along the Pennsylvania Railroad, near Warsaw.

83. Hordeum jubatum L. Wild Barley. Squirrel-tail Grass.
Found in scant tufts along the Pennsylvania Railroad.

84. Elymus virginicus L. Wild Rye.
Scattered.

85. Hystrix hystrix (L.) Millsp. Hedge-hog Grass.
Some found at the edges of a field east of Eagle Lake.

86. Cyperus diandrus Torr. Low Cyperus.
In the lake plain, especially along the south part of Chicago Hill.

87. C. strigosus L. Straw-colored Cyperus.
Common in moist places.

88. C. filiculmis Vahl. Slender Cyperus.
Abundant on open sandy hillsides.

89. Dulichium arundinaceum (L.) Britton. (*D. spathaceum* Pers.)
Common in marshy places. Most abundant in Market-street pond.

90. Eleocharis interstincta (Vahl.) R. and S.
A few patches in the lake. One in the south end, the others near Yarnelle's landing.

91. E. mutata (L.) R. and S. Quadrangular Spike Rush. (*E. quadrangulata* R. Br.)
A few small patches in nearly the same regions as the above.

92. E. ovata (Roth.) R. and S.
The most abundant species of the genus. Found everywhere in moist places.

93. E. palustris (L.) R. and S. Creeping Spike Rush.

Scattered along the edge of the lake, among the *scirpi*. A good patch just a little way north of Chicago Hill pier.

94. E. acicularis (L.) R. and S. Needle-spike Rush.

Tolerably abundant, often found in flower but rarely in fruit, at the edge of the lake and in marshes.

95. E. tenuis (Willd.) Schultes. Slender Spike-rush.

Some found in the lake plain.

96. Stenophyllus capillaris (L.) Britton. (*Fimbristylis capillaris* Gray.)

Found in sandy soil. Some in a field, some at the edge of the lake plain, on the bank at Chicago Hill.

97. Scirpus smithii Gray.

Some found in the county, but not near Eagle Lake.

98. S. americanus Pers. Chair-maker's Rush. (*S. pungens* Vahl.)

Quite abundant along the edges of the lake.

99. S. lacustris L. Great Bulrush.

The most abundant of the species, forming a broad belt around the margin of the greater part of the lake.

100. S. atrovirens Muhl. Dark-green Bulrush.

Common in swamps.

101. S. lineatus Michx. Reddish Bulrush.

Common in wet grounds.

102. S. cyperinus (L.) Kunth. Wool Grass.

Grows in clumps, in ponds.

103. Eriophorum virginicum.

Scattered in marshes—generally old tamaracks.

104. Rynchospora alba (L.) Vahl. White-beaked Rush.

In a marsh south of the lake, also in the tamarack northeast of Eagle Lake.

105. R. Capillacea laeviseta E. J. Hill.

In a marsh south of the lake.

106. Cladium mariscoides (Muhl.) Torr. Twig Rush.

In the lake plain and along the edge of the lake on the west side of the lake.

107. Scleria verticillata Muhl. Low Nut Grass.

Found in a tamarack, and in a flat pasture south of Eagle Lake.

108. Carex lupulina Muhl. Hop Sedge.
Found in swampy places, abundant.

109. C. pseudo-cyperus L.
Found occasionally in swamps.

110. Carex comosa Boot. Bristly Sedge.
Along the edges of the lake, near the outlet, and in ponds.

111. C. lanuginosa Michx. Woolly Sedge.
Some growing in the vicinity of the laboratories.

112. C. filiformis L. Slender Sedge.
A small patch near a pond on the southeast part of the lake plain.

113. C. granulatus Muhl. Meadow Sedge.
Scattered, moist places.

114. C. albursina Sheldon. White Bear Sedge.
Found occasionally in damp woods.

115. C. pennsylvanica Lam.
Found on dry hills, scattered.

116. C. pubescens Muhl. Pubescent Sedge.
A few plants found in dry ground at the southwest side of the lake.

117. C. leptalea Wahl. (*C. polytrichoides* Willd.)
Found in a tamarack northeast of the lake, and in a marsh southeast.

118. C. vulpinoidea Michx.
Common, scattered.

119. C. rosea Schk. Stellate Sedge.
Found sparingly in shaded places.

120. C. cephalophora Muhl.
Found scattered in dry soil, back from the lake.

121. C. tribuloides Wahl.
Growing in clumps, among various grasses in parts of the lake plain.

122. Arisaema triphyllum (L.) Torr. Jack-in-the-Pulpit. Indian Turnip.
Found in forests.

123. A. dracontium (L.) Schott. Green Dragon.
Found in quite moist woods.

124. Peltandra virginica (L.) Kunth. Green Arrow Arum.
Found in a tamarack northeast of the lake.

125. Spathyema foetida (L.) Raf. Skunk Cabbage. (*Symplocarpus foetidus* Nutt.)

Common in moist places, especially up along Cherry Creek.

126. Acorus calamus (L). Sweet Flag. Calamus.

Found in low ground along the lake and various other moist places.

127. Spirodela polyrhiza (L.) Schleid. Greater Duckweed.

Very common in lagoons, some in sheltered parts of the lake, near shore.

128. Lemna trisulca L. Ivy-leaved Duckweed.

In lagoons and ditches; common.

129. Lemna minor L. Lesser Duckweed.

In lagoons, and in ponds near the lake.

130. Wolffia columbiana Karst.

Very abundant in lagoons.

131. W. braziliensis Wedd.

In lagoons, but not very common.

132. Tradescantia virginiana L. Spiderwort.

Grows everywhere in dry ground; not much seen in moist ground here.

133. Pontederia cordata L. Pickerel Weed.

Common about the edges of the lake.

134. Heteranthera dubia (Jacq.) MacM. Water Star-grass. (H. graminea Vahl.)

Both forms found, the larger in the water and the short on muddy banks.

135. Juncus effusus L. Soft Rush.

Grows along the steamboat canal leading to Warsaw.

136. J. tenuis Willd. Yard Rush.

Abundant.

137. J. canadensis J. Gray.

Found in low ground along the railroads northeast of the lake.

138. Juncoides campestre (L.) Kuntze. Common Wood Rush. (*Luzula campestris* D. C.)

Found scattered in woodlands.

139. Tofieldia glutinosa (Michx.) Pers.

Found in a tamarack northeast of the lake.

140. Allium canadense L. Meadow Garlic.
Found in moist woods.

141. Lilium umbellatum Pursh. Western Red Lily.
Found on sand hills northeast of the lake.

142. L. canadense L. Yellow Lily.
Found growing in moist places.

143. L. superbum L. Turk's Cap Lily.
Grows in the southwestern part of the lake plain.

144. Asparagus officinalis L. Asparagus.
Scattered, quite frequent.

145. Vagnera racemosa (L.) Morong. Wild Spikenard. (*Smilacina racemosa* Desf.)
Found growing in forests.

146. V. stellata (L.) Morong. Star-flowered Solomon's Seal. (*Smilacina stellata* Desf.)
One patch across Cherry Creek from the laboratory.

147. Unifolium canadense (Desf.) Greene. False Lily of the Valley.
In dried tamarack swamps.

148. Polygonatum commutatum (R. and S.) Dietr. Smooth Solomon's Seal. (P. giganteum Dietr.)
Common, especially along the railroad.

149. Trillium recurvatum Beck. Prairie Wake Robin.
Found abundantly in damp woods.

150. Smilax herbacea L. Carrion Flower.
Found in considerable abundance.

151. S. hispida Muhl. Hispid Green Briar.
Found in dry places.

152. Dioscorea villosa L. Wild Yam.
Found in moist, rich woods.

153. Iris versicolor L. Larger Blue Flag.
Abundant in various places along the shore of the lake.

154. Sisyrinchium angustifolium Mill. Blue-eyed Grass.
Abundant in open places, especially along the railroad.

155. Cypripedium acaule Ait. Moccasin Flower.
Found abundantly in a tamarack south of the lake.

156. C. reginae Walt. Showy Lady's Slipper. (*C. spectabile Salisb.*)
Found in a marsh west of the lake.

157. C. hirsutum Mill. Large Yellow Lady's Slipper. (*C. pubescens* Willd.)
Found in dry soil by Yarnelle's landing.

158. Habenaria lacera (Michx) R. Br. Ragged Orchis.
Found in the southwestern portion of the lake plain.

159. H. leucopaea (Nutt) Gray. White-fringed Prairie Orchis.
In the tamarack marsh northeast of the lake.

160. H. psycodes (L.) Gray. Purple-fringed Orchis.
Southeast edge of lake plain.

161. Pogonia ophioglossoides (L.) Ker. Rose Pogonia.
In the tamarack northeast of the lake.

162. Gyrostachys gracilis (Bigel) Kuntze. Slender Ladies' Tresses.
Found in a dry wood east of the lake.

163. Corallorhiza odontorhiza (Willd.) Nutt. Small-flowered Coral Root.
Not rare in a wood south of the outlet.

164. Limodorum tuberosium L. Grass Pink. (*Calopogon pulchellus* R. Br.)
Abundant in tamarack northeast of the lake.

165. Saururus cernuus L. Lizard's Tail.
In wet grounds along Cherry Creek and Clear Creek.

166. Juglans nigra L. Black Walnut.
Scattered in rich woodlands.

167. J. cinera L. Butternut.
Occasional, in woodlands.

168. Hicoria ovata (Mill) Britton. Shagbark Hickory. (*Carya alba* Nutt.)
In woodlands.

169. H. laciniosa (Michx. f.) Sarg. Big Shellbark. (*Carya sulcata* Nutt.)
In woods near Cherry Creek.

170. H. alba (L.) Britton. Mocker Nut. White-heart Hickory. (*Carya tomentosa* Nutt.)
A few trees noted.

171. Populus alba L. White Poplar.
A few trees have escaped cultivation near Warsaw.

172. P. grandidentata L. Great-toothed Aspen.
Occasional.

173. P. tremuloides Michx. American Aspen.
Grows along the lake shore near Chicago Pier.

174. P. deltoides Marsh. Cottonwood. (P. *monilifera* Ait.)
Not rare in low grounds.

175. Salix nigra.

Common along the shores of the lake.

176. Salix discolor.

Forming clumps in low flat grounds. The willows were neither in flower nor fruit during the period of investigation, and were consequently indeterminate; there are doubtless more present than mentioned.

177. Carpinus caroliniana Walt. Water Beech.

In woodlands along the sides of gullies.

178. Ostrya virginiana (Mill) Willd. Ironwood.

In locations similar to the preceding.

179. Corylus americana Walt. Hazelnut.

Abundant in dry ground.

180. Betula pumila L. Low Birch.

Abundant in tamarack marshes.

181. Fagus americana. Sweet Beech. (*F. ferruginea* Ait.)

Not very abundant, only a few trees seen.

182. Castanea dentata (Marsh) Borkh. Chestnut. (*C. sativa americana Wats. and Coult.*)

A quite large tree in the park, evidently pretty old, but probably not native.

183. Quercus rubra L. Red Oak.

In woodlands.

184. Q. palustris Du Roi. Pin Oak.

Found pretty abundantly at the edges of some low slopes.

185. Q. coccinea Wang. Scarlet Oak.

Quite common.

186. Q. imbricaria Michx. Laurel Oak.

Only one tree seen, far up Cherry Creek gully.

187. Q. alba L. White Oak.

Abundant in woodlands.

188. Q. macrocarpa Michx. Bur Oak.

Not particularly abundant; only a few trees noted.

189. Q. platanoides (Lam.) Sudw. Swamp White Oak. (*Q. bicolor* Willd.)

Pretty common in moist places.

190. Q. acuminata (Michx.) Sarg. Yellow Oak. (*Q. muhlenbergii* Engelm.)

A few trees noted; none very near the lake.

191. Ulmus americana L. American or White Elm.
Abundant.

192. U. fulva Michx. Slippery Elm. Red Elm.
Not many trees seen.

193. Celtis occidentalis L. Hackberry. Sugar Berry.
A few trees noted.

194. Morus rubra L. Red Mulberry.
Found in woods; not rare.

195. M. alba tartarica. Russian Mulberry.
An abundant escape in waste land east of the lake.

196. Toxylon pomiferum Raf. Osage Orange. (*Maclura aurantiaca* Nutt.)
Used abundantly for hedges.

197. Humulus lupulus L. Hop.
Found growing in low rich grounds.

198. Cannabis sativa L. Hemp.
A common escape on commons near Warsaw.

199. Urtica gracilis Ait. Slender Nettle.
In clumps in waste places.

200. Urticastrum divaricatum (L.) Kuntze. Wood Nettle. *Laportea canadensis* Gaud.
Abundant in low woods.

201. Adicea pumila (L.) Raf. Clear Weed. Rich Weed. (*Pilea pumila* Gray.)
Abundant in moist places.

202. Boehmeria cylindrica (L.) Willd. False Nettle.
Abundant in moist woods.

203. Parietaria pennsylvanica Muhl.
Not particularly abundant.

204. Commandra umbellata (L.) Nutt. Bastard Toad Flax.
Found growing abundantly in dry places, along the road east of the lake.

205. Asarum canadense L. Wild Ginger.
Rather common in shady woods.

206. Aristolochia serpentaria L. Virginia Snake Root.
Scattered in loose soil of forests.

207. Rumex acetosella L. Field Sorrel. Red Sorrel.
A common nuisance in sandy fields.

208. R. verticillatus L. Swamp Dock.

Found at the edge of bayous and in shallow water.

209. R. brittanica L. Great Water Dock.

Not rare in the lake plain and in low, flat places.

210. R. crispus L. Curled Dock.

Common in waste places.

211. R. obtusifolius L. Bitter Dock.

In situations similar to the preceding.

212. Fagopyrum fagopyrum (L.) Karst. Buckwheat. (F. *esculentum* Moench.)

Along roadsides where it has escaped.

213. Polygonum amphibium L. Water Smartweed.

Common at the edges of the lake.

214. P. emersum (Michx.) Britton. Swamp Smartweed. (P. *muhlenbergii* Watson.)

Abundant in bayous and low places about the lake.

215. P. incarnatum Ell. Slender Pink Smartweed.

Common in wet soil.

216. P. pennsylvanicum L.

Abundant.

217. P. hydropiperoides.

Common, especially in a shallow pond in the southeastern portion of the lake plain.

218. P. orientale L. Prince's Feather.

Escaped cultivation in a field east of the lake.

219. P. virginianum L. Virginia Knotweed.

Rather sparingly found at the edges of low woods.

220. P. aviculare L. Doorweed.

Common in yards.

221. P. erectum L. Erect Knot Grass.

Not so abundant as the preceding, and in moister places.

222. P. convolvulus L. Black Bindweed.

In dry cultivated fields.

223. P. scandens L. Climbing False Buckwheat. (*P. dumetorum scandens* Gray.)

Some in moist ground along Cherry Creek.

224. P. saggitatum L. Arrow-leaved Tear Thumb.

In moist soils about the lake. Very abundant.

225. P. arifolium L. Halberd-leaved Tear Thumb.
Some found along Clear Creek, south of the lake.

226. Chenopodium album L. Lamb's Quarters.
Common in waste grounds.

227. C. boscianum Moq.
Only a few plants seen, over near Warsaw.

228. C. urbicum L. Common or City Goosefoot.
Common in waste places.

229. C. hybridum L. Maple-leaved Goosefoot.
Common; somewhat scattered in waste places.

230. C. botrys L. Feather Geranium. Jerusalem Oak.
Not rare along the railroad.

231. Salsola kali L. Common Saltwort.
Found quite abundantly along the railroad.

232. Amaranthus retroflexus L. Rough Pigweed.
Abundant in waste places.

233. A. blitoides S. Wats. Prostrate Amaranth.
Found along the Pennsylvania railroad.

234. A. graecizans L. Tumbleweed. (*A. album* L.)
Found in waste places and along the railroad.

235. Phytolacca decandra L. Pokeberry.
In moist, rich grounds.

236. Mollugo verticillata L. Carpetweed.
Abundant in sandy fields.

237. Portulaca oleracea. Purslane.
Plentiful in fields and gardens.

238. Agrostemma githago L. Cockle. (*Lychnis githago* Scop.)
Abundant in grain fields.

239. Silene stellata (L.) Ait. Starry Campion.
In woods and corners of fields.

240. S. virginica L. Fire Pink.
Found in woods.

241. S. antirrhina L. Sleepy Catchfly.
Common in sandy, open places.

242. Saponaria officinalis L. Bouncing Bet.
Abundant, especially along the embankment of the Pennsylvania railway.

243. Alsine media L. Common Chickweed (*Stellaria media* Cyr.)
Abundant, especially in the park.

244. A. longifolia (Muhl.) Britton. Long-leaved Chickweed. (*Stellaria longifolia* Muhl.)
Found in moist ground.

245. Cerastium longipedunculatum Muhl. Nodding Chickweed. (*C. nutans* Raf.)
Found near Cherry Creek.

246. Anychia canadensis (L.) B. S. P. Slender-forked Chickweed. (A. *capillacea* D. C.)
Scattered in open, sandy woods.

247. Brasenia purpurea (Michx.) Casp. Water Shield. (B. *Peltata* Pursh.)
A little in Eagle Lake; much, and profusely flowering, in Market-street pond.

248. Nymphaea advena Soland. Spatterdock. (*Nuphar advena* R. Br.)
Quite plentiful in Eagle Lake.

249. Castalia odorata (Dryand) Woodv. and Wood. White Water Lily. (*Nymphaea odorata* Ait.)
Abundant in Eagle Lake.

250. Ceratophyllum demersum L. Hornwort.
Abundant in Eagle Lake.

251. Liriodendron tulipfera L. Yellow poplar. Tulip tree.
In woods, no longer particularly abundant.

252. Asimina triloba (L.) Dunal. Pawpaw.
Not many trees seen.

253. Caltha palustris L. Cowsiip.
Common in marshy places.

254. Coptis trifolia (L.) Salisb. Gold-thread.
In a tamarack swamp southeast of the lake.

255. Actaea alba (L.) Mill. White Baneberry.
Common in woods.

256. Anemone cylindrica A. Gray. Long-fruited Anemone.
Found abundantly, principally along the Pennsylvania railway.

257. A. virginiana L. Tall anemones.
Plentiful in open places.

258. A. canadensis L. Canada Anemone. (*A. pennsylvanica* L.)
Found in moist ground along the Pennsylvania railroad.

259. A. quinquefolia L. Wind Flower. (A. *nemorosa Michx.*)
Plants found, out of flower, along Clear Creek.

260. Hepatica hepatica (L.) Karst. Round-leaved Liverwort. (*H. triloba* Chaix.)
Scattered in woodlands about the lake.

261. H. acuta (Pursh.) Britton. Liverwort. (*H. acutiloba* D. C.)
Found at some distance from the lake; none seen near.

262. Syndesmon thalectroides (L.) Hoffmng. Rue Anemone.
Found in woods; abundant.

263. Clematis virginiana L. Virgin's Bower.
Abundant in places, generally in rich, damp places.

264. Ranunculus abortivus L. Kidney-leaved Crowfoot.
Abundant in shaded places.

265. R. recurvatus Poir. Hooked Crowfoot.
Common in the regions at some distance from the lake.

266. R. pennsylvanicus L. Bristly Buttercup.
Some found north of the lake, near Clear Creek.

267. Caulophyllum thalictroides L. Blue Cohosh.
Found in the Clear Creek region.

268. Podophyllum peltatum L. Mayapple.
Scattered in woods.

269. Menespermum canadense L. Moonseed.
Not very abundant in the region of the lake.

270. Sassafras sassafras (L.) Karst. Sassafras. (*S. officinale* Nees.)
Abundant in open places.

271. Benzoin benzoin (L.) Coulter. Spice Bush. (*Lindera benzoin* Blume.)
Not rare in moist, rich woods.

272. Papaver somniferum L. Garden Poppy.
A few were found growing in the railroad gravel pit northeast of the lake.

273. Sanguinaria canadensis L. Blood Root.
Common in open woods, by bluffs and Clear Creek.

274. Stylophorum diphyllum (Michx.) Nutt. Celandine Poppy.
One seen, out of flower, up Clear Creek gully.

275. Bicuculla cucullaria (L.) Millsp. Dutchman's Breeches. (*Dicentra cucularia* Torr.)
Old plants and roots found, Clear Creek gully.

276. Lepidium virginicum L. Pepper Grass.
Common in dry ground.

277. Sisymbrium officinale (L.) Scop. Hedge Mustard.
Common in dry ground in waste places.

278. Brassica juncea (L.) Cooson. Indian Mustard.
A plant found along the Pennsylvania railroad.

279. Roripa palustris (L.) Bess. Marsh Cress. (*Nasturtium palustre* D. C.)
Common in flat, marshy ground.

280. R. nasturtium (L.) Rusby. Water Cress. (*Nasturtium officinale* R. Br.)
Common, especially near springs.

281. Bursa bursa-pastoris (L.) Britton. Shepherd's Purse. (*Capsella bursa-pastoris* Moench.)
Some plants seen; dry ground.

282. Arabis laevigati (Muhl.) Poir. Smooth Rock Cress.
On bluffs along Clear Creek.

283. Polanisia graveolens Raf. Clammy Weed.
Abundant in the railroad gravel pit.

284. Sarracenia purpurea L. Pitcher Plant.
In tamarack bogs.

285. Saxifraga pennsylvanica L. Swamp Saxifrage.
Occasional in wet places.

286. Heuchera hispida Pursh. Rough Heuchera.
Some plants found. Chapman's Hill.

287. Mitella diphylla L. Bishop's Cap.
On a bank along Cherry Creek.

288. Parnassia caroliniana Michx. Grass of Parnassus.
Tolerably plentiful in low, wet grounds.

289. Ribes cynosbatti L. Wild Gooseberry.
Common in woods.

290. R. oxyacanthoides L. Northern Gooseberry.
Found especially in tamaracks.

291. R. floridum L. Her. Wild Black Currant.
Occasional in moist, flat woods north of Eagle Lake.

292. Hamamelis virginiana L. Witch Hazel.
On dry hills southeast of the lake.

293. Platanus occidentalis L. Sycamore.
On low ground common; a few on high ground.

294. Spiraea salicifolia L. Meadow Sweet.
Common in low, flat ground, as the lake plain.

295. S. tomentosa L. Hardhack.
Sparingly found in moist grounds.

296. Rubus strigosus Michx. Wild Red Raspberry.
None near the lake; some found in a tamarack swamp some distance away.

297. R. occidentalis L. Black Raspberry.
Very common in neglected fields and open woods near the lake.

298. R. americanus (Pers.) Britton. Dwarf Raspberry.
Quite abundant in a tamarack northeast of the lake.

299. R. villosus Ait. High Bush Blackberry.
Abundant near the lake.

300. R. hispidus L. Running Swamp Blackberry.
Common in the marsh along the steamer canal, near Warsaw.

301. R. canadensis L. Dewberry. Low Blackberry.
Common on sandy banks and in sandy fields.

302. Fragaria virginiana Duchesne. Wild Strawberry.
Common in dry ground.

303. Potentilla argentea L. Hoary Cinquefoil.
In a field east of Eagle Lake.

304. P. monspeliensis L. Rough Cinquefoil. (*P. norvegica* L.)
Common in low grounds.

305. P. fruiticosa L. Shrubby Cinquefoil.
Common in wet grounds.

306. P. canadensis L. Five-finger.
Common everywhere in open places.

307. Comarum palustre L. Marsh Five-finger. (*Potentilla palustris* Scop.)
Common in tamarack bogs.

308. Geum canadense Jacq. White Avens. (*G. album* Gmelin.)
At edges of woods and shady places.

309. G. strictum Ait. Yellow Avens.
At the southeast edge of the lake plain.

310. Agrimonia mollis (T. and G.) Britton. Soft Agrimony. (*A. eupatoria mollis* T. and G.)
Common in light woods.

311. A. parviflora Soland. Small-flowered Agrimony.
Abundant in low, flat ground.

312. Rosa setigera Michx. Climbing Rose. Prairie Rose.
Not very common. I have seen only one plant in the region.

313. Rosa carolina L. Swamp Rose.
Very abundant in low places.

314. R. humilis lucida (Ehrh.) Best. (*R. lucida* Ehrh.)
Abundant in dry ground.

315. R. rubignosa L. Sweet Briar.
A few scattered plants were noted.

316. Malus coronaria (L.) Mill. Crab Apple. (*Pyrus coronaria* L.)
A few scattered trees.

317. Aronia nigra (Willd.) Britton. Black Choke Berry. (*Pyrus arbutifolia melanocarpa* Hook.)
Not rare in tamarack swamps.

318. Amelanchier canadensis (L.) Medic. June Berry.
Found on the brows of hills and bluffs.

319. A. botryapium (L. F.) D. C. Shad Bush.
A small bush found in the tamarack swamp northeast of the lake.

320. Crataegus coccinea L. Red Haw.
Scattered; generally found along in open woods and fence rows.

321. Prunus americana Marsh. Red Plum.
Scattered.

322. P. serotina Ehrh. Wild Cherry.
Some trees noted, scattered about in forests.

323. Cercis canadensis L. Red Bud. Judas Tree.
Some trees near the lake up Cherry Creek a little way from the lake.

324. Cassia marylandica L. Wild Senna.
Common in wet places.

325. Gymnocladus dioica (L.) Koch. Coffeenut. (*G. canadensis* Lam.)
Common up Cherry Creek gully.

326. Baptisia tinctoria (L.) R. Br. Wild Indigo.
One plant seen along the railroad, 1899.

327. Lupinus perennis L. Wild Lupine.
Common along the railroad.

328. Medicago sativa L. Alfalfa.
Along the road near the Assembly grounds; probably an escape.

329. Melilotus alba Desv. White Sweet Clover.
Abundant about the park entrance.

330. Trifolium procumbens L. Low Hop Clover.
Found along streets in Warsaw.

331. T. arvense L. Rabbit's Foot Clover.
Scattered, in sterile soil.

332. T. pratense L. Red Clover.
Abundant in open places.

333. T. hybridum L. Alsike.
Scattered at edge of roadsides.

334. T. repens L. White Clover.
Abundant in open places.

335. Amorpha canescens Pursh. Lead plant.
A few plants growing in the park.

336. Robinia pseudacacia L. Black Locust.
Planted in various places.

337. Meibomia nudiflora (L.) Kuntze. Naked Flowered Tick Trefoil. (*Desmodium nudiflorum* D. C.)
In open woods.

338. M. michauxii Vail. Prostrate Tick Trefoil. (*Desmodium rotundifolium* D. C.)
In an open, dry thicket.

339. M. canadensis (L.) Kuntze. Showy Tick Trefoil. (*Desmodium canadense* D. C.)
Common in damp situations.

340. Lespedza violacea (L.) Pers. Bush Clover.
Abundant in open, dry places.

341. L. capitatata Michx. Round-headed Bush Clover.
Common in dry soil.

342. Vicia americana Muhl. Pea-vine.
In damp places near the lake.

343. Falcata comosa (L.) Kuntze. Hog Peanut. (*Amphicarpaea monoica* Ell.)
Common in rich woods.

344. Apios apios (L.) MacM. Groundnut. (*A. tuberosa* Moench.)
Common in various parts of the lake plain.

345. Geranium maculatum L. Wild Geranium.
Common in open woods.

346. G. carolinianum L. Carolina Crane's Bill.
Along the tracks in the railroad gravel pit.

347. Oxalis stricta L. Sheep Sorrel. (*O. corniculata stricta* Sav.)
Abundant.

348. Linum virginianum L. Wild Yellow Flax.
In dry ground, on hillsides, in open woods.

349. Xanthoxylum americanum Mill. Prickly Ash.
In woods; not abundant.

350. Ptelea trifoliata L. Hop Tree.
A few plants noticed in open woods.

351. Polygala verticillate L. Whorled Milkwort.
On hillsides.

352. Polygala viridescens L. (*P. sanguinea* L.)
Found on open hillside, east of the lake.

353. Acalypha virginica L. Three-seeded Mercury.
Found growing in the park.

354. Euphorbia humistrata Engelm. Hairy Spreading Spurge.
Common in dry, open, sandy places.

355. E. nutans Lag. Large or Upright Spotted Spurge. (*E. preslii* Guss.)
Common on dry banks and embankments.

356. E. corollata L. Flowering Spurge.
Very common in dry, open places and old fields.

357. E. cyparissias L. Cypress Spurge.
Escaped from an old cemetery near Warsaw.

358. Rhus copallina L. Dwarf or Black Sumac.
In scattered clumps, various places in dry soil.

359. R. hirta (L.) Sudw. Staghorn Sumac. (*R. typhina* L.)
Occasional in clumps in open places.

360. R. glabra L. Scarlet Sumac.
Grows in clumps, frequently on dry hill sides at the edges of fields.

361. R. vernix L. Poison Sumac. (*R. venenata* D. C.)
Common in tamarack swamps.

362. R. radicans L. Poison Ivy. (*R. toxicodendron* L.)
Common.

363. Ilex verticillata (L.) A. Gray. Winterberry.
Not rare in low marshes, as tamarack swamps.

364. Ilicioides mucronata (L.) Britton. (*Nemopanthes fascicularis* Raf.)
Not rare in tamarack marshes.

365. Euonymus obovatus Nutt. Running Strawberry Bush. (*E. americanus obovatus* T. and G.)
In moist woods, near hillsides or slopes.

366. E. atropurpureus Jacq. Burning Bush.
Common up Cherry Creek gully on flat, rich ground.

367. Celastrus scandens L. Bittersweet.
In woodlands, especially near the edges.

368. Staphylea trifolia L. Bladdernut.
Found growing in moist, shady woods.

369. Acer saccharinum. Silver Maple. (*A. dasycarpum* Ehrh.)
In moist situations.

370. A. saccharum Marsh. Sugar Tree. (*A. saccharinum* Wang.)
In dry ground, in woodlands.

371. A. negundo L. Box Elder. (*Negunde aceroides* Moench.)
Up Clear Creek valley.

372. Aesculus glabra Willd. Ohio Buckeye.
A few trees noted, not very near the lake.

373. Impatiens aurea Muhl. Pale Touch-Me-Not.
Some plants noted some distance from the lake.

374. I. biflora Walt. Spotted Touch-Me-Not. (*I. fulva* Nutt.)
Common about the lake.

375. Ceanothus americanus L. New Jersey Tea.
Abundant in dry sand.

376. Vitis aestivalis Michx. Summer Grape. Small Grape.
Common.

377. Vitis bicolor LeConte. Blue or Winter Grape. (*Vitus aestivatis var bicolor* LeConte.)
Common, but I have seen very little in fruit.

378. Parthenocissus quinquefolia (L.) Virginia Creeper. Wild Ivy. (*Ampelopsis quinquefolia* Michx.)
In woodlands and on fences.

379. Tilia americana L. Basswood. Lin.
Not very common; a few trees seen.

380. Malva rotundifolia L. Common Mallow Cheeses.
Common in waste places, about houses, etc.

381. Abutilon abutilon (L.) Rusby. Velvet Leaf. (*A. avicennae* Gaertn.)
Common in rich grounds.

382. Hypericum prolificum L. Shrubby St. John's Wort.
Abundant in moist places.

383. H. mutilum L. Dwarf St. John's Wort.
Common near the lake.

384. Triadenum virginicum L. Marsh St. John's Wort. (*Elodes campanulata* Pursh.)
Abundant in marshes.

385. Helianthemum canadense (L.) Michx. Frost Weed.
Abundant on dry hills.

386. Lechea villosa Ell. (*L. major* Michx.)
Not rare on dry hills.

387. Viola obliqua Hill. Common Blue Violet. (V. palmata cucullata.)
Common.

388. V. pedata L. Bird's-foot Violet.
On dry hills.

389. V. blanda Willd. Sweet White Violet.
Common in tamarack bogs.

390. Decodon verticillatus (L.) Ell. Swamp Loosestrife.
Common in wet places, especially in a tamarack southeast of the lake.

391. Lythrum alatum Pursh. Loosestrife.
Common in the lake plain.

392. Isnardia palustris L. Water Purslane. (*Ludwigia palustris* Ell.)
In ditches and pools. In Cherry Creek.

393. L. alternifolia L.
Not rare about a pond near the lake plain and northeast of the lake.

394. Chamaenrion angustifolium (L.) Scop. Great Willow Herb. (*Epilobium angustifolium* L.)
Low grounds near Warsaw.

395. Epilobium coloratum Muhl.
Common in low flat grounds.

396. E. adenocaulon Haussk.

A specimen collected by a student and examined in the laboratory was of this species.

397. Onagra biennis (L.) Scop. Common Evening Primrose.

Abundant. A patch, probably of recent introduction, of var grandiflora was found in moist ground near Warsaw.

398. Knieffia pumila (L.) Spach. (Œnothera pumila L.)

A few plants found along the Pennsylvania Railroad.

399. Circaea lutetiana L. Enchanter's Nightshade.

In shady woods.

400. C. alpina L. Smaller Enchanter's Nightshade.

In moist woods.

401. Proserpinaca palustris L. Mermaid Weed.

Common in swamps near the lake.

402. Myriophyllum verticillatum L. Whorled Water Millfoil.

Common.

403. Aralia nudicaulis L. Wild Sarsaparilla.

Found in damp woods.

404. Heracleum lanatum Michx. Cow Parsnip.

Common in wet grounds.

405. Eryngium aquaticum L. Button Snakeroot. (*E. yuccaefolium* Michx.)

In wet soil along the railroad.

406. Sanicula marylandica L. Black Snakeroot.

In damp woods.

407. Pimpinella integerrima (L.) Gray. Yellow Pimpernel.

In sandy places.

408. Washingtonia claytoni (Michx.) Britton. Woolly Sweet Cicely. (*Osmorrhiza brevistylis* D. C.)

In damp woods.

409. Sium cicutaefolium Gmel. Hemlock Water Parsnip.

Abundant south of the lake.

410. Cicuta maculata L. Water Hemlock.

Common in low grounds about the lake.

411. Deringa canadensis (L.) Kuntze. Honewort. (*Crypotaenia canadensis* D. C.)

Common in rich woods.

412. Hydrocotyle umbellata L. Marsh Pennywort.

Found within the county, but not near Eagle Lake.

413. Cornus florida L. Flowering Dogwood.
In woods, frequent.

414. C. amonum. Mill. Silky Cornel. (*C. sericea* L.)
A species, thought to be this, common at the edge of the lake.

415. C. stolonifera Michx. Red Osier Dogwood.
Very common at the edge of the lake.

416. C. candidissima Marsh. Panicled Cornel. (*C. paniculata* L'Her.)
Some bushes seen near a marsh east of the lake.

417. C. alternifolia L. f.
A few trees seen far up Cherry Creek gully.

418. Nyssa sylvatica Marsh. Sour Gum.
A few scattered trees seen.

419. Pyrola elliptica Nutt. Shin Leaf.
Seen in woods, on hillsides.

420. Monotropa uniflora. Indian Pipe.
Scrace, in woodlands.

421. Andromeda polifolia L. Wild Rosemary.
Found in a tamarack swamp southeast of the lake.

422. Gaylussacia resinosa Lam. Black Huckleberry.
At the edges of woods in sandy soils.

423. V. pallidum Ait. Mountain Blueberry. V. corymbosum pallidum Gray.
In sandy soils in woods.

424. Oxycoccus macrocarpus (Ait.) Pers. Large Cranberry.
Found in tamarack swamps; not common.

425. Samolus floribundus H. B. K. Water Pimpernel.
Occasional in moist places.

426. Lysimachia terrestris (L.) B. S. P. Bulb-bearing Loosestrife.
At the edge of the lake in various places.

427. Steironema ciliatum (L.) Raf. Fringed Loosestrife.
Common in damp situations.

428. S. lanceolatum (Walt.) Gray. Lance-leaved Loosestrife.
Common in wet places.

429. Trientalis americana Pursh. Chickweed. Wintergreen.
Found in a tamarack east of the lake.

430. Dodecatheon meadia L. Shooting Star.
Found east along the Pennsylvania Railroad.

431. Fraxinus americana L. White Ash.
Common in woods.

432. Sabbatia angularis (L.) Pursh. Rose-Pink.
Occasional, open woods.

433. Gentiana andrewsii Griseb. Closed Gentain.
A few plants found north of the lake.

434. Frasera carolinensis Walt. American Columbo.
Occasional in open woods.

435. Bartonia virginica (L.) B. S. P. Yellow Bartonia. (*B. tenella* Muhl.)
Found in the county, but not near Eagle Lake.

436. Menyanthes trifoliata L. Marsh Bean.
In a tamarack northeast of the lake.

437. Apocynum androsaemifolium L. Spreading Dogbane.
Common at the edges of fields.

438. A. canabinum L. Indian Hemp.
In similar situations to the preceding.

439. Asclepias tuberosa L. Butterfly Weed.
Common in dry sandy places.

440. A. incarnata L. Swamp Milkweed.
So abundant its blossoms give their color, when in bloom, to the southern part of the lake plain, in places.

441. A. syriaca L. Common Milkweed. (*A. cornuti Decaisne.*)
Abundant in dry soils.

442. Ipomoeca pandurata (L.) Meyer. Man-of-the-Earth.
Found west of the lake.

443. Convolvulus sepium L. Hedge Bindweed. (*C. sepium americanus* Sims.)
Common in parts of the lake plain.

444. C. spithaemus L. Upright Bindweed.
Common on the Pennsylvania Railroad embankment. Not seen in flower.

445. Cuscuta polygonorum Engelm. Smartweed Dodder. (*C. chlorocerpa* Engelm.)
In moist grounds near the lake on various plants.

446. C. gronovii Willd. Common Dodder.
Common on various plants in low places.

447. Phlox pilosa L. Downy Phlox.
Not rare; found along the Pennsylvania Railroad.

448. Polemonium reptans. L. Jacob's Ladder. Blue Bells.
In moist, shady places.

449. Hydrophyllum appendiculatum Michx.
In various places in damp woods.

450. Cynoglossum officinale L. Hound's Tongue.
Common on dry, open hills.

451. Lappula lappula (L.) Karst. Stickseed. (*Echinospermum lappula* Lehm.)
Common in open places.

452. L. virginiana (L.) Greene.
Common in dry places.

453. Lithospermum arvense L. Corn Gromwell.
Not rare in Winona Park in places.

454. Verbena urticifolia L. White Vervain.
Quite common.

455. V. hastata L. Blue Vervain.
Very abundant in low, flat places, at various parts of the lake plain. In places, its blossoms lend great blue unbroken stretches to the landscape.

456. V. stricta.
Common along the railroad.

457. V. bracteosa.
Some found along the railroad.

458. Teucrium canadense L. Wood Sage.
Quite common in low grounds.

459. Scutellaria lateriflora L. Mad-dog Skullcap.
Common in wet places in the lake plain.

460. S. galericulata L. Marsh Skullcap.
Quite common in parts of the lake plain.

461. Marrubium vulgare L. White Horehound.
Common on a bank about a mile up Cherry Creek.

462. Agastache nepetoides (L.) Kuntze. Giant Hyssop. (*Lophanthus nepetoides* Benth.)
Some plants found in the county (up by Chapman's Lake).

463. A. scrophulariaefolia (Willd.) Kuntze. Figwort. Giant Hyssop. (*Lophanthes scrophulariaefolius* Benth.)
In dry soils near Eagle Lake.

464. Nepeta cataria L. Catnip.
Common in dry soil.

465. Stachys palustris L. Common Hedge Nettle.
Common in damp soil.

466. Monarda fistulosa L. Horsemint. Wild Bergamot.
Common on dry hills.

467. M. punctata L. Spotted Horsemint.
A few patches along the Pennsylvania Railroad.

468. Blephilia hirsuta (Pursh.) Torr.
Abundant in woods near Clear Lake gully.

469. Koellia virginiana (L.) MacM. Mountain Mint. (*Pycnanthemum lanceolatum* pursh.)
Abundant, especially in low, flat places, and parts of the lake plain.

470. Lycopus americanus Muhl. Cut-leaved Water Horehound. (*L. sinnatus* Ell.)
In various places along the shore of the lake.

471. Mentha spicata L. Spearmint.
A large patch noted in a low place along the Piercetou Road.

472. M. piperita L. Peppermint.
Rather common in moist places.

473. M. canadensis L. Wild Mint.
Quite common in moist places.

474. M. rotundifolia.
A patch of this near the station at Winona Lake.

475. Collinsonia canadensis. Horsebalm.
In moist soil near Chapman's Lake.

476. Physalis pubescens L. Low Hairy Ground Cherry.
Abundant in dry soils.

477. P. lanceolate Michx. Prairie Ground Cherry.
Rather common in dry soils.

478. Solanum nigrum. Black Nightshade.
Scattered in dry soils.

479. S. carolinense L. Horse Nettle.
Found along the railroad.

480. S. dulcamara L. Bittersweet. Nightshade.
A few plants found along the south shore of the lake.

481. Datura tatula L. Purple-stemmed Jimson.
Common in waste places, about barnyards.

482. Verbascum thapsus L. Common Müllein.
Common in dry places.

483. V. blattaria L. Moth Mullein.
In dry places; not so common as the preceding.

484. Scrophularia marylandica L. Pilewort. (*S. nodosa marylandica* Gray.)
Common in dry places.

485. Chelone glabra L. Snake-head. Turtle-head.
Common in moist or wet places.

486. Mimulus ringens L. Monkey Flower.
Common in low places, especially abundant about the Market-street pond.

487. Ilysanthes gratioloides (L.) Benth. False Pimpernel. (*I. riparia* Raf.)
Common in wet places.

488. Veronica anagallis aquatica L. Water Speedwell.
Scattered, in wet places.

489. V. officinalis L. Common Speedwell.
In various places in the Assembly grounds.

490. V. serpyllifolia L. Thyme-leaved Speedwell.
In open places, in dry soil, common.

491. V. peregrina L. Purslane Speedwell.
Common in cultivated places.

492. Leptandra virginica (L.) Nutt. Culvers Root. (*Veronica virginica* Nutt.)
Growing in clumps, in moist soils.

493. Afzelia macrophylla (Nutt.) Kuntze. Mullein Foxglove. (*Seymeria macrophylla* Nutt.)
In woods, near Hamilton Mound.

494. Dasystoma flava (L.) Wood. Downy False Foxglove. (*Gerardia flava* L.)
Not rare in dry woods.

495. D. virginica (L.) Britton. Oak-leaved False Foxglove. (*Gerardia quercifolia* Pursh.)
Common in dry woods.

496. Gerardia purpurea L. Large Purple Gerardia.
Common in low places and in parts of the lake plain.

497. Utricularia vulgaris L. Greater Bladderwort.
Abundant in ditches along the railroad and in Market-street pond; some, but not very abundant, in the neck of Eagle Lake.

498. U. intermedia Hayne. Flat-leaved Bladderwort.
Common in the lake plain south of the neck of the lake, and in a flat about one-half mile southeast of the lake.

499. Leptamnium virginianum (L.) Raf. Beech-drops. (*Epiphegus virginiana* L.)
Some found in dry woods south of Eagle Lake, near Clear Creek.

500. Phryma leptostachya L. Lopseed.
Common in moist woodlands.

501. Plantago rugelli Decaisne. Rugel's Plantain.
In cultivated grounds, common.

502. P. lanceolata L. English Plantain.
Not very common; found in cultivated fields.

503. Cephalanthus occidentalis L. Button Bush.
Common near the lake on the lake plain at various places, and at the edge of woodland ponds.

504. Galium aparine L. Cleavers.
Found in damp places up Cherry Creek valley.

505. G. circaezans Michx. Wild Liquorice.
Common in dry woods.

506. G. trifidum L. Small Bedstraw.
Found in flat, damp places; some at the outer edge of the lake plain.

507. G. asperellum Michx.
Some found east of Eagle Lake.

508. Sambucus canadensis L. Elder.
Rather common in clumps in open places, or more scattered in low, damp woods.

509. Viburnum acerfolium L. Maple-leaved Viburm.
Found growing in forests, rather common.

510. V. lentago. Sheepberry.
Grows along the south side of the lake.

511. Triosteum perfoliatum L. Horse Gentian.
Some found in open places.

512. Lonicera hirsuta Eaton. Hairy Honeysuckle.
Found, but not in flower, in the tamarack northeast of the lake.

513. Micrampelis lobata (Michx.) Greene. Wild Cucumber. (*Echinocystis lobata*, Torr. and Gray.)
Common in damp places and parts of the lake plain.

514. Companula aparinoides Pursh. Marsh Bell-flower.
Common in parts of the lake plain.

515. C. americana L. Tall Bellflower.
Common in woods.

516. Legouzia perfoliata (L.) Britton. Venus's Looking-glass.
In open sandy soil.

517. Lobelia cardinalis L. Cardinal Flower.
Common in damp situations.

518. L. syphilitica L. Great Lobelia.
Very common in the lake plain and damp grounds elsewhere.

519. L. leptostachys A. D. C.
In dry sandy soils, in open places.

520. L. kalmii L.
Common in the lake plain.

521. Cichorium intybus L. Chicory.
Escaped cultivation in various places.

522. Adopogon virginicum (L.) Kuntze. Virginia Goatsbeard. (*Krigia amplexiculmis* Nutt.)
Not rare in open woods.

523. Taraxacum taraxacum (L.) Karst. Dandelion. (T. officinale Weber.)
Common everywhere.

524. Lactuca scariola L. Prickly Lettuce.
Common in waste places.

525. L. canadensis L. Wild Lettuce.
Common.

526. L. spicata (Lam.) Hitchk. Fall Blue Lettuce.
Not common, found in moist rich soil.

527. Hieracium scabrum Michx. Rough Hawkweed.
Scattered in dry woodlands.

528. H. gronovii L. Hairy Hawkweed.
In dry open woodlands.

529. Ambrosia trifida L. Great Ragweed. Horseweed.
Found in moist rich soil.

530. A. artemisiaefolia L. Ragweed.
Common, especially along roadsides.

531. Xanthium strumarium L. Cocklebur.
Common in rich moist places.

532. Vernonia gigantea (Walt.) Britton. Tall Ironweed. (*V. altissima* Nutt.)
Common in moist rich soils.

533. V. fasciculata Michx. Western Ironweed.
Common in open places.

534. Eupatorium purpureum L. Joe-Pye-Weed.
Very common in moist places, especially on the southern lake plain.

535. E. perfoliatum L. Boneset.
Common in moist ground.

536. Lacinaria scariosa (L.) Hill. Large Blazing Star. (*Liatris scariosa* Willd.)
Not common. Found along the railroad.

537. L. spicata (L.) Kuntze. *Liatris spicata* Willd.)
Quite common in parts of the lake plain, especially the south-eastern part.

538. Solidago caesia L. Blue-stemmed Golden Rod.
In moist woodlands.

539. S. ulmifolia Muhl. Elm-leaved Golden Rod.
Common in open places.

540. S. canadensis L. Canada Golden Rod.
Common in dry soils.

541. S. nemoralis Ait. Field Golden Rod.
Quite abundant in open places.

542. S. riddelli Frank.
Not rare in portions of the lake plain.

543. Euthamia graminifolia (L.) Nutt. Fragrant Golden Rod. (*Solidago lanceolata* L.)
Common in low grounds.

544. Aster macrophyllus L. Large-leaved Aster.
A few plants found along the bluff, north of Cherry Creek.

545. A. shortii Hook.

Common in dry, open places.

546. A. nova-angliae L.

Common along the railroad.

547. A. ericoides L. White Heath Aster.

Common along the railroad.

548. Erigeron aunnus (L.) Pers. Daisy Fleabone.

An abundant weed in fields.

549. Leptilon canadense (L.) Britton. Horseweed. (*Erigeron canadensis* L.)

Common in open places.

550. Antennaria plantiginifolia (L.) Richards. Plantain-leaved Everlasting.

Quite common in dry places and open woods.

551. Gnaphalium oblusifolium L. Common Everlasting. (*G. polycephalum* Michx.)

Common in dry places.

552. Silphium perfoliatum L. Cup Plant.

Some found in low, rich ground up Cherry Creek.

553. S. integrifolium Michx. Entire-leafed Rosinweed.

Rather common in low places along the railroad.

554. S. terebinthinaceum Jacq. Prairie-dock.

Not rare in damp places.

555. Heliopsis scabra Dunal. Rough Ox-eye.

A few scattered patches noted in dry places.

556. Rudbeckia hirta L. Black-eyed Susan.

Common in both dry and moist soil.

557. R. laciniata L. Tall Cone Flower.

A few plants noted; grows in moist ground.

558. Ratibida pinnata (Vent.) Barnhart. Gray-headed Cone Flower. (*Lepachys pinnata* T. and G.)

Rather common along roadsides.

559. Helianthus giganteus L. Giant Sunflower.

Common and widely scattered in moist rich soil.

560. H. divaricatus L. Rough Sunflower.

Common in dry woods.

561. Verbesina alternifolia (L.) Britton. (*Actinomeris squarrosa* Nutt.)

Not rare in low woods.

562. Coreopsis tripteris L. Tall Tickseed.
Some noted in open waste places.

563. Bidens connata Muhl. Swamp Beggar Ticks.
Common in wet places.

564. B. frondosa L. Common Beggar Ticks.
Common, especially in moist soil.

565. B. trichosperma (Michx.) Britton. Tall Tickseed Sunflower. (*Coreopsis trichosperma* Michx.)
Very common in some swamps: sometimes the flowers make the whole landscape yellow.

566. Helenium autumnale L. Sneezeweed.
Common along the lake shore.

567. Achillea millefolium L. Yarrow.
Common in old orchards.

568. Anthemis cotula L. Dog-fennel.
In dry soils in waste places.

569. Chrysanthemum leucanthemum L. Ox-eye Daisy.
Some plants found in dry soil.

570. Erechtites hieracifolia (L.) Raf. Fire Weed.
Not rare in open woods.

571. Mesadenia atriplicifolia (L.) Raf. Pale Indian Plantain. (*Cacalia atriplicipolia* L.)
Some plants noted up Cherry Creek in dry soil.

572. M. tuberosa Nutt.
A few plants noted in boggy ground southeast of Eagle Lake.

573. Arctium lappa L. Burdock.
Common in waste places and about dwellings.

574. Carduus lanceolatus L. Common Thistle. (*Cnicus lanceolatus* Willd.)
Common everywhere in open and waste places.

575. C. altissimus L. Tall or Roadside Thistle. (*Cnicus altissimus* Willd.)
Rather common in open and waste places.

576. C. muticus (Michx.) Pers. Swamp Thistle. (*Cnicus muticus* Pursh.)
Common in swampy ground.

577. C. arvensis (L.) Robs. Canada Thistle. (*Cnicus arvensis* Hoff.)
A large patch in a pasture one-fourth mile east of the lake. Plants scattered at various places about the region of the lake.

ADDITIONS AND CORRECTIONS.

578. Anaphalis margaritacea (L.) Benth. and Hook. Pearly Everlasting. (*Antennaria margaritacea* Hook.)

Scattered, in dry places. Out of flower during the season at Eagle Lake, but noted, and found and determined in subsequent work. The patch of *Mentha rotundifolia* was noted too late to press, so the identification is doubtful.

SUMMARY.

The area included within a line along the crest of the hills surrounding Eagle Lake presents for study a remarkable variety of conditions and ecological regions, as (1) upland forest, with native trees and shrubs; (2) cleared and abandoned upland with the flora that has subsequently taken possession; (3) creek, valleys and gullies, with their peculiar soil and flora; (4) railroad and introduced flora; (5) lowland forest; (6) lake plain; (7) tamarack swamp; (8) ponds, temporary and permanent, and quaking bogs and bayous; (9) ice ridge; (10) beach; (11) the lake, with several zones of plants.

The upland forest is much like forests in general throughout Northern Indiana. In some places there is underbrush and herbs, in others a thick carpet of dried leaves. The soil is sandy, and many of the herbs of xerophytic habit. Fungi are abundant.

The cleared land is covered with sassafras, sumac, scrub oaks, Russian mulberry and so on. Many mat plants are present, and there is a tendency of various species of herbs to occupy exclusively the ground they grow on. Among these plants are five-finger and dewberry. Just at the base of the slopes *Fimbristylis* is abundant.

Creek valleys and gullies have a peculiar flora on their slopes, and also in the rich alluvial soil of their bottoms. In many cases they resemble extensions of the lake plain. Among many characteristic plants are skunk cabbage, *Conocephalus*, *Blephilia*, and so on.

The railroad has an interesting introduced flora of wild lupine, *Salsola kali*, squirrel-tail grass, white amaranth, and many other species.

The Lowland Forest, a dense, tangly jungle with a rich sandy loam soil, contains numerous and interesting species. Quaking asp, elm and sycamore are representative trees. The herbs are various, rank, shade and moisture loving species.

The lake plain is a perfectly flat area composed of muck and marl. In many places it is covered with copses of low willows, *Cornus, Cephalanthus Spirea* and carolina rose, and this is perhaps its original form. In other places it is a sedgy meadow. Peculiarities are (1) the distribution of plant species in horizontal strata, as, bushes above, then sedges, then ferns, and lower, mosses and *Selaginella*. (2) The flora is so crowded that when a predominant species is in flower it frequently gives its tint to the whole landscape, so we have a succession of "color waves" during the year, as the blue of blue vervain, deep purple of *Lythrum alatum*, light purple of swamp milkweed or joe-pye-weed, brown of *Osmunda regalis*, or yellow of tickseed sunflower or *Rudbeckia*.

The tamarack was nearly extinct, but others near by showed probable former flora of *Sphagnum*, pitcher plants and an interesting assortment of heaths and orchids.

Temporary woodland ponds are mostly bare of bottom except for dead leaves and some shrubs and water crowfoot. The temporary ponds in the open are overgrown with *Scirpus cyperineus* and various species of Eleocharis. These temporary ponds are interesting as they contain plants showing *seasonal* dimorphism, an aquatic form during wet seasons and a land form during dry periods of the year. They also contain plants, the lower leaves of which are fitted to submersed life, and the upper to aerial life, as water parsnips and water crowfoot.

Permanent ponds, quaking bogs and bayous are similar to the lake, except that they contain a greater number and variety of duckweeds.

The Ice Ridge is interesting in many ways, but does not contain many plants peculiar to itself.

The Beach contains a mixed flora. Sometimes its flora is of such plants as *Scirpus Americanus* or various *Eleochari*, sometimes it is seedlings of elms, maples, etc., which have been deposited by waves.

The lake has several zones of plants. Near the shore and extending both ways are plants with well marked dimorphism—a well developed land form, and an aquatic form. Among such plants are, spatterdock, white water lily, *Utricularia intermedia*, water plantain, *Heteranthera dubia*, and many others. *Scirpus lacustris* has two well marked forms which frequently grow side by side and form a distinct contrast. At other places what appear to be intermediate forms are found. Many of the *Potamogetons* have emersed leaves dissimilar in form and structure from the submersed ones. Among the various zones of plants are:

(1) The shore plants, as some species of *Eleocharis*.

(2) Aquatic with emersed leaves (or culms) as *Scirpus lacustris*, spatterdock, water lilies and pontederia, also many *potamogetons*.

(3) Short stemmed aquatics; species near shore as *Naias* and species of *Chara* and *Nitella*.

(4) Long stemmed aquatics, in deep water, as various *Potamogetons*, *Ceratophyllum* and *Myriophyllum*.

(5) Beyond these Phanerogams, and intermixed with them, are the Algae.

The lake disseminates such winged seeds as those of elm and maple, and sows them on the beach.

Various water plants, as *Scirpus* and species of *Potamogeton*, protect the shore from waves. They also serve as points for the attachment of various organisms.

D. The Plant Ecology of Winona Lake.

Lucy Youse.

In the following discussion of plant societies and their distribution about Winona Lake, Warming's system of classification of plant societies will be used. This system of classification, now in general use by botanists, groups plants, except in the case of salt plants, on the basis of their relation to moisture. He distinguishes the following types: Xerophytes, those requiring least moisture; hydrophytes, those requiring most; mesophytes, those of medium moisture conditions; and halophytes, plants of alkaline soil or salt water.

Many things besides climate help to determine the amount of moisture. The quality of the soil has a marked influence upon the water content; clay, for instance, holds water and sand does not. Of all such factors, the topography of the country, since it plays so important a part in determining not only the drainage and the humus content of the soil, but also exposure to the wind, to light and to heat, is held by some to be more important even than surface geology in its influence upon the character of the vegetation. Dr. Henry C. Cowles, in his report upon the plant societies of Chicago and vicinity, has shown this influence to be secondary to that of topography. In his discussion of the same he says: "The flora of a youthful topography in limestone, so far as the author has observed, more closely resembles the flora of a similar stage in sandstone than a young limestone topography resembles an old limestone topography. A limestone ravine resembles a sandstone ravine far more than a limestone ravine resembles an exposed limestone bluff, or a sandstone ravine resembles an exposed sandstone bluff. We may make the above statements in another form. Rock as such or even the soil which comes from it, is of less importance in determining vegetation than are the aerial conditions, especially exposure. And it is the stage reached by the evolution of the topography which determines the exposure."

Much might be said on this subject of the chemistry versus the physics of the soil. It is discussed by both Schimper and Warming, and even the latter says that the chemistry of the soil best accounts for the halophytes. In making observations and recording experiments both sides of the question must be kept in mind if our conclusions are to be accurate.

The soil, or edaphic influence is local, and is in direct contrast to that of climate which is widespread. To the latter are due our pineries of the north and also our own growth of deciduous trees. Beech-maple-hemlock forests, the climax type, toward which, it may be said, everything is tending, are climatic. Oak societies, on the other hand, are a predominant but not permanent feature of Winona Lake, and the conifers of the Atlantic coast are edaphic, being due to soil or local atmospheric conditions. The first plant societies of a region are the result of extreme or pronounced local conditions and are edaphic. Less pronounced conditions gradually obtain and we have climatic types. And even then the types are not permanent, for we have climatic changes. The earth is perhaps gradually growing colder and a period of glaciation may be approaching. Beech fossils in Sweden show the former existence of beech forests in a region which is now too cold for their growth.

It is the purpose of the author to indicate some of the changes which are now taking place in the region under discussion and to show how edaphic are giving way to climatic influences as the territory develops from youth to maturity.

Crustal movements and erosion, with its consequent deposition, must be taken into account. By erosion we have the constant wearing away of hills, which is retarded in no small degree by the vegetation growing upon them and the deposit at a lower level of the material carried away. By this process, which is hastened by the decay of plants, in swamp and lake, xerophytic hills and hydrophytic lowlands both become more mesophytic and a planation called base level is approached. This planation is interfered with by crustal movements. If the movement be upward, the mesophytic development of hills is retarded while that of the swamp is hastened. A downward movement, on the other hand, would hasten the mesophytic development of upland and retard that of the lowland. From this, it will be seen that the ultimate tendency, at least in this climate, is toward the mesophytic condition. Whether the change is slow or rapid is determined by the locality in which it occurs. A granite hill develops much more slowly than a morainic region like that about Winona Lake.

Here we have the "knob and kettle hole" lake and swamp of the terminal moraine. The soil is that attendant upon such a region, a mixture of sand, gravel and clay, with here and there a predominance of sand or clay, the whole being varied by stretches of the muck of the swamp and the sand of the beach.

There are probably three main types of vegetation—the hydrophytic or semi-hydrophytic societies of lake and swamp, the xerophytic or semi-xerophytic of the morainic uplands, and the mesophytic along the streams. In reality we have various combinations of these types and the different plant societies are not limited to the respective topographic forms as indicated. since the region shows marked evidence of development toward the climax type.

1. The Lake.—There are all gradations in the "kettle hole" in the immediate vicinity of Lake Winona, from the lake itself to the various undrained and half-drained swamps scattered here and there about the margin of the lake and representing old ponds which have gradually become filled up by the encroachment of vegetation upon them.

Where the vegetation in the lake is most luxuriant, we find, in the outermost zone, Nymphaea odorata and Nuphar advena (the white and yellow water lilies); next. Pontederia cordata (pickerel weed), and nearer the shore the bulrushes (Scirpus lacustris and Scirpus pungens). A number of species of Potamogetons are found among all of these, in some places reaching far out into the lake. At the mouth of Cherry Creek Potamogeton fluitans predominates, with Potamogentons pectinatus, Potamogeton zosteraefolius and one or two other species nearby, together with Hydrophyllum (water milfoil) and Ceratophyllum (hornwort). In this society Chara has a place by no means unimportant. It is especially prominent in the northwest arm of the lake, which, in its luxuriant growth of vegetation, beautifully illustrates the ultimate fate of the entire body of water. The outlet, which flow from this arm at its southern end, has become so thoroughly choked up with vegetation at its beginning that the water has grown almost stagnant and the lake flora is gradually working its way up the stream. Fig. 1 shows part of this arm in the left foreground and the lilies at the entrance to the outlet. With the exception of this arm the lake vegetation is most luxuriant near the southwest shore.

Fig. 1. View across the lake to the east. The general basin form is distinguished. The highlands can be seen in the background. Tongues of land are seen being reclaimed from the lake bottom. On the right is the outlet to the Tippecanoe. Zones of white and yellow water lilies in the foreground, followed by cat-tails and sedges. Zones of willows, Carolina rose and osier dogwood are in the center, while to the right is an oak and hickory forest. On the left is a swamp meadow.

This is perhaps explained by the fact that the winds in this region are from the southwest. The greatest wash of the waves is toward the east and northeast, and here, as we might expect, we find the greatest dearth of plants and plant growth. This southwest beach is overlaid with muck, a natural result of the decay of plants along its margin.

At some places around the lake, notably in the same arm, the bulrushes are followed by the cat-tails (Typha latifolia) with sedges and grasses on the shore beyond. This is shown in Fig. 1, at the left. On the south shore, however, where the land is raised by an ice beach, the lake is bordered by the button bush (Cephalanthus occidentalis), osier dogwood (Cornus stolonifera). Rosa Carolina. Cottonwood (Populus monilifera) and willow. A region similar in vegetation is shown in Fig. 2. This succession of societies is carried a step further on the west shore of the lake southwest of Yarnelle's landing. In addition to the foregoing are swamp white oak (Quercus bicolor), silver maple (Acer dasycarpum),

Fig. 2. View across lake from Yarnelle's landing. The basin effect is more apparent here. The transition in vegetative types is very rapid at this point, owing to the somewhat abrupt rise in the topography. It quickly passes from hydrophytic through the marsh stage to mesophytic. On the shore, zones of the button bush and osier dogwood are followed by those of Carolina rose, willow and, lastly, elm. The coming of this tree means permanent conditions looking to the mesophytic types.

and sycamore (Platanus occidentalis). The land adjoining this on the west, which is slightly elevated and better drained, and which might show a still higher stage of development, has been cleared and cultivated. So we must look toward the south where the hand of man has not interfered with the work of nature. Here, as we might expect, in the same relation as to position, that is a step further from the lake, higher, drier, and well drained, we find the hazel (Corylus Americana), the grape, Mayapple (Podophyllum peltatum), Catnip (Nepeta Cataria), Smilacina racemosa, and the Elder (Sambucus Canadensis). This mesophytic strip forms a zone of tension between the more nearly hydrophytic beach and the semi-xerophytic hill adjoining on the west. At Yarnelle's landing, north of the dredge, where the land rises quite suddenly from the water's edge, joining the hills a short distance beyond, there are comparatively few willows. The sycamores and cottonwoods of the shore are accompanied by the aspens (Populus tremuloides), the elm (Ulmus Americana), black haw (Viburnum prunifolium), the hickory and Sassafras officinale. Closely adjoining are the mayapple, grape, red bud (Cercis Canadensis), and prickly ash (Xanthoxylum Americanum). This evolution of plant societies on the lake shore is perhaps shown even more beautifully in the vegetation of the two long points of land projecting out into the northwest arm. These are shown at the left in Fig. 1, the one in the foreground showing the more advanced stage.

2. The Swamp.—The encroachment of vegetation upon the lake, with its death and decay, makes the water shallower and finally unfits it for the plants themselves. This filling up process is aided by the deposition of material carried in by the streams that feed its waters, and ultimately we have a swamp taking the place of the lake. These may be found in various stages of construction and destruction in the region about Winona which was at one time itself a part of the lake.

One of the youngest of these, near the east shore of the lake and bordering upon Cherry Creek, has its surface covered with duckweed (Lemna, Spirodela and Wolffia) with arrowhead and yellow water lilies near the shore in some places, followed by grasses, the Iris (Versicolor) and sedges (Carex vulpinoidea and Carex lupulina). Surrounding these are the button bush, osier dogwood, willows, swamp white oak and elm and the fern (Aspidium thelypteris). In some places where the swamp is becoming filled up, a dense growth of Polygonum is found in the center.

At many places about the lake is the swamp meadow, a wide stretch of flat land with rich muck soil. One of the most interesting of these lies just north of the lake. Here are grasses, sedges, Salix amygdaloides, the shield fern (Aspidium thelypteris), Potentilla fruticosa (shrubby cinquefoil), Eupatorium purpureum, osier dogwood, Carolina rose, Joe-Pye-Weed, Solidago lanceolata, Campanula aparinoides (marsh bellflower), Lycopus lucidus (water horehound), Asclepias incarnata (swamp milkweed), Pycnanthemum lanceolatum (mountain mint), Boehmeria cylindrica (false nettle), Betula pumila (low birch), Steironema longifolium, Osmunda regalis.

Convolvulus arvensis (bindweed), Apocynum androsaemifolium (spreading dogbane), Verbena urticaefolia (white verbena), Rudbeckia hirta (cone flower), and Lythrum alatum (loosestrife), together with the following mesophytic pioneers: Eupatorium perfoliatum (boneset), Pilea pumila (rich weed), and Impatiens.

At places where the swamp is better drained its ultimate tendency is indicated, notably at a point about a quarter of a mile south of the southeast corner of the lake. We see here black oaks (Quercus coccinea tinc-

Fig. 3. View showing rich mesophytic meadow reclaimed from the lake bottom. This area is rapidly becoming more mesophytic and the remaining hydrophytic plants are dying out. In the background, on the morainic upland, is seen an oak-hickory forest, with the white oaks at the base and black oaks on slope. It is probable that the meadow has never been forested.

toria), white oaks (Quercus alba), silver maple (Acer dasycarpum), sycamore (Platanus occidentalis), walnut (Juglans nigra), hickory, poison ivy (Rhus Toxicodendron), richweed (Pilea pumila), Indian turnip (Arisaema triphyllum), May-apple (Podophyllum peltatum), Viola palmata, Viola pubescens. These patches of mesophytic woods are sometimes found in the very center of the swamp at places where the land is somewhat higher. The soil contains a larger amount of moisture than that of the mesophytic woods on the lake shore spoken of above, and the vegetation represents a higher type of mesophytic society.

In the evolution of the swamp of Turkey Lake, the first vegetation is of water plants. These are followed by bulrushes or sedges, and next come shrubs and trees, in some cases those noted above, but in others Cassandra calyculata which is followed by the tamarack (Larix Americana). These swamps are destined to become forests, while in the case of the lake like Lake Calumet, near Chicago, Ill., the destiny of which

Fig. 4. View of a portion of the beach in Cherry Creek Embayment. The slope is gentle, rising from the low channel of the creek on the right to over 20 feet on the left. The soil is very boggy and most of the bogs are associated with mineral springs. Rows of willows in the right center, with sycamores and oaks on left. The rich nature of the soil is apparent in the heavy herbaceous vegetation. Semi-fossilized bivalve shells were found here.

is the prairie, the bulrush stage is followed by grasses. It is suggested by Dr. Cowles that this difference in the ultimate development of the swamp may be due to the depth of the kettle and consequently the depth of the muck, the forest type being found by him to have originated from deep kettles and the prairie type from shallow ones. The muck in the swamps spoken of above is deep and their destiny is evidently forest, as has been pointed out, but there is very little evidence of the Cassandra and the Tamarack stages. There are a few tamarack swamps in the vicinity of Lake Winona containing some of the plants typical of the tamarack stage, such as the pitcher plant (Sarracenia purpurea), and the peat moss, Sphagnum. But in the old Winona Lake bed there are barely three lone tamaracks, standing in the bottom of an old arm of the lake, with nothing to indicate the share they took in the development of the swamp. Further data obtained by a comparison with other specimens of this kind of swamp are necessary before a definite conclusion can be reached concerning its evolution.

Quite an interesting type of swamp is found in a narrow belt of lowland which adjoins the lake and represents an old arm of it, lying like a ditch between the hills there. It contains Ludwigia polycarpa, Ludwigia hirtella, ditch stone-crop (Penthorum sedoides), manna-grass (Glyceria fluitans), Polygonum acre, Polygonum hydropiper, Polygonum sagittatum and Polygonum Muhlenbergii. The flora of the margin is swamp white oak, black alder (Ilex verticillata), sour gum (Nyssa sylvatica), Carolina rose, and the swamp, white or silver maple (Acer dasycarpum). Riccia fluitans carpets the wet soil.

A swamp in the hollow of the hills is filled with Polygonum hydropiper, Iris, skunk cabbage (Symplocarpus foetidus), and Rosa Carolina. Around the margins are dying willows, elm and ash. Fossils of ferns point back to former days when moisture was more abundant. Withering Mnium and flourishing Polytricium, the relict and the pioneer, show past and future. To the south, the hill has been cleared and xerophytic conditions are being hastened in the margin of the swamp. Dying Iris and vigorous Canada thistle grow side by side. On the east, west and south are the morainic hills covered with oak-hickory forests. The fate of this swamp is gradual filling up by dead vegetation and downwash from the surrounding uplands and the ultimate encroachment of the neighboring plants upon its territory.

3. The Morainic Uplands.—The sand-gravel-clay hills are even more numerous about the lake than are the swamp meadows and their vegetation is only slightly varied at different places, this being usually in clearings. The oak-hickory stage prevails. Near the summit of the hill is the black oak (Quercus coccinea tinctoria), with the white oak (Quercus alba), on the lower slopes. These are accompanied by the hickories (Carya alba and Carya sulcata), wild oats (Danthonia spicata), wire grass (Poa compressa), plantain-leaved everlasting (Antennaria plantaginifolia), Polytrichum, New Jersey tea (Ceanothus Americanus) and Silene stellata. At

the base of the hills, on the tension line adjoining the swamp, is the black huckleberry, Gaylussacia resinosa. (See background of Fig. 3.) The oak stage has required so long a time to develop and has been in existence so long that we have only the result and little evidence of what preceded this type. In the north the coniferous forest comes first. Clearings give some intimation of the order of succession, and they are numerous, though somewhat deceptive, as the stages in this case follow one another much more rapidly than they would in a virgin soil in which

Fig. 5. View of the channel and abutments of the upper or lesser dam. From the condition of the vegetation in the foreground, it is evident that the stream's gradient is small. Upon the left and right the surface rises abruptly to 12 feet, and is covered with heavy mesophytic trees. The soil is sandy. This is a place where vegetation is capable of closing the drainage lines.

there had been no foundation laid for later types. Where the soil has been cleared the first plants that follow, as shown on the north and west sides of the lake, are Xerophytic annuals and perennials, such as poke weed (Phytolacca decanda), mullein (Verbascum thapsus), Canada thistle (Cnicus arvensis), hounds-tongue (Cynoglossum officinale), Leonurus Cardiaca, Arctium lappa, Echinospermum lappula. These seem to be followed by elm and hickory. The beech-maple forest is working its way in so slowly around Winona that at first glance there seems to be no

Fig. 6. View across the valley from the left abutment of the lower or greater dam. The width of the valley is here about 165 feet, with the earth walls rising abruptly 22 feet on either side. The soil is a glacial deposit, sand predominating.

Fig. 7. View up the channel of the outlet at the greater dam. The depth of the valley is shown by the altitude of the right abutment in the background. The evidence of the ascending erosion line is in the foreground.

indication of it whatever. It has made its appearance in only one region in the old lake bed, namely, within a mile of the present lake shore around Clear Creek. The beech forest west of the lake is outside of the territory covered by this report. Why this type has lagged so far behind is perhaps due to the large percentage of gravel in the soil, as its development is much slower in gravelly soil than in that in which we have a large percentage of clay. The presence of beeches depends upon the amount of humus in the soil. Then, too, both beech and maple seedlings can grow in the dense shade these trees themselves make or in the lighter forests of oak and hickory. The plants of the latter type, on the other hand, do not flourish in the deeper shade of the beech.

Accompanying the beech (Fagus ferruginea) which is yet somewhat rare in this type of forest about the lake, and the sugar maple (Acer saccharinum) are the tulip tree (Liriodendron tulipifera), the walnut, the pawpaw (Asimina triloba), Hepatica, Trillium, Virginia Creeper, Mayapple, skunk cabbage, various species of ferns, together with the older oaks and hickories, which point back to the past.

4. The Stream.—The territory over which now flows the lower part of the two streams that feed the lake was once the lake bed and is now a flood-plain. Cherry Creek, the largest of these, is a pre-erosion type in what is apparently an erosion valley. Along the lower course of this is a mixture of influences which results in a "hodge podge" of vegetation not easy to unravel. Lake and swamp, spring and stream, all combine their forces to produce this effect. Near the mouth of the stream Potamogeton fluitans is abundant. In that part most often submersed are the rice cut grass (Leersia oryzoides), cat-tails, bulrushes and sedges, among them Scirpus atrovirens, Carex lupulina, and Carex vulpinoidia. Many plants characteristic of springs and spring brooks are found, such as swamp milkweed (Asclepias incarnata), skunk cabbage (Symplocarpus foetidus), Eupatorium purpureum, Eupatorium perfoliatum, Lycopus lucidus (water horehound), and several other species of mint, Lobelia leptostachys and Lobelia syphilitica. Salix longifolia and Salix nigra are common (see Fig. 4), and in the locality west of the creek and bordering upon the lake seedlings of the river or silver maple (Acer dasycarpum) and the aspens (Populus tremuloides) form a marked feature of the landscape. Other plants characteristic of this flood-plain are the ash (Fraximus Americana), the walnut (Juglans nigra), the red-bud (Cercis Cana-

densis), the sycamore (Platanus occidentalis), the mulberry, the hazel (Corylus Americana), the hornbeam (Carpinus Caroliniana), poison ivy (Rhus toxicodendron), Virginia creeper (Ampelopsis quinquefolia), grape (Vitis), greenbriar (Smilax), Indian Turnip (Arisaema Dracontium), ground ivy (Nepeta Glechoma), nettles, blue grass (Poa pratensis), meadow rue, strawberry (Fragaria), Impatiens, Aspidium thelypteris, Onoclea sensibilis and Osmunda regalis.

Looking forward to the future of this stream we expect greater erosion, retrogression toward the xerophytic, and, as the ultimate base level is approached, progression again toward the mesophytic.

Niagara Group Unconformities in Indiana.

Moses N. Elrod, M. D.

Prof. Richard Owen, in the Indiana Geological Survey, 1859-60, calls attention to an unconformity near Huntington, which he supposed to indicate the dividing line between the Devonian and Upper Silurian. He describes the arenaceous limestone of the Devonian as resting unconformably, rate of dip 25 to 40 degrees southeast, on the silicious limestone of the Silurian. Of the Linn's Mill exposure, on Treaty Creek, Wabash County, he says: "Here we again found evidence of the convulsions and unconformable stratification noticed at the Fair Ground quarries of Huntington and in this county. On the west side of the creek, opposite the mill and close to the dam, a hill is formed by an anticlinal axis, the beds dip northward and southward about 43 degrees. But the extreme summit of the hill has evidently been subsequently denuded and abraded by water until a hollow affords a channel for a rippling rivulet, while in the bed of the main stream, beneath the axis, the undisturbed strata are visible." In the light of more recent investigations it is probable Prof. Owen's arenaceous limestone of Huntington and the upper member of his Wabash County unconformities should be correlated with the porous lime-rock of Prof. Collett, and the picket rock of Messrs. Elrod and Benedict. It snould also be noted that the underlying layers of stone, at Treaty Creek, are approximately horizontal, and exclude an uplift as the cause of the distorted bedding.

Prof. John Collett, in the Geological Survey of Indiana, 1872, describes an unconformity seen by him at Calvert's quarry, near Georgetown, Cass County. He found a gray limestone resting unconformably on the "silico magnesia with a small parting of clay." This clay parting, he claims, is general, and is often found in wells some 20 or 30 feet below the surface at Logansport. At a later period the observations of Prof. Collett were confirmed by Mr. A. C. Benedict. Commenting on a section made, near Georgetown, for the report on the Geology of Cass County, 1894, he describes the surface of the first layers under the "gray limestone" as showing evidence, when exposed, "of having been eroded into channels and hummocks before the overlying rock was deposited."

Prof. Collett, under the section of his 1872 report devoted to Wabash County, correlates the "gray limestone seen at Logansport and at a few localities in Miami County" with the "thin-bedded paving stone" of Wabash. The silico magnesian beds of Logansport, he says, "part with the greater portion of the calcareous matter at Peru, becoming argillaceous, while in Wabash this bed is characteristically argillaceous, and in appearance very similar to the hydraulic stone at Louisville." In his general section of Wabash County he places (1) porous limerock at the top, and gives its thickness at from 0 to 40 feet; (2) paving stone, 8 feet; (3) thick-bedded argillaceous limestone, 10 to 20 feet; (4) hydraulic limestone, 10 to 50 feet, and referred the whole series to the Niagara group. The subdivisions adopted by Elrod and Benedict in their report on the Geology of Wabash County, 1891, do not differ greatly from those of Prof. Collett. They placed the quarry stone, the equivalent of his paving stone and thick-bedded argillaceous limestone, at the top of the series. Between the quarry stone and his hydraulic limestone they recognized a local stratum of laminated shale, closely related to the quarry stone, and all below the laminated shale was called cement shale or cement rock. The porous limerock was not given a separate place in the section, because it was the opinion of the writers that it did not form a distinct geologic horizon; but was composed of the changed materials derived from the quarry stone and the underlying formations, but came mainly from the quarry stone layers. The materials were recemented by infiltration, and, as a consequence, the beds have no true stratification planes. For it they adopted the name picket rock, a local term then in common use at Wabash.

These correlations are deemed necessary that the reader may understand the stratigraphic position of the Wabash County unconformities. and the probable relations of the others of the Wabash Valley.

A very remarkable and plain example of unconformity between the quarry stone layers and the blue cement rock may be seen on the east bank of Lagro Creek, one-half mile north of Lagro. Here 30 feet of horizontal quarry stone abuts against a nearly perpendicular wall of cement rock. Below the unconformity, in the creek channel, the cement rock is found to be continuous and connected with the south wall of the unconformity and to pass under the more recent quarry stone. Dip is scarcely appreciable in any of the layers. Other unconformities of great interest are those at the Martin Willis quarry, south of Lagro, on the township line pike, and at Leonard Hyman's quarry, on the Mississinewa River. At these quarries the quarry stone rests on the laminated shale in a valley. On one side of the Martin Willis quarry the shale rises 10 feet above the lowest exposed horizontal layers of quarry stone.

Some convulsion of nature, a local upheaval and subsidence of the earth's crust, was among the theories generally accepted for a time, to account for the false bedding of the Wabash Valley rocks. Prof. Collett, in 1872, was the first to offer an explanation more nearly in accord with recent observations. Of a Delphi locality he writes: "The Pentamerus bed is an irregular deposit, variable in its mode of occurrence and thickness, evidently deposited by currents flowing across irregularities in the surface of the regularly deposited rocks below. It is generally found thrown down upon or against these irregularities, and consequently exhibits remarkable peculiarities of false bedding." But his theory does not account for the uneven surface of the regularly deposited rocks. The most obvious explanation is to suppose that they are due to erosion, and that they indicate the upper surface of the lower member of an unconformity. Especially must this be true where the stratification of the stone, comprising the irregular surface, is found to be level and the layers of uniform thickness. Where the irregularity forming the axis or center of a cone is composed of shale it is not impossible that it may have been formed by currents. The effect of currents on the contour of a shale bed was clearly demonstrated in an example of irregular bedding seen in the quarry of James Lambert at South Wabash. Here an axis of shale had been deposited between the quarry stone layers, which maintain a uniform thickness while conforming to the irregular surface of the shale. Near Lagro, at the Watson Briggs ravine, is a beautiful exposure on a large scale of the picket rock passing over a central axis of a cement shale with the dip in opposite directions. On the flanks of the axis the dip changes from 20 to 12 degrees and the layers become horizontal as they pass over the top. These exposures are supposed to show the primary origin of the false bedding in nearly all cases, and especially so when the distorted layers are of nearly uniform thickness. But in many cases other phenomena are involved and the explanation is not so simple. Irregularities of the underlying surface do not account for the brecciated condition, changed physical characters and the nearly vertical planes of so-called stratification.

The brecciated character of the Indiana stone seems to have been first pointed out by Prof. Orton in the eighth annual report of the United States Geological Survey. Of the Ohio stone, with which he compares the Indiana outcrop, he says: "The layers of limestone appear to have been traversed by joints dividing them into cubical blocks of two or ten inches in diameter, and the separate blocks have been recemented by material of the same sort that composes the substance of the rock. The cause is not obvious, but the phenomena is certainly not referable to uplift and disturbance. It seems more probable that if we were able to trace out the history we should find some modification of the force that produces joints, whatever it may be, as the cause of the phenomena we are considering."

The high angle stylolite planes of the interior conformation of the cones is another feature which should be considered in connection with the brecciated structure. The columnar part of the stylolite seam is peculiar in having its axis lie parallel with the separation plane, and seems to show that the columnar structure is the result of a downward movement of the overlying layer. At the Stauffler quarry, two miles west of South Wabash, and at Rockyway Creek the angle of the separation planes does not exceed 25 degrees, and it is probable that they may be modified bedding planes, something like those described by Mr. T. C. Hopkins in his report, of 1896, on the Bedford oolitic limestone of Indiana.

The exposures at Stauffler's and Rockyway also show that the picket rock gradually changes into even bedded quarry stone, and that the picket rock is a modified form of the other. At the same time the dip changes from an angle of 25 degrees to nearly horizontal.

The high angle stylolite planes are too nearly vertical to have been the result of sedimentation. They evidently grow out of a number of conditions. Briefly, the picket rock cones and ridges rest on a core or axis of cement rock or shale, the latter being the result of erosion. It is probable the layers of stone, overlying the core, were of continuous thickness when deposited, and that the brecciated character and stylolite planes are the result of pressure and unequal resistance to a downward shear.

A somewhat similar system of brecciated and irregularly bedded stone extends from the interior of Ohio, across Indiana and into Illinois. Through Indiana and in the vicinity of Chicago high angle stylolite planes are a marked feature of the exposures. In Ohio the distorted bedding is referred to the Waterline formation. In Indiana similar irregularities are supposed to be confined to the Niagara group beds. Dr. A. J. Phinney has been the only Indiana geologist to dissent from this opinion by assigning the Delphi and much of the Logansport exposures to the Lower Helderberg. Prof. Orton, in his report on the Ohio and Indiana gas field, says: "The well-known Wabash flaggings are here counted of Lower Helderberg age." Dr. Phinney, in a report on the natural gas field of Indiana, eleventh United States Geological Survey, dissents from this opinion, and says: "The exposures in the vicinity of Wabash have been considered Niagara limestone, as the fossils are identical with those found at Marion, where the exposure is undoubtedly Niagara." In the Wabash County report of 1891 forty species of fossils are tabulated, which were collected from the quarry stone. The most of these were characteristic Niagara fossils. The Illinois geologists have always considered the equivalent beds of that State as of Niagara age.

By some writers great significance is attached to the brecciated structure in determining the age of the stone in which its occurs. However, Dr. Phinney describes the Waterline at Kokomo as "an even-bedded limestone." About Logansport, he says, the Lower Helderberg is a common rock, and "finely exposed," but, so far as known, never shows a brecciated surface. If the Waterline formation is excluded from the Lower Helderberg it is probable no true representative of that period is to be found in Indiana.

Prof. Dana, in the fourth edition of his Manual of Geology, assigns the Waterline formation to the Salina group. And in a bulletin of the Geological Society of America, May, 1900, Mr. Charles Schuchert presents facts to show that all of the Lower Helderberg above the Waterline and Tentaculite limestone should be included with the Devonian. Mr. Schuchert seems to consider the Tentaculite limestone as transitional to the Lower Helderberg. Of twenty-six species found in the Tentaculite beds of New York, only four are known to occur in some higher member of the Lower Helderberg. In Ohio, out of thirteen species described from the hydraulic limestone only four are known to occur in the higher beds. So, then, in view of what is now known, it seems safe to assume that the Wabash County unconformities and pronounced irregularities of bedding were the result of forces in operation near the close of the Niagara epoch, and at all events before the close of the Silurian age.

The subdivisions of the Niagara group in Southern Indiana have been much better defined and correlated than those of the Wabash Valley. The remarkable uniformity in the bedding of the Laurel limestone from Connersville to the Ohio River has been fully described, and the Waldron shale exposures traced from Milroy to Charlestown landing. Slight irregularities of bedding had been noticed in the layers immediately above the

Waldron shale, but nothing worthy the name of an unconformity until Mr. Foerste, in the twenty-second Indiana Geological Report, called attention to the Avery quarry as showing evidence of a period of erosion. Other unconformities on Flatrock and Conn's creeks have been described and illustrated by Messrs. J. A. Price and E. M. Kindle in later reports.

Avery Quarry, Southeast Corner.

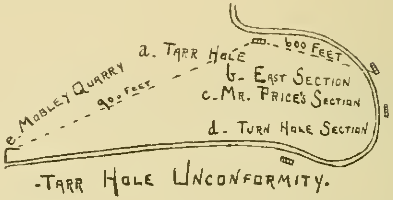
The Avery quarry is located on the east bank of Conn's Creek, one mile south of Waldron. The Louisville limestone, as the workable bed of stone has been called, rests conformably on the Waldron, is 10 feet thick on the north wall and five feet thick in the southeast corner. The layers have a general dip to the north of three degrees. On the south face of the quarry, near the southeast corner, three discontinuous layers are exposed at the top of the Louisville limestone. They aggregate nine inches in thickness at the west end, and thin to nothing before reaching the southeast corner. Immediately under the attenuated strata is a 6½-inch layer which is continuous around the south and east faces of the quarry. From 6½ inches at the southwest end it gradually diminishes to 2½ inches at the northeast corner. Below the continuous layer is a layer which measures 11 inches at the north end; it soon divides into two layers, whose combined thickness is 9 inches at the south end. On the east face two layers, near the top of the wall, were measured, one of which changed in thickness from 2¼ to 5 inches in 33 inches, and the other from 2½ to 5½ inches in 21 inches. At the northeast corner of the quarry there is 5 feet of Louisville limestone about the 6½-inch continuous layer, which diminishes in thickness to nothing at the south end. The layers composing this 5-foot stratum do not thin gradually, but by an abrupt ending of the several layers. Twenty feet north of the southeast corner is a slight thickening in the upper layer, which causes a slight dip north and south. These measurements show that the thickness of some layers increase and others decrease with the dip. Below the 6½-inch continuous layer the stone is evenly bedded.

Above the nearly level line of unconformity is from 20 to 48 inches of coarse, sandy-looking limestone in broken layers, with a thin covering of earth above it. Viewed from across the quarry the exposure looks like a broken wall of rubble stone. The results of weathering are very evident, but has not wholly destroyed the lines of continuity, which show irregular bedding.

The color of the Louisville limestone changes from blue or blue-gray at the bottom to a gray near the unconformity. The overlying layers are very nearly brown. The upper Louisville layers change color gradually, and the freshly broken surface of the brown stone can scarcely be distinguished from it, but a marked difference is developed by weathering.

The quarrymen allege that the underlying shale is five feet thick, which is very nearly its average thickness at other places. So far as the thin-bedded shale can be said to have dip it seems to conform to that of the Louisville limestone. If this is true the surface of the Laurel limestone, on which it rests, must be irregular. The exposed Laurel limestone in the bottom of Conn's Creek nearby shows that it has no appreciable dip, nor has it been disturbed by an uplift. Hence it is reasonable to conclude that the irregular surface below the Waldron shale has been the result of erosion which took place after the Laurel beds were deposited and before the Waldron shale came into existence. The inclined position of the Louisville limestone layers is the outcome of irregularities formed during sedimentation.

The unconformities described on Flatrock Creek are minor affairs compared with the Avery quarry locality. The horizon of the Geneva and Louisville limestone unconformities change, and at one place is found between the layers of the "soft, sandy limestone." Generally they appear to be nothing more than lines of irregular bedding, with a slight difference in the structure of the upper and lower members.

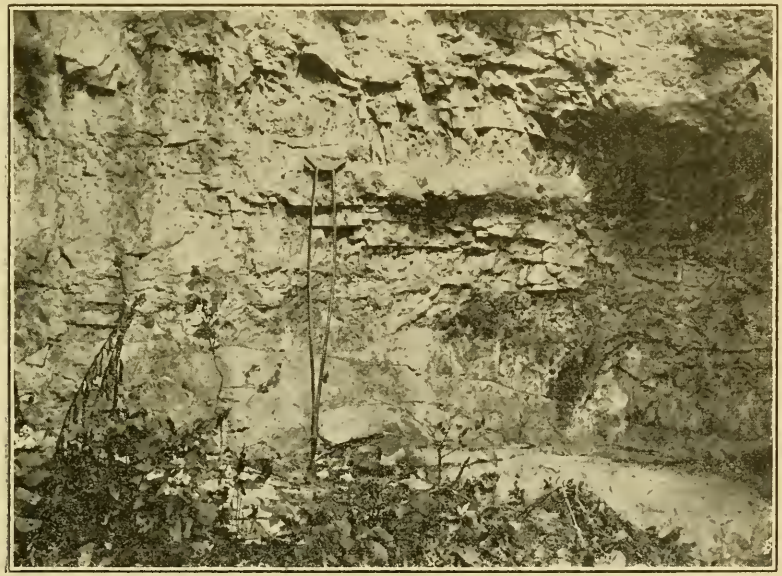


The top of the Waldron shale at *a* is 12 feet, at *b* 17 feet, at *c* 18 feet, at *d* 9 feet above low water; at *e* it is below the surface. The fall in the creek bed from *a* to *e* is 40 inches.

One mile south of Hartsville, in the Tarr hole vicinity, there seems to be conclusive evidence of a period of erosion after the Laurel limestone beds were formed and before the shale beds were deposited. Below the Tarr hole Clifty Creek makes a horseshoe bend within a radius of one-fourth mile. The Tarr hole exposure shows that the top of the Waldron shale is 12 feet above low water, and the shale nearly 7 feet thick. Six hundred feet east the top of the shale is 17 feet above low water and 4½ feet above the same level at the Tarr hole. Near the middle of the bend Mr. Price estimates the shale to be 3 feet thick and its top at from 18 to 21 feet above the bed of the creek. In 1881, when the shale was better exposed than now, a section was made at the Turn hole which showed the top of the shale at 12 feet above low water, and the shale 5 feet and 8 inches thick. After due allowance is made for the decline in the bed of the creek, where it passes over a long riffle, it indicates the surface of the shale is 3 feet below a corresponding level north of it at the Tarr hole. Seven hundred feet west of the last locality is the Jesse Mobley quarry, where a well was put down a few years ago that penetrated the Waldron shale 20 feet below the surface. Twenty feet below the surface, at this place, puts the top of the shale below the bed of the creek. The writer is certain of the position of the shale in this well, as he has a number of the Waldron fossils taken from it at the time the well was dug. Here the top of the shale, after adding 3 feet for decline in creek bed, is seen to be 15 feet below the same level at the Tarr hole, and from 18 to 21 feet below two other points.

Following the bend of the creek on the east side some four or five feet of thin bedded Laurel limestone is exposed, next to the shale, that is not found at the Tarr or Turn holes. The Mobley quarry, since the report on Bartholomew County was written, has developed a number of irregularities of bedding not then visible. There is a slight irregularity on the line dividing the lower grayish stone from the brown layers, and if weathered a few more years might be classed with the Flatrock unconformities.

In lithologic structure and color the Louisville limestone at the Tarr hole and Mobley's quarry very closely resembles the upper and equivalent layers at Avery's quarry. It is probable the quarry stone at both places was deposited under similar conditions, and does not show dip at Mobley's because the quarry is not located over a marked irregularity on the surface of the underlying Laurel limestone. Where investigations have been made it has become evident that all large displays of Louisville limestone are located in an erosion valley or on an anticline connected with a synclinal axis, and that the exposure of the Louisville beds are correspondingly local.



Devonian Exposure, Cave mill Park.

The irregular bedding of the Devonian at Cass, Cass County, is quite marked, and the same is true of the Geneva beds in some parts of Southern Indiana. A fine exposure of mixed bedding is to be seen in the Geneva limestone at the Cave mill park, which presents an eighteen-foot wall of discontinuous, uneven and distorted stratification, overlying what appears to be Louisville limestone. This seems to be the formation from which Mr. Kindle collected a number of Devonian fossils, three-quarters of a mile farther up the creek, opposite Charles' mill, and the equivalent of the Devonian bluffs near Hartsville. According to Mr. Price, irregular bedding is common above the Waldron shale in Rush County. It is probable that further search will reveal many more irregularities that are now obscured by weathering. The irregular bedding of the Louisville and Geneva limestones is probably the result of marine currents, and it certainly is not necessary to invoke a local uplift or convulsion of nature to account for its origin or that of the unconformities.

No unconformities have been reported from the Upper Helderberg, but there is evidence that the Niagara limestone and New Albany black shale are not conformable at Delphi.

By Mr. Foerste and others the Louisville beds are referred to the Niagara epoch, and this may be their place if based on paleontologic evidence. Its horizon, however, can not be established by the existence of a few minor unconformities at the top of Louisville limestone. If unconformities are conceded to have occurred during the Niagara epoch or Silurian age, in the Wabash Valley, they certainly show that the changes in the coast line necessary to their formation, whether submarine or aerial, did not destroy a large per cent. of the fauna in existence before the erosion period began. Of course it is conceded that many of the species found in the Waldron shale are peculiar to that formation, but many of them also came up from the preceding epoch. Therefore, the Upper Niagara and Geneva limestone unconformities have very little significance in determining the age of the formation between which they occur.

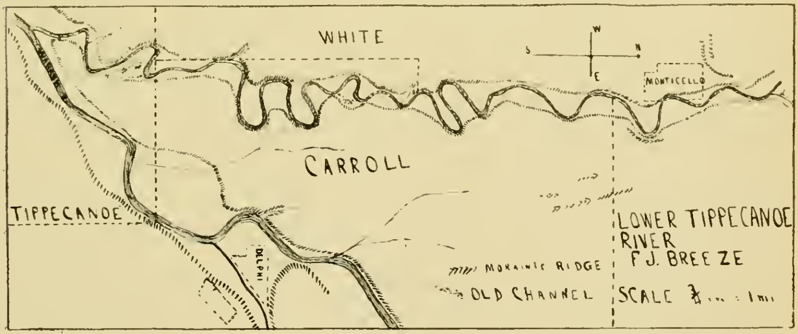
An interesting question arises whether the Waldron shale can be correlated with the quarry stone of Wabash County. Not enough is known to give anything like certainty to what now may be said on the subject, but it may not be improper to call attention to a few observations which indicate that they occupy the same horizon. It is generally known that the Waldron shale is often highly calcareous, with intercallated plates of limestone, and changes to thin layers of limestone as it is traced northward. Frequently on Clifty Creek a stratum of stone below the Waldron shale is seen which very much resembles the hydraulic beds of Wabash County, both in appearance and jointed structure. The laminated shale of Wabash is duplicated by some of the more argillaceous shales of Clifty Creek. The Wabash Valley and Laurel-Waldron unconformities seem to be of the same horizon and lend color to the inference that the quarry stone of Wabash County and the Waldron shale are of the same age.

The Valley of the Lower Tippecanoe River.

Fred J. Breeze.

[Abstract.]

The Tippecanoe River deserves far more attention from the geographer and geologist than has ever been given to it. A careful study of this stream will shed light upon some of the problems of glacial phenomena, and will doubtless yield something of interest concerning stream and valley development. Believing this, the writer has begun a somewhat systematic study of this river. Several days of the last three months have been devoted to the necessary field work in the preparation of a map of



the lower part of the Tippecanoe Valley. This map shows the meanders of the stream and of its valley, and is presented at this time with the hope that it may be some little contribution to the geography and geology of Indiana.

By Lower Tippecanoe is meant that part of the river from the point where it leaves the region of the Glacial Lake Kankakee to its mouth.

A short distance north of Monticello are sandy ridges which doubtless marked the southern limit of the glacial lake, so that this town is near the upper end of this part of the valley, although the gorge-like character of the valley has extended up to the town of Buffalo.

At Monticello the river flows in a valley not over half a mile wide and about eighty feet deep. Farther down the valley widens and deepens so that at some points the valley is a mile wide and the bluffs about one hundred feet in height. The only exposure of bedrock, New Albany shale and Devonian limestone, in this part of the valley is found a short distance above Monticello. Nowhere in the valley were wells found that were cut down to bedrock. The slope is great, the river falling almost 100 feet from Monticello to the mouth.

At this time no explanation as to the causes of the existing features is offered, the writer preferring to present these conditions for interpretation by more competent members of the Academy. This study of the Tippecanoe River will be continued, and some results of this work may be presented at future meetings.

Concerning Well-Defined Ripple Marks in Hudson River Limestone, Richmond, Indiana.

Joseph Moore and Allen D. Hole.

In the Proceedings of the Indiana Academy of Science for 1894, page 53, Mr. W. P. Shannon, under the title, "Wave Marks on Cincinnati Limestone," gives an interesting description of undulations in strata in the southwest part of Franklin County, Indiana. The present paper is a record of similar phenomena in Wayne County, Indiana.

In the spring of 1901 Prof. Joseph Moore observed what appear to be well-defined ripple marks in an exposed stratum of Hudson River limestone. The exposure occurs about five miles southwest from Richmond, Indiana, in the bed of a small tributary of the Whitewater River. The stream at this point flows approximately N. 35° E., and the series of undulations, which will be called "ripple marks" in this paper, are nearly, though not exactly, parallel, and lie in a direction about N. 72° 30′ E. This direction is the mean of the measured direction of several axes. The width of the stream is from ten to fifteen feet, and the ripple marks are exposed more or less plainly for a distance of two hundred feet in the bed of the stream.

The ripple marks have rounded crests and hollows, the slopes on the two sides of a crest being in general symmetrical about the axis. The mean distance from crest to crest is approximately uniform for the series, and the average for twenty such distances is found to be 2.63 feet. The average depth of lowest part of troughs below crests is one and one-half to one and six-tenths inches; total number of crests exposed is forty. The ripple marks in the up-stream portion of the exposed area, constituting the majority of the number named, extend entirely across the bed of the stream; in the down-stream portion, a part of the ripple marks have been worn away by erosion of the stream, leaving the crests only near the margins.

The stratum which has the ripple marks is about three inches in thickness, measured to top of crests; the bottom of this layer is as nearly plane as are the surfaces of the other layers of Hudson River rock in this locality; that is, no indication of the undulations (which are on the upper surface), is found on the lower side of the layer; and this layer containing the ripple marks is not noticeably different in thickness from that of the other layers of the same formation just above or just below it geologically.

The ripple-marked stratum, in the southwesterly (up-stream) direction, disappears beneath other strata of Hudson River limestone. This stratum above, when broken up and removed, showed a layer of blue shale or mud, filling the hollows, and barely covering the crests of the ripples; the ripple marks, however, were as clearly defined where the upper stratum was broken away as in the exposed portion farther down the stream.

The right bank of the stream is steep and higher than the left bank; and here the Hudson River rock outcrops up to a height seven or eight feet above the water; the upper stratum of Hudson River rock in this vicinity is estimated at forty feet above the ripple-marked stratum. The left bank is a part of a flood-plain. At one point a trench was dug back from the water's edge on this side. When soil, sand and gravel were removed, the ripple marks were found clearly defined as far as the digging extended, some of the blue shale being found adhering to the surface.

The under side of the ripple-marked stratum is paved in nearly every square inch with well-preserved fossils, consisting in far the greater part of *Leptaena sericea*. These are associated with *Rafinesquina alternata*, *Orthis occidentalis*, *Rhynchotrema capax*, and a very few other brachiopods.

Let it be understood all the time that the under surface of this layer is entirely flat. The upper, or rippled surface, is very smooth and shows almost no fossils in form to be identified, but only small fragmental and finely comminuted shells very firmly compacted. This triturated and very compact character of the rippled surface is not confined to the surface, but extends to a slight depth, gradually shading into coarser shell fragments.

The first layer below the stratum bearing the ripples contains substantially the same fossils, with possibly a still larger proportion of *Leptaena sericea*, and an occasional specimen of each of the following, viz.: *Zygospira modesta, Orthis testudinaria*, and *Crania scabiosa*. This layer indicates a somewhat agitated condition of the water in which it was deposited.

Above the layer of tough, pasty blue clay which covers the rippled surface, lies a consolidated layer consisting of whole and fragmental fossils cemented by hardened clay. The shells and fragments are, so far as examined, pitched at all angles and crowded together in a way to indicate an agitated condition of the waters during their deposition. There appear to be few, if any, species in this upper layer different from those already named.

We conclude that the undulations referred to in this paper are ripple marks for the following reasons:

1. The axes of the series in general are parallel, yet with some variation in direction and continuity such as is seen in ripple marks formed on sandy bottoms now.

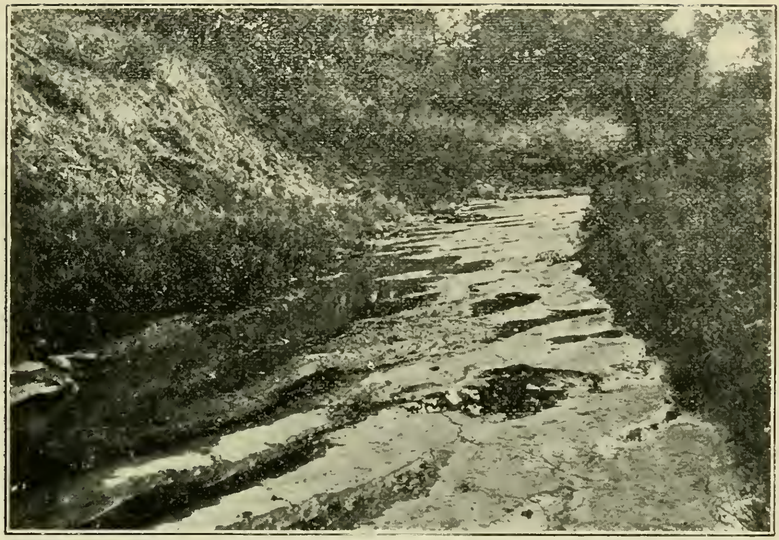
2. The crests of the entire series are spaced with approximate uniformity; that is, there is no increase or decrease in distance from crest to crest in passing from one edge to the other of the exposed area, which might be the case if the undulations were beach marks.

3. The fragments composing the surface of this stratum are much finer than those found in the bottom, and finer than most of the fragments in the strata lying above and below.

4. The arrangement of fragments in the strata lying next above and next below give evidence of considerable agitation of the water at the time those strata were being deposited.

The accompanying plates show the appearance of the ripple marks. Plate I. is from a photograph, up-stream view; Plate II., the down-stream view; Plate III., a small portion of bed of stream, looking downwards from the high right bank of stream.

PLATE I.

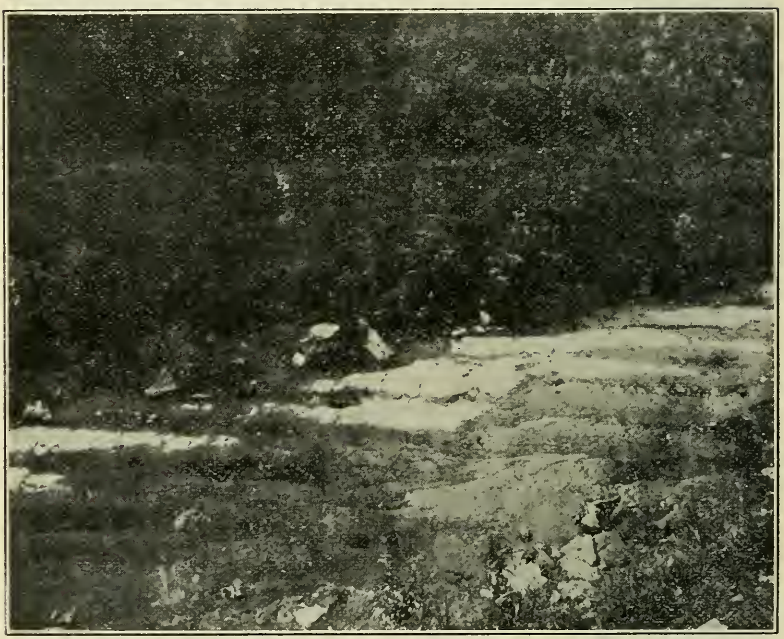


Ripple Marks—Up-stream View.

PLATE II.

Ripple Marks--Down-stream View.

Plate III.



Ripple Marks—View from Right Bank.

Note on the Variation of the Spires in Seminula argentia (Shepard) Hall.

J. W. Beede.

[Abstract.]

Owing to the systematic importance and the rarity of good material of the brachial framework of the brachiopods, any light on the extent of individual variation of these parts is of considerable importance. In examining several specimens of *Seminula argentia* (shepard) Hall, which show the position and form of the spiralia, some remarkable results were obtained.

Both valves of this species are quite convex, old specimens always being very ventricose. However, the species is very variable in form. Four of the thirteen specimens were somewhat compressed, but it so happens that three of these approach the normal type very closely, while the fourth does not vary from it greatly. Those showing greatest variation have not been subject to any visible external deformation.

The normal position of the spire is with the apex pointing to the side, near the margins of the valves, at or a little in front of the middle of the shell, which is also its widest part. In the central part of the cavity of the shell the edges of the spire nearly or quite meet. Anteriorly they flare apart leaving a subcircular opening. For convenience in this paper this opening will be referred to as the frontal aperture of the spiralia.

A specimen from the Topeka limestone, Upper Coal Measures, shows the spires with the apex of one of them pointing almost directly forward toward the anterior end of the shell, turned through an angle of about 90 degrees from its normal position; while, as nearly as can be determined from the ground specimen, the apex of the other is directed toward the median line of the pedicle valve just in front of the hinge. This specimen was selected and ground nearly to the center because it was one of typical form and perfect exteriorly. The remaining specimens are all from one horizon in the Permian of Cowley County, Kansas. One of these has the spire turned through an angle of 45 degrees or more in a vertical direction (when held brachial valve up and hinge away from observer) pointing near the middle of the right side of the brachial valve, while the opposite spire points toward the middle of the opposite side of the pedicle valve. Another specimen from the same locality is intermediate between this and the normal form. There are other specimens showing a similar variation and several are normal. The frontal aperture varies from subcircular to a mere slit.

The form of the spire varies from a fairly well-developed spiral cone with flaring base and acute apex to a form approximating a disk with very obtuse apex. The most disk-like form observed belongs to a shell less ventricose than the average and the spire is turned from the normal position. The number of whorls in the spires seems to vary slightly, though the material at hand does not admit of certain determination in this respect. Unfortunately the crural attachments of the spires are not shown in any of the specimens. However they must have been somewhat modified to accommodate the twisted position of the spires, unless, in the specimens examined, the spires which are abnormal had broken loose in the shell prior to fossilization, which I believe is improbable.

The above variations, except in the case cited, do not seem to accompany any particular form of shell. There is nothing visible in the specimens to show the cause of their abnormality.

It is dangerous to generalize much on the observations based on a single species. All that I suggest is that the foregoing seems to indicate that in those spire-bearing brachiopods, particularly the Athyridae, where the form of the shell does not govern the form and position of the spire, i. e., those which approach a spherical form, the spiralia may be subject to a considerable variation both as to the form of the spire and its position.

Topography and Geography of Bean Blossom Valley, Monroe County, Indiana.

V. F. Marsters.

In Monroe County, Indiana, and others lying to the southwest (Owen, Greene, Martin, Dubois, Pike and Gibson) occur a number of preglacial river valleys the present topography and content of which unmistakably suggest the existence of a temporary period of laking. Inasmuch as the attenuated edge of the Illinoian till plain passes diagonally through the above counties and crosses the mouths of many of the southern tributaries to the west branch of White River, which present evidence of arrested drainage near the limit of the till plain, it seems probable that the laking was consequently connected with the glaciation of the immediate region.

In Monograph XXXVIII, U. S. G. S., Mr. Frank Leverett has mapped and given a brief description of the probable preglacial drainage, the areal extent of the laking and the final adjustment of the postglacial drainage within the counties mentioned above. For the discovery of a few of the cases described, Leverett is indebted to Mr. C. E. Siebenthal, who furnished much of the data relative to the laked valleys found in Monroe and Owen counties. Mr. Siebenthal has also referred to this same topic in a paper published in the annual reports of the Indiana State Geological Survey. It is to one of these cases that I wish to devote the main part of the description and discussion presented in this paper.

Bean Blossom River takes its rise in the northern tier of townships in Brown County, flows a little south of west to Monroe County, reaching the northwest corner of Bloomington Township, where it turns rather sharply and continues in a due northwest course to the White River, into which it empties at a point about one mile below Gosport, Owen County. The topographic features of this rather picturesque valley, which are regarded as giving the key to its geographic history, are, briefly, these: First—The steepness of the valley sides and its persistence in close contact with the valley floor, together with its peculiar variations in direction. Second—The predominance of a broad flat floor, sometimes a mile or more in width, now occupied by a small meandering stream which for the greater part of its course insists upon keeping to the south or southwest side or edge of the valley floor. Third—The occurrence of both isolated and attached hummocks and ridges, the former usually located near the middle of the valley floor, the latter standing in rather close proximity to the valley slope. The rock content of these striking bits of relief is precisely the same as that which composes the upland on either side of the valley, namely, the subcarboniferous limestone and underlying sandstone locally known as the "knobstone." Fourth—The occurrence of a series of benches or so-called terraces rimming the valley slopes at various points and ranging in height above the valley floor from thirty to seventy feet. These consist of mixtures of sandy material and clay which have been derived from the rock formations as appear on the surface of the upland. Fifth—The development of V-shaped valleys just scarring the valley sloped to the present valley floor and not extending beneath it.

In attempting to unravel the geographic history of a river valley whose drainage has been subject to arrest by the invasion of an ice sheet, we find that the story of its life resolves itself into three fundamental parts.

First, what were the topographic characteristics of the valley before the laking stage; in other words, what was its preglacial history. Second, what happened to the valley during the laking stage, its glacial history. Third, what has happened since the disappearance of the lake, its post-glacial history.

DESCRIPTION OF TOPOGRAPHIC FEATURES.

Valley Slopes. While the average slope of the valley side is somewhere between twenty-five and thirty degrees, it very rarely falls as low as fifteen and in many places attains a slope as high as forty degrees. The variation in the slope bears a direct relation to the minuteness of dissection, or the spacing of the streams crossing it. Observation bears out the conclusion that the closer the streams to each other, the more subdued the slope. For a number of stretches along the valley sides very few streams crossed them, and there the slope was invariably found to assume the steepest angle. Moreover, the trend of the slopes appear to have a peculiar and persistent variation in direction, considered with reference to the general direction of the valley. It is believed that these features afford certain criteria by which something of the early history of Bean Blossom may be determined.

Valley Floor. The greater part of the valley is remarkably smooth and flat. There is, however, some systematic variation from an absolute plain. If we should construct a cross-section of the relief of the valley, especially in the central or upper parts, we should find that its systematic departures from a plain are such as to suggest that such aggrading as occurred in the valley was governed to a very large degree, at least on the present surface, by fluviatile agencies and not to the promiscuous distribution of sediments over its bottom during a period of laking.

It should also be noted that the present river channel throughout a large part of its course persists in keeping to the south and west side of the valley floor. Only at a few points within the limits of Monroe County do we find that the present Bean Blossom succeeds in meandering across the entire width of the valley floor. In other words, this river is not appropriate to and does not fit the broad valley which it now occupies.

The monotonous plain of the valley is broken at various places within the limits of Monroe County by the projection of conical hills and elongate ridges through its floor. In nearly all the cases examined in detail it was found that they were made up of the same rock as compose the uplands, sheeted over with a thin soil, and not of the same sort of incoherent mass of silts, clay, etc., constituting the valley floor.

The slopes vary between twenty and forty degrees and usually maintain a sharp angle with the valley floor as did the valley sides. They vary in size and shape from conical hills with almost circular bases one or two hundred feet in diameter, to ridges a half mile long, one to four hundred yards in width. Their tops fall a little short of the general level of the upland. They invariably lie either with their longer axis parallel to the trend of the valley or with their outer ends pointing diagonally across and down stream. In the latter case the trend of their slopes bears some linear arrangement and relation to the valley slope adjacent to it.

These elevations or "islands," when isolated, stand out well towards the middle of the valley; when, however, they happen to approach the valley slope, they are usually *attached* to the valley slope. Their nearness or remoteness to the valley slope determines the comparative elevation of the connecting part or extension of the valley slope to the outstanding bit of relief, or "island."

Terraces or Benches. Rimming the valley slopes are to be found a number of benches of variable widths, with surfaces sometimes as flat as a floor or with an exceedingly gentle decline valley-ward, with outer edges lobate in shape and descending with a marked angle to the level of the valley floor. These occur at various points within the limits of Monroe County, invariably situated on the north and east side of the valley, and varying in elevation from twenty feet in the lower part of the stream to seventy or more feet in the upper part of the valley near the east line of Monroe County. In all the cases examined they were found to be composed of mixtures of clay and sand undoubtedly derived from the disintegrated rock formations constituting the surface of the uplands. No glacial debris of any sort was found either on the surface or in any of the sections or cuts in the benches noted within the limits of Monroe County.

PREGLACIAL HISTORY OF BEAN BLOSSOM.

Inasmuch as the greater part of the clay and silt occupying the valley floor is precisely the same in kind as that covering the unglaciated uplands and valley slopes, it is evident that this filling simply represents the wash and soil-creep from the slopes and uplands on either side. Moreover, the rate of filling was so far in excess of the ability of the stream to carry off its load that the preglacial valley became clogged with the waste to such a degree that the stream now occupying the valley floor is for much of its course quite unable to spread its meanders over the entire width; only at the narrowest sections does Bean Blossom succeed in occupying the entire valley from slope to slope, as seen in sketch map No. I.

Sketch Map No. I. Section 9, Bean Blossom Township.

Inasmuch as the filling of Bean Blossom at its mouth and for some little distance up stream is covered over by a patchy film of glacial sand associated with boulders, composed partly of crystalline rocks, the underlying clays, silts, etc., antedate the glacial coating. Moreover, the occurrence of benches (to be associated with the glacial history) resting upon the valley filling also point to the same conclusion, that the present filling of the valley, less the benches and the glacial sands, etc., near the mouth of the valley, is preglacial.

The question then arises, what was the topographic expression of Bean Blossom before it was aggraded. There are a number of observations which throw some light on its early history, but much more data should be gathered over the adjacent area before a detailed analysis can be given.

That the preglacial Bean Blossom valley *was very much* narrower than the present one, is attested to by the occurrences of various knobs and remnants of ridges protruding through the aggraded floor. Some of these are subcentrally located, suggesting that the prefilled valley must have been confined between the slopes of the half-covered ridges and the opposite valley slope, thus decreasing the average width of the pre-filled valley by nearly one-half its present cross-section within the limits of Bloomington and Bean Blossom Townships, Monroe County.

There are also certain features which suggest that Bean Blossom must have been at grade at a time antedating the completion of the filling of the preglacial valley.

At a number of points within the limits of Monroe County are to be found curved valley sides extending for a half mile or more, with steep slope, making an angle with the valley floor of thirty-five to forty degrees. Such regularly curved slopes and at such steep angles at once suggest a *meander-cut* slope.

Moreover, there is no evidence that these slopes have been cut by a meandering stream on the *present floor*. We must conclude, then, that they antedate the present surface of the valley floor, and if meander-cut in origin, as the topographic relief very strongly suggests, Bean Blossom must have been at grade before the present filling, at least completed, because a meandering habit is not begun until the stream has already finished its vertical cutting, or, in other words, has cut down the slope of its channel to such a gentle descent that it could not be lessened. Then it was that Bean Blossom must have begun its side cutting and carved the curved slopes, only remnants of which are now seen projecting above the level of the *present* valley floor.

Another set of facts also points toward the conclusion that the preglacial Bean Blossom had reached grade and become a mature stream long before the laking or the completion of preglacial filling of the valley.

A small tributary (Jack's Defeat) running northeast from Steinsville presents some features evidently of interest in connection with the geographical history of Bean Blossom. This stream, now rather diminutive, runs upon a flat floor, and hence at grade. The topography, however, of the valley slopes reveals incised meanders. The present slopes are steep and sharp cuspate points now project into the valley on either side. Such only could have been produced by a stream that had at some time reached grade after the incision of its meander. The crests of the meander-cut slopes now stand some 80 to 100 feet above the valley floor. If this view be correct, it would seem altogether probable that the main stream, Bean Blossom, inasmuch as both flow over the same kind of rocks with the same structure and texture, had also passed through the same stages as did its tributary.

But so deeply has the valley been filled after grade was reached that such meander-cut slopes as were developed have been largely buried beneath the present filling. Either, then, Bean was early at grade and widened its valley by meandering, or after it came to grade was compelled to incise its meanders, nearly all of which have been subsequently buried beneath its present valley floor.

Moreover, so deeply has Bean Blossom been aggraded that many of the tributary valleys are also aggraded for some distance up stream. This wholesale filling would necessarily force the slopes to rapidly retreat at the junction of the tributary with the main stream, so that, as a result, the trend of the valley sides would assume a systematic angularity. The consequent narrowing and broadening is well exhibited in the lower ten miles of Bean Blossom.

LOST RIDGES AS EVIDENCE OF AGGRADING.

It is evident, should a valley be refilled, in part, with waste from the uplands, that any relief left between its valley slopes, as well as the dissected slopes included, would lose relief in proportion to the amount of filling brought into the valley. In such a case we should expect to find many successive stages of burial of the dissected slopes, according as they were near or remote from the center of the prefilled valley. Many of these stages are well shown in the lower portion of Bean Blossom.

In the middle of Bean Blossom valley occur a number of illustrations in which the inter-stream spaces of moderate relief have been so deeply buried that the uppermost portion of the same now stands above the valley floor, as isolated ridges or "islands," with very steep side slopes, extending to and beneath the present floor of the valley. These are locally spoken of as "lost ridges," a term quite appropriate to their geographical history. Such islands are shown in a number of sketch maps. In sketch map I a small subcircular knob (Section 5, Bean Blossom Township) stands in line with a point standing between White River on the left and Bean Blossom on the right. Its position suggests that it is the *buried* end of this point (see Plate No. 1).

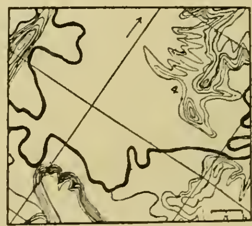
About one mile up the valley is another elongate ridge about one-third of a mile in length, some three or four hundred yards in width and with an elevation of some eighty feet above the valley floor. This is found in section 9, Bean Blossom Township, and illustrated in sketch Map No. I, and by the photograph plate II. The same topographic feature is again duplicated in section 24, Bean Blossom Township. This illustration is locally known as Lost Ridge. This case is not so centrally located as the former one, but lies close to the east side of valley—but still separated from it by a hundred yards or more of flat floor. As in other cases, the trend of its slopes and that of the adjacent valley slope shows such an alignment as to strongly suggest attachment beneath the present valley floor. See sketch map No. II. Photograph plate III gives some idea of

Sketch Map No. II. Section 24. Bean Blossom Township.

steep slopes, presented by an end view of the Ridge. Other cases of the same thing might be enumerated, but the above are sufficient to show the type of relief consequent upon the more complete stages of burial of the spurs near the central part of the preglacial valley.

As a further test of partially aggraded valley, we should also expect to find as additional criteria, spurs of variable relief but attached to the valley slopes by narrow necks, still above the present level of the valley floor. Moreover, various stages of the tied-on knob or ridge ought to be in evidence if the present width of Bean Blossom is due to aggrading. Such additional stages are fairly well shown in contour sketch map No. I, where three small cases of attached knobs may be seen. A still better case is shown in the pen sketch, which occurs in section 32, Washington Township. A photograph of one, the south knob, is shown in Plate IV. Variation in the widths and elevation of the necks connecting the partially buried spur is well illustrated in the sketch.

In map No. III, section 4, Bloomington Township, is shown another illustration of special interest. This occurs at the rather abrupt turn of Bean Blossom Valley, on the northeast side, where the upland forms a point projecting into the valley. The point shows the same sort of topography (see Plate No. V) as noted in other cases—the rounded tops, increasingly steep slopes, descending to the valley floor, and the neck connecting it with the upland on the north. This case attains additional interest, as just to the west and opposite the gap or sag between the knob and the upland, is a bench varying in elevation above the valley floor from twenty to forty feet, and flanking the slopes of the projecting headland and spur. The geographical significance of the benches will be observed in another part of the paper.



Sketch Map No. III. Section 4, Bloomington Township.

In the center of the valley floor and just opposite (or to the south of) the last named spur, and also up stream for some two and one-half miles, still more evidence of valley filling is apparent. To the southeast of the point occurs a rather subdued ridge, somewhat irregular in relief, extending up stream for three-quarters of a mile, or thereabouts. A portion of this is shown in sketch map No. III. Bean Blossom flows close to its northern edge. On the south side of the elevation flows Muddy Fork Creek from the southeast, and reaches Bean Blossom some distance beyond its west end. So full has Bean Blossom, and its tributaries, as well, been filled with waste that the aggraded floor of both valleys have for some distance up the respective streams from their junction merged into *one* broad flat floor.

Plate I.

Plate III.

Plate IV.

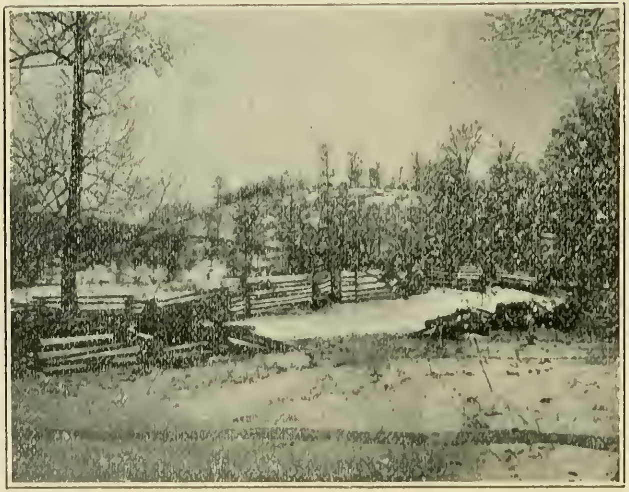


Plate V.

Plate VI.

There is still another case of the same thing in section 3, Bloomington Township, which touches the almost covered spur last mentioned on the east and extends to Dolan, east side of section 3. The little village of Dolan lies in the gap, or sag, between the knob and the spur of upland separating Bean from Muddy Fork. Had the valley floors of these respective streams been aggraded some twenty-five feet above their present level, the attached spur would have passed into the "island" type, as the floors of the two valleys would in that case have been confluent.

Additional illustrations might be appended, but the above series is sufficient to bring out the variations in topographic relief which furnish a key to this particular stage in the history of the valley.

In a word, then, we may say these various phases of topographic relief are not confined to a limited part of the valley within Monroe County, but are prominent features throughout its entire course. Moreover, they exist as inevitable consequences resulting from processes of aggrading and hence may be used as legitimate and trustworthy criteria by which to determine a part of the life history of the respective valley.

GLACIAL HISTORY OF BEAN BLOSSOM.

That Bean Blossom and the adjoining uplands near its mouth have been occupied by an ice sheet is attested to by a series of observations. The occurrence of glacial boulders, gravel and fine sand near the mouth (section 9, Bean Blossom Township) and patches of sand with occasional boulders as far up stream as section 24, near Lost Ridge, warrant this conclusion. From section 24 Mr. C. E. Siebenthal has traced the edge of the till plain to the northeast, it being found to follow along the line of Indian Creek, and passing out of Monroe at Godsey into Morgan County, but returning again to Monroe some two miles east, where Hacker's Creek crosses the north line. From this point to the southeast the edge of the till is exceedingly difficult to trace. Patches of sand and gravel, however, occur in the head waters of some of the northern tributaries to Bean Blossom, in northeastern Monroe and Brown counties. Furthermore, glacial gravel and pebbles are known to occur within the limits of Bean Blossom itself, not far from the east line of Monroe; but whether this was ice or water-laid has not been determined. Enough facts, however, are at hand to show that the heads of northern tributaries of Bean must have

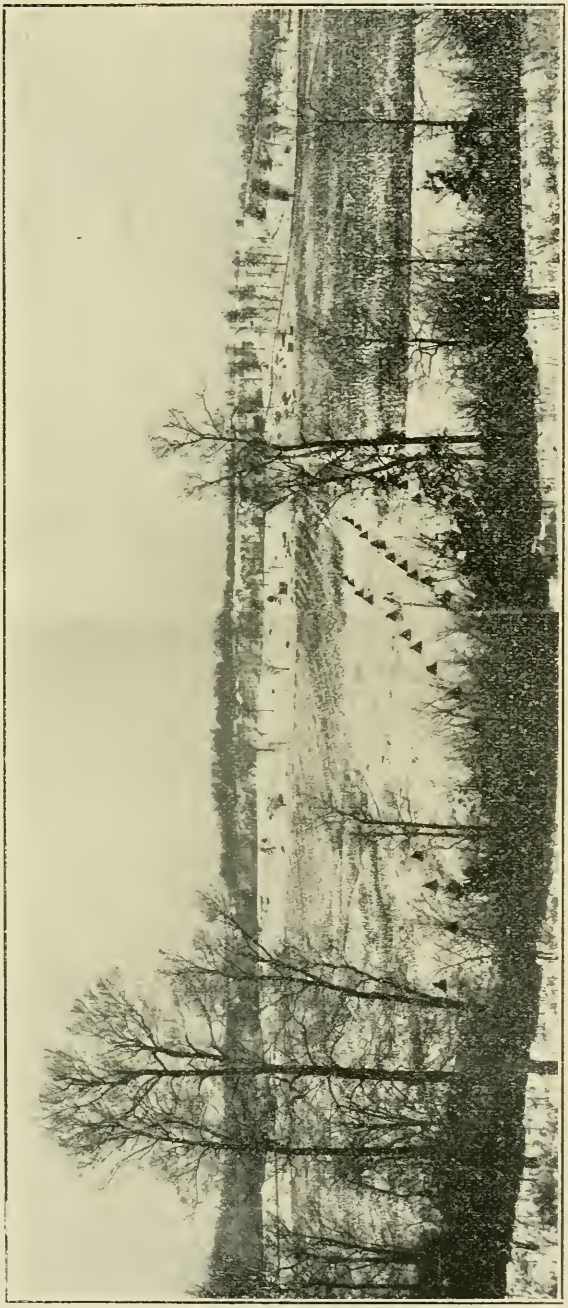


Plate II.

been invaded by the ice sheet, and at the same time the drainage was held up by the interference of the ice sheet at the mouth of Bean Blossom.

The evidence of the arrest of drainage at the time of ice invasion is found in the occurrence of a series of benches, inaptly termed terraces by some writers, rimming the eastern and northern slope of the valley at various points within the limit of Monroe County and are reported to occur with increased frequency in Brown.

In all the sections and cuts found in the benches, only clay and sandy materials appeared. No limestone and sandstone exposures, such as make up the valley slopes, were found in the benches; their contents are undoubtedly made up of the wash and soil-creep brought into the valley from the uplands, the clay portion being derived from the decomposed limestone and the sand constituency from the underlying knob stone.

The benches vary much both in form, areal extent and elevation above the valley floor. They are invariably attached to the slope, and exhibit in most instances a remarkably flat or sometimes gently sloping surface towards the outer edge. The outer rim is usually lobate in form, with narrow, young valleys extending towards the rock slopes, and sometimes, so far, as to traverse the entire width of the bench. The slope of the outer edge is usually steep and well defined. In some cases the tops of the benches are slightly undulating or rolling. Those, however, seldom attain the elevation of the flat-topped ones. In Marion and Washington Townships they may be traced continuously for three or more miles, and attain a width of something over half a mile. They also vary much in elevation above the valley floor, attaining a maximum height in Marion Township, sections 19 and 20, of seventy or more feet, and decreasing gradually down stream, until in section 32, Washington, they are found to be some twenty-five to thirty feet above the valley floor.

That these benches must have been deposited in water is attested to by various criteria. The flat tops, steep angle on the front, and stratification show that they are delta-like accumulations brought in during the arrest of the drainage and not terraces in technical sense, although they appear very much like the latter so far as form is concerned.

The various elevations attained in different parts of the valley may be due to different levels at which the laked valley stood during the laking period, or it may be accounted for in part, at least, to the larger contribution of residual materials from uplands to the upper part of the valley by the northern tributaries, than by similar streams emptying into Bean

Blossom nearer its mouth, so that only in the upper part were the benches built up to the highest level, while in the lower part the amount contributed was insufficient to bring them up to similar altitudes.

If the laked Bean Blossom stood at different levels during the laking stage, we should expect to find somewhere in the valley a lower lying bench corresponding in elevation to the successive lake levels and adjacent to the higher bench. Nothing of this sort was found. I am therefore inclined to attach more importance to the former interpretation, namely, that irregularity of height above the valley floor is largely due to the variation in amount of the residual material brought into the valley. The tributaries bringing the least amount of material constructed the smaller and lower benches.

Another interesting feature is associated with two of the largest northern tributaries to Bean Blossom, namely, Buck and Wolf creeks. Beside the portion of each creek, wriggling across the valley bottom, are rather long and narrow strips or delta-like accumulations similar in content to the benches already described, and extending from the valley slope to within a few yards of the Bean Blossom channel which hugs the south slope of its valley. The surface does not attain the characteristic flatness of the rimming benches, but is slightly irregular in relief and increasingly so towards the slope to which it is attached. This is especially true for the Buck Creek case, but not for the Wolf Creek. The increasing irregularity may be in part due to the nearly complete burial of a projecting spur, whose top is barely coated over with the delta deposits now spread almost across the entire width of Bean Blossom; but it must be said that no outcrops of limestone or sandstone, such as make the slopes of the valley, have been discovered within its limits. On the other hand, the irregularity of relief may have been produced by the piling up of the great load of silt within Bean Blossom by the tributary, but did not succeed in building it up to the lake level; in other words, it is an incomplete delta, or bar.

The Wolf Creek case differs from the former only in having a moderately flat top, or at least the higher flats on it attain about the same level, thus suggesting that it was built up nearer to water level, and hence more even and uniform in relief. These differ from the rimming benches only in that they *extend across the valley floor*, while the former, being made by smaller streams close to each other, have built a series of small benches or deltas which have become confluent, and hence continuous *along the valley side*.

The pen sketch plate No. 1 gives some idea of the appearance of one of these benches (see pen sketch section 32, Washington Township). Plate VI shows beyond the trees a side view of one of the spur-like extensions of a bench occurring in section 4, Bloomington Township. (See contour map No. III, which also shows position of the partly buried headland.)

No. 1. Pen Sketch of Attached Spurs and Benches. Section 32, Washington Township.

Post-glacial History. Since the close of the laking stage Bean Blossom River has developed a meandering course on its broad floor. Only in the narrowest sections of the valley has it succeeded in spreading its meander belt across the entire floor. For the most part it keeps to the west or south side of the valley, and yet still assumes a meandering habit for considerable stretches. In other words, the stream does not fit the *present* dimensions of the broad valley, which accordingly must have been brought about by other conditions than that resulting from lateral cutting, by a mature stream. Cross sections of the valley at its broadest places reveal a slight curvature of surface in the center and occasional abandoned meandering channels. This slight variation from a plain surface suggests flood plain construction. Whether this constructive work antedates the glacial episode of Bean Blossom is not certain, but it would seem from the data at hand, that the present post-glacial Bean Blossom has not had time or the ability to do much constructive work since pleistocene time.

Young Valleys. Traversing the steepest slopes of Bean Blossom, are to be found numerous V-shaped valleys, with remarkably steep channels, ending their lower course at the point of intersection of the valley floor with the adjacent slope. In all cases small alluvial fans are built on the valley floor with their apex projecting but a few feet or yards at most beyond the mouths of the young valleys. In none of the observed cases was it found that the level of the valley floor would extend into the mouth of the young valley. It is therefore believed that the greater part of the cutting of these young valleys may date subsequent to the preglacial filling. The fact that alluvial fans and not deltas with steep outer edges and flat tops occur at their mouths, suggest that they have been constructed since the laking of the valley, and hence are regarded post-glacial.

Note. For a portion of the data used in the preparation of the contour maps, the author begs to acknowledge the assistance of Mr. E. R. Cumings and Mr. J. W. Beede, Instructors, Department of Geology, Indiana University, and Mr. J. W. Frazier, student, Indiana University.

Wabash River Terraces in Tippecanoe County, Indiana.

William A. McBeth.

General Description.—The Wabash Valley, in Tippecanoe County, Indiana, embraces an area of about eighty square miles. Its average width is about three miles. It is much wider below LaFayette than above, and it is less wide at that place than elsewhere within the county below the mouth of Tippecanoe River. The width of this valley above the city averages at least two miles, while below it is not less than four.

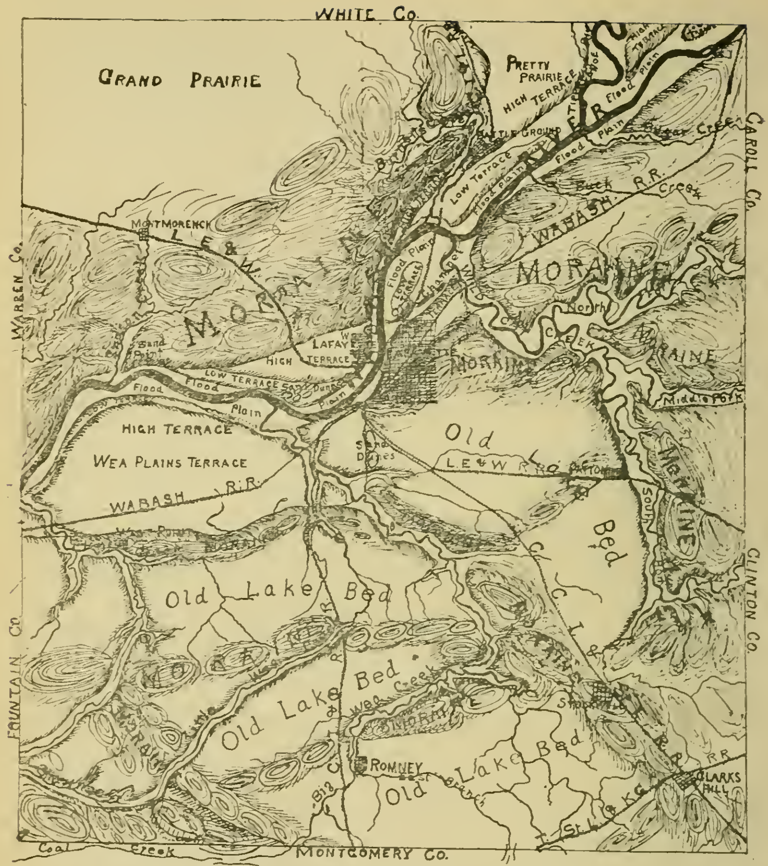
The valley comprises a broad, shallow trench, cut by a deeper and narrower trench, into the bottom of which is carved the river channel.

The general surface is about seven hundred feet above sea-level, and the bottom of the river channel is about two hundred feet below this. The inner valley or flood-plain tract averages about one mile in width and along this rise the terrace fronts from one hundred to one hundred and fifty feet above the stream. The inner valley is quite uniform in width throughout the county, but the terrace areas are much more conspicuous below LaFayette than above.

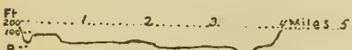
The outer valley is quite straight compared with the inner valley, which meanders from side to side, while the river crossing from side to side of this flood-plain meanders most.

The Terraces.—The terraces begin a few miles below Delphi, on the west side of the river, an island in the Deer Creek Prairie flood-plain comprising the farthest up-stream area so far observed.

The point between the Tippecanoe and the Wabash, where it rises above the flood-plain near the junction, is of this formation. Below the mouth of the Tippecanoe the terraces become conspicuous. On the west side of the stream the region called Pretty Prairie descends gently from the Grand Prairie and terminates in a bluff front which runs parallel with the Wabash at an average distance of a mile from it.



A MAP OF TIPPECANOE COUNTY, INDIANA.
To Show Terraces, Flood-plains, Moraines & Drainage.
Scale 1 2 3 4 5 Mi. By W. A. McBeth.



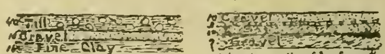
Cross profile at Battle Ground

Cross profile at mouth of Indian Creek

Cross profile at Lafayette

Cross profile at Independence.

Cross section at Lafayette. (Ideal.



Near Pyrmont 3½ mi. South of Lafayette
Sections showing interstratification

This is of terrace structure to an unknown distance back from the river and is not limited on the west by a perceptible bluff. At Battle Ground the level of the prairie is continued south to the point where the river swings across the valley against the foot of the west bluff. This part of the high terrace is nowhere more than one-fourth of a mile wide. The Tippecanoe battle field occupies its entire width of a few rods between the lower terrace on the east and the valley of Burnett's Creek, which separates it from a high bluff on the west.

The low terrace just mentioned averages about one mile in width and its border along the flood-plain takes the form of a distinct ridge, apparently a sand-bar, higher than the general surface of the terrace. This surface is ten to fifteen feet above the flood-plain.

Below the westward bend of the river the flood-plain occupies the full width of the valley separating the terrace tracts below from those above. This flood-plain surrounds a detached section of low terrace which evidently was cut off from that on which LaFayette stands by a former course of the river. This channel was later the lower course of the Wild Cat Creek and still contains a chain of ponds. The creek was by some means deflected and now joins the river several miles farther up stream than formerly.

The LaFayette terrace slopes gently from flood-plain level back one mile to the bluffs. It corresponds in elevation to the detached area in the flood-plain and the low terrace above the bend. It is about four miles long and is slightly higher at the upper end than at the lower.

The West LaFayette terrace is two miles wide in its greatest width and eight miles long. Opposite LaFayette it presents a bold bluff to the river and lies at an elevation of one hundred and twenty to one hundred and fifty feet above it. Two miles below a low terrace begins and extends between the higher terrace and the flood-plain nearly to the mouth of Indian Creek.

The most extensive area is the beautiful region embracing the Wea Plains, southwest of LaFayette. This great terrace begins just below the city and extends ten miles to the west line of the county. Its width averages at least four miles. Its height agrees with that of the West LaFayette terrace, the narrow strip between lower Burnett's Creek and the bluffs and Pretty Prairie. This correspondence in elevation seems to indicate a former continuous surface of these terraces throughout the valley at a height of one hundred to one hundred and fifty feet above the present river channel.

The Pre-glacial Valley.—As the stream flows on a valley floor of rock at Delphi, eighteen miles above LaFayette, and again at Black Rock, at the west line of the county, fourteen miles below, the nature of the intervening depression, its shape, direction and extent have been and are still matters of interesting speculation. It is probably a section of the valley of the pre-glacial Wabash. This valley bottom is sixty or eighty feet above the bottom of the filled valley at Terre Haute and the two sections possibly are connected by a buried valley somewhere near the present stream line.

There are signs that its former course was north of its present course from the west line of Tippecanoe County into the immense pre-glacial valley of Kickapoo Creek, opening into the Wabash Valley at Attica. Cates' Pond, a traditionally bottomless kettle hole pond or lake, about two miles northwest of Independence, Warren County, is a good link in the evidence of such a former course.

The abrupt drop of two hundred feet from the valley bottom at Delphi to the rock floor beneath LaFayette indicates that the part of the stream above Delphi is not in the old valley. The north fork of Wild Cat Creek perhaps more nearly represents the pre-glacial drainage line. The little creeks between this creek and the Wabash show rock in their channels, while Wild Cat does not cut down to bed-rock at any place in Tippecanoe County, so far as I know, although its valley is one hundred feet or more in depth as far up as the county line.

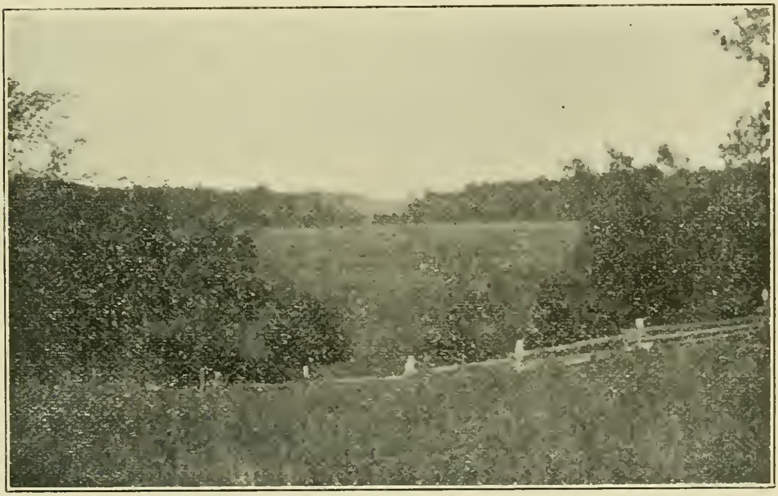
Rock outcrops in the bed of Indian Creek near Porter's Station, in the bed of Little Wea Creek at the Monon Railway crossing and along Flint Creek for four or five miles above its mouth.

Borings are few and not many are deep. A well driven forty or fifty feet below the bed of the Big Wea Creek, where it is crossed by the moraine about five miles south of LaFayette, passed through gravel hardpan and into quicksand, producing a constant flow of water.

Materials and Structure of the Terraces.—The terraces and the whole valley region are composed of sand, gravel and bowlders with interposed beds of clay. The whole deposit is of great depth, in places as much as three hundred or four hundred feet. The channel of the river at LaFayette is two hundred feet below the general surface of the county and one hundred and fifty feet above the bed-rock, giving total depth of three hundred and fifty feet of deposits.

The material is bedded in layers that lie at a high angle, such as is seen in delta structure; the dip is in a general direction down stream. Ample opportunities for observation occur in gravel pits and stream sections.

The streets in West LaFayette are improved by opening pits in the street lines and afterward filling them with the top-soil and graveling over them. These excavations uniformly show steeply inclined beds. The railroad cuts through the terraces on both sides of the river show this structure. The valley of the Wea through the gravel deposits shows the same thing. In the Wea Valley a layer of conglomerate is a conspicuous



Cates' Pond, a kettle hole two miles northwest of Independence, Ind.

feature, dipping toward the creek on the north side and from it on the south side.

The conglomerate stratum is formed of the sand and gravel of the deposit cemented with carbonate of lime. It lies apparently at a uniform horizon and is of uniform thickness. The cement is so abundant in some places as to fill completely the interstices in the mass of sand and gravel. Indeed, a block left in a yard fronting on State Street in West LaFayette has its upper flat surface completely covered with a layer of pure carbonate of lime a half inch thick.

An interesting feature of these deposits is the occurrence of beds of bowlder clay interstratified with the sand and gravel. This is noticeable more particularly about the east end of the Wea Plains along ravines opening into the Big Wea Creek. An exposure 3.5 miles south of LaFayette shows a deep layer of false bedded fine sand overlaid by three feet of very dense till, above which is ten feet of sand and gravel. This interstratification of materials appears even more strongly marked along the Wild Cat Creeks. At the bridge across South Fork near Monitor are two beds of clay differing in color and overlaid by twenty feet of sand and gravel. Near Pyrmont, on the north fork, ten feet of dark alluvial clay appears above the waters of the creek, above this ten feet of coarse gravel, and above this forty feet of gray bowlder clay.

Allied Topography.—The topography of the county about the border of the terrace deposits is interesting and suggestive. A moraine ridge containing much gravel, some of it water laid, extends along the entire south side of the Wea Plains. A heavy moraine lies along the north side of the valley from Battle Ground south, bending away from the river just above West LaFayette. Stream sections in the mass of this moraine show compact till as deep as they extend. At the mouth of Indian Creek the upper hundred feet of the bluff is a layer of fine sand resembling the dune sand of Lake Michigan, and the sand ridges of northern Indiana. This may be the source of the sand built into the ridges and dunes a mile further up the valley. The bluffs back of LaFayette are of till and are possibly a section of the moraine west of the river extending east in the direction of Monitor.

Explanation.—An attempt at explanation would revert immediately to the glacial period. The great valley was obstructed somewhere to the west, probably in the region of the great bend, by an ice sheet moving east or south. This may have been a result of one of the earlier ice invasions. The obstructed valley forming a lake has been filled by the deltas of streams flowing into it. The high angle of the layers indicate this. The layers of till represent movements of the ice sheet over the delta plain. These may have been minor advances and recessions of the same ice sheet. The material has been assorted out of the drift sheet overlying the basins of the streams traversing the region. The lime cement in the conglomerate is easily explained as being derived from the Niagara limestone region lying immediately to the east.

The problems in detail are of such complexity that any attempt at explanation is made with extreme diffidence. There are good reasons for believing that the valley was over-ridden by ice from the east and also from the north at various times during the accumulation of the deposits. The sheets of till found at different depths in the terrace gravels indicate this. The moraine extending along the south side of the Wea Plains as far east as the Little Wea Creek is composed of hills and ridges of gravel, while farther east it becomes a ridge of till.

This may indicate that after the valley had been filled nearly to its present level the ice swept over it from the north, transporting the gravel from the valley and depositing it in the moraine.

The arrangement of the moraines on either side of the river at LaFayette, together with the narrowness of the valley at that point, may indicate that the front of the ice sheet lay across the valley while the moraines were deposited.

The terminal drainage may have spread gravel deposits over the surface of the Wea Plains much as the Yahtse River is building its delta below its outlet from the Malaspina Glacier in Alaska. This may have been a line of interlobate drainage between lobes from the Lake Erie and Lake Michigan basins, and much of the material may have been furnished by the slow, but long-continued creep of the glacier toward the stream line.

The height of the terraces was determined by the height of the rock surface crossed by the river between the west line of the county and Attica. The terraced arrangement is continued here, but the upper valley has been made by the removal of the drift from the surface of the rock, while the inner valley has been cut through the rock (mainly shales) since the gravel was deposited above. The excavation of the inner valley through Tippecanoe County proceeded as the channel through the rock sill below was cut down. The stream that did this work carried the waters of the melting sheet of ice as it retreated slowly to the north and east. Its width probably corresponded to that of the inner valley.

The Tippecanoe River and Wild Cat Creek were streams of great volume as the size of their valleys show, and this volume was doubtless maintained through a long period of time.

The sand dunes southwest of LaFayette along the eastern edge of the Wea Plains Terrace, those on the terrace edge on the north side of the river opposite the mouth of Wea Creek, and the deep deposit on the crest of the bluff above the mouth of Indian Creek were probably gathered and piled up from the surface of the Wea Plains by the southwest winds, while, after the recession of the ice, the surface remained bare.

History of the Wea Creek in Tippecanoe County, Indiana.

William A. McBeth.

The Wea Creek has two principal forks, known as Big Wea and Little Wea. These both rise near the south line of Tippecanoe County and flow roughly parallel with each other five or six miles apart, first to the northeast through nearly half their course, then bending to the northwest, they gradually approach each other and unite.

The course below the junction continues northwest to the Wabash. The Big Wea receives a tributary which joins the main stream near the elbow-like bend, coming from the southeast near the south line of the county.

These branches all rise in marshy meadows or prairies now generally drained. These marshy tracts are usually long, narrow sags or shallow valleys extending across the divide.

Streams flowing to the south and southwest rise near the heads of the Wea Creeks. In the map of Tippecanoe County, on page 238, it will be noticed that Shawnee Creek rises near the source of Little Wea Creek, Coal Creek near the head of Big Wea Creek and a tributary of Sugar Creek near the source of the east fork of Big Wea Creek.

The upper course of Little Wea Creek follows a valley with gently sloping sides twenty to thirty feet in depth and one-fourth of a mile wide. Just below where it is crossed by the Chicago, Indianapolis & Louisville Railroad, near its abrupt bend, this valley widens out and comes to an end. For two or three miles the creek flows through a flat prairie with a channel just large enough to carry its flood waters. This channel is forty or fifty feet wide and five or six feet deep. For two or three miles above its junction with the Big Wea Creek it again follows a valley of about the same width as its upper valley but having much steeper bluffs and a more level bottom.

The upper seven or eight miles of the Big Wea Creek flows in a channel three or four feet deep and ten to twenty feet wide, over the smooth, gent'y sloping prairie. Near Romney it flows from the smooth prairie into a valley one-fourth of a mile wide and twenty to thirty feet deep. The tributary from the southeast joining the Big Wea near its abrupt bend has its upper course without a notable valley, but enters one of considerable size near its mouth. After the main stream bends to the northwest, its valley within

Channel of Wea Creek, one mile south of Romney, Ind. The stream here flows through an old lake bed.

Valley of Wea Creek, one mile north of Romney, Ind. The stream has cut this part of it valley deep and drained the lake bed shown above.

a few miles becomes much shallower. The bluffs become low and for some distance on the east side entirely disappear at a wide gap opening into an extensive prairie to the east. Just below this the northeast bluff becomes considerably higher than the one on the opposite side of the stream. About two miles below a deep broad valley begins and continues to the Wabash flood-plain. The lower course of the Wea for several miles, is cut through the Wea Plains terrace and the Wea Valley itself is terraced. The levels of parts of the terrace farthest up stream conform apparently to the surface of the Wea Plains.

The peculiarities of valley and course noticed in these streams invite an attempt at explanation. This is found in the interpretation of the glacial features of the region.

By reference to the map it will be noticed that several moraines cross the county south of the Wabash River. The one forming the divide between the Wea system and the streams to the southwest extends southeastward across the southwest corner of the county. Another extends east along the south side of the Wea Plains terrace to a point nearly south of LaFayette, where it bends to the southeast and continues to the southeast corner of the county. Between these ridges others trend east and west. All the ridges together thus form a complex network. Enclosed by the ridges are tracts of level prairie formerly marshy over large areas but now generally drained.

The creeks cross these flat prairies, cut through some of the ridges and follow along the sides of others. The Wea streams are entirely post-glacial in their origin and history. Their channels are cut in the beds of glacial drift that overlies the country, the underlying bed-rock being reached and exposed for a distance of a few rods in only one place in all the Wea system. This is in the bed of Little Wea Creek where it enters the Wea Plains terrace.

The retreat of the ice sheet from this region uncovered the basin of the Wea Creeks before it did the present course of the Wabash River. It may be that melting of the ice between the Michigan and Erie lobes occurred across the course of the Wabash River and along the Tippecanoe River, while the Wabash, farther west, was still obstructed to a much later period. This caused the waters of the melting ice to gather along the front of the ice border until they covered the whole Wea basin and flowed out at the sags across the divide where the heads of the Wea Creeks are so near the heads of Shawnee, Coal and other creeks. This would have made a lake of all of southern Tippecanoe County. This lake would have been about one hundred and fifty feet deep at Dayton, in the east part of the county. Some of the moraines were entirely covered with water. The broad upper valley of Little Wea was probably made by a stream flowing in the opposite direction to that of the present stream from where it is crossed by the Chicago, Indianapolis & Louisville Railroad. Some part of the valley of the Big Wea below Romney may have been made by a stream afterward reversed. When the Wabash was uncovered the lake covering nearly the whole south part of the county fell to a much lower level and the general course of the present Wea streams was laid out. As the water fell the tops of the moraines appeared and the waters flowed across their crests at the lowest places. But the streams were not continuous as now. The region was nearly covered by several smaller lakes held in by bordering moraines and the streams connected the lakes and formed the outlet of the lowest. The deep valleys show the parts of the streams that flowed across the moraines from lake to lake. As the streams deepened their valleys, the lakes were gradually drained, leaving their smooth, muddy bottoms exposed to become the level marshy prairies found at the settlement of the country. As the lakes fell to lower and lower levels, the streams were extended across the lake beds, where they now meander in sluggish courses in narrow, shallow channels.

Paleontology of Bartholomew County, Indiana, Mammalian Fossils.

J. Jep. Edwards, M. D.

1. *Mastodon americanus* (Blum.).

   This animal is represented in this county by two specimens.

   a. *Os sacrum.*

      Weight of fossil, eight pounds and nine ounces. Found in 1898 upon a sand-bar in White River, one mile east of Wailesboro; identified by Dr. M. N. Elrod. It is in a fair state of preservation, with foramina and tuberosities well defined. In possession of the writer. A brief account of the find appeared in the *Indianapolis News* of January 15, 1901, and the Columbus (Ind.) *Daily Herald* of same date.

   b. Tooth. Found in Ohio Township, Bartholomew County, in 1900. Have been unable to see it.

2. *Elephus primigenius.*

The only known specimen found in the county was a tooth unearthed in a gravel pit one-half mile south of Wailesboro in 1898. It was covered with seven feet of soil and gravel. Weight, nine pounds. It was destroyed by fire in the office of Dr. Webster Peck, at Frankton, Indiana. Identified by the writer. See Columbus, Ind., *Home Advocate* of September 9, 1898.

3. *Cariacus americanus* (Harlan).

Extinct elk. Post pliocene fossil. The specimen is the *Os frontis* to which is attached the antler with two branches. Present length two feet, weight five pounds. When found it measured over seven feet in length and was then incomplete. By handling it has crumbled to its present length. Found in White River one mile east of Wailesboro. Identified by the writer. A meager description appeared in the *Columbus Herald* of January 15, 1901.

4. *Cervus virginianus.*

Virginia deer. Sub-fossil. Specimen is the right frontal appendage (antler). Found in Wayne Township in 1898. Identified by the writer.

Organic Acid Phosphides.

P. N. Evans.

Phosphorus in the organic phosphines shows such a perfect analogy to nitrogen in the amines, that it seems strange that we should not be familiar also with the phosphorus analogues of the acid amides—which we may appropriately call *phosphides.* Of this class of bodies no mention is made in most books on organic chemistry, and an examination of the literature shows only two of these substances to have been prepared and very superficially investigated, namely, mono- and tri-chlor-acetyl phosphides, dating back to the seventies.

With a view to preparing other representatives of this class and examining them, the methods used to make the acid amides were considered as to their applicability; the reaction between hydrogen phosphide (PH_3) and acid chlorides seemed to be the most promising by which to attempt to prepare new acid phosphides.

Preliminary experiments were made several years ago with some of the simpler acid chlorides, but the very imperfect absorption of the phosphine, and the formation of solid hydrogen phosphide seemed to make the attempts unpromising, and the subject was dropped for a time.

A year ago, with Charles E. Vanderkleed, the subject was taken up again, and dichlor-acetyl chloride selected as the acid chloride to experiment with first, since the reaction had been shown to take place with the chlorides of mono- and tri-chlor-acetic acids. The reaction proceeded satisfactorily, though slowly, and the originally liquid chloride gradually thickened to a thick, yellow, transparent mass, from which by solution in alcohol and precipitation by ether a fine crystalline powder was obtained, giving on analysis figures for phosphorus and chlorine corresponding to the phosphide expected, $CHCl_2 COPH_2$.

This substance is extremely soluble in alcohol, insoluble in ether, chloroform, and petroleum ether, insoluble in but soon decomposed by water, especially on warming, with the formation of hydrogen phosphide (PH_3) and dichlor-acetic acid, judging by the odor. It is quite stable in dry air and chars without melting at about 200° centigrade. Its behavior is what might be expected from a comparison with the amides, especially its greater tendency to decompose with water, on account of the more weakly basic character of phosphine compared with ammonia.

Experiments are being now made by Miss Frances M. DeFrees on the preparation and properties of benzoyl phosphide, $C_6 H_5 COPH_2$, and a crystalline compound has been obtained, charring without melting, and showing similar solubilities and decompositions to those of the dichlor-acetyl phosphide.

Adsorption of Dissolved Substances.

P. N. Evans.

The term "adsorption" is used for the attraction exerted by a solid surface on gases or dissolved substances. With regard to gases, the effects are familiar in the action of porous solids, such as charcoal, which seem to condense gases within the pores as if under considerable pressure; the action is a selective one, however, for in the case of charcoal some gases, ammonia for instance, are very much more affected than others. The numerous chemical reactions taking place in the presence of such porous solids as platinum sponge may probably be attributed to this surface attraction.

That solids in contact with solutions concentrate the dissolved substances on their surfaces, has been assumed in many cases, and some very superficial quantitative experiments carried out. It is commonly accepted by analysts that the first portion of the solution passing through a filter should be rejected in volumetric work on account of a possible change in concentration due to the action of the filter, but little experimental work has been done to learn how general this effect is among solids and among solutions, and very little to ascertain the magnitude of the change produced. The results obtained by different observers are difficult to harmonize; most of the experimenters simply show that adsorption takes place between certain solids and certain solutions; a few attempt a quantitative examination but omit to report factors essential to the drawing of general conclusions; a very few investigate the influence of concentration—with more or less contradictory results. One claims that the adsorbed quantity, that is, the weight of the solute close to the solid surface in excess of that in the same volume of other parts of the solution, is not dependent on the concentration in the strict sense of Henry's Law, but that dilution always lowers the quantity of the dissolved substance in the solution more markedly than that of the adsorbed substance; another, that Henry's Law applies throughout approximately; still another ascribes the results to chemical union and not physical attraction.

About four years ago the writer, with Donald Davidson, carried out a series of experiments to learn how general the adsorbing action of solids on solutions might be, and the magnitude of the effect. The details of the experiments would be out of place here, and some factors now realized to be essential to their interpretation were not recorded, but briefly, the experiments showed the following facts:

Twentieth-normal tartaric acid showed a loss of nearly 12 per cent. by contact with filter paper; twentieth-normal potassium hydroxide about the same with filter paper; 2.6 per cent. sucrose solution with animal charcoal was reduced to 1.9 per cent.; fiftieth-normal acetic acid with silica gave over 5 per cent. loss; fiftieth-normal hydrochloric acid with silica 2.5 per cent. loss; fiftieth-normal hydrochloric acid with cotton cloth 4 per cent. loss; fiftieth-normal ammonia with cotton cloth about 15 per cent. loss. All of these experiments showed, then, a positive adsorption of from 2.5 to 15 per cent. of the dissolved substance. Several others, however, showed no effect whatever; 2.5 per cent. sucrose with charcoal made from sugar, with lampblack, with sand; tartaric acid with cloth; tenth-normal sodium thiosulphate with silica.

Some experiments with sodium chloride and filter paper seemed to indicate negative adsorption, that is, the concentration of the solution was increased, possibly by adsorption of the solvent, and the same result has been reported in some cases by another observer, but in this instance it was found to be due to chlorides in the paper, none of the laboratory supply of filter paper being really free.

The weights of adsorbing substances and volumes of the solutions were unfortunately not recorded in these experiments.

The conclusion from this series of experiments is that while adsorption may be very marked in some cases, it is not shown by all solids and all solutions.

Later, experiments were carried out with Miss Frances DeFrees with a view to ascertaining the relation between adsorption and concentration. The adsorber selected was filter paper, and the dissolved substance copper sulphate. The same quantity of the solution was allowed to stand in contact with a fixed weight of paper in every case, and titrations were made with potassium cyanide solutions of suitable concentrations on this copper solution and the same solution not treated with paper. The figures obtained showed the interesting facts that above a certain concentration—about fifth-normal—no adsorption took place; that is, the concentration of the solution underwent no change by contact with the paper. As the concentration was decreased from this point the effect became more and more marked, the amount of copper removed by the paper increasing in absolute quantity up to about twelfth-normal and then decreasing with the concentration to about two-hundred-and-fiftieth-normal, farther than which it could not be followed. The decrease in concentration of 100 c. c. of this solution by contact with 5 grams of paper amounted to over 25 per cent.

To learn whether both parts of the copper sulphate were equally affected a number of determinations were made on the sulphuric acid and showed a very close agreement with the copper results, an evidence that the adsorption is of the non-ionized electrolyte and not of the ions independently.

As to the time required for the action to complete itself, the same results were obtained after a few minutes and after several days, showing that the equilibrium is very quickly established.

A similar series of experiments carried out with potassium chloride and filter paper gave analogous results, the adsorption, however, beginning at twentieth-normal, and only rising to something over 5 per cent. of that present at five-hundredth-normal concentration.

The work is being continued and promises further interesting results.

The Determination of Manganese in Iron and Steel.

W. A. Noyes and G. H. Clay.

The process proposed involves no new principle, but is a combination of several old methods.

REAGENTS.

Ferrous ammonium sulphate.—Dissolve 8.56 g. crystallized ferrous ammonium sulphate in water containing 40 cc. of dilute sulphuric acid (25 per cent.) and make up to one liter.

Potassium permanganate.—A standard solution of such strength that 1 cc. is equivalent to about 0.001 g. Fe. The manganese equivalent for the present method is found by multiplying the iron equivalent by $\frac{55}{112}$

Sodium acetate.—Thirty grams of crystallized sodium acetate, 30 cc. of acetic acid (30 per cent.) and 170 cc. of water.

Bromine water.—A saturated solution.

PROCESS.

Dissolve 1.5 grams of the sample in 20 cc. of nitric acid (1.20) and 5 cc. of hydrochloric acid (1.12). Heat till dissolved, transfer to a 300 cc. flask, add a solution of sodium carbonate till nearly neutral and then zinc oxide slowly till the precipitate of ferric hydroxide forms. After two minutes add an excess of zinc oxide.

Make up the volume to 300 cc., mix by pouring back and forth into a dry beaker and filter through a dry filter. Take 200 cc. of the filtrate, add 20 cc. of the sodium acetate solution and 40 cc. of bromine water..

Heat nearly to boiling, stirring occasionally and adding more bromine water, if necessary, till the precipitate of manganese dioxide separates. Filter and wash. The precipitate adhering to the beaker need not be removed, but the beaker must be rinsed thoroughly. Place the beaker under the funnel containing the precipitate and drop upon the latter, from a burette, the solution of ferrous ammonium sulphate till solution is complete, breaking up the precipitate occasionally with a fine stream of water from a wash bottle. Unless the manganese exceeds 0.4 per cent., not more than 20 cc. of the solution need be used. Wash out the filter and titrate the filtrate with the standard permanganate solution. The difference between the number of cc. of permanganate used and the amount which would have been employed if no manganese dioxide had been dissolved in the ferrous ammonium sulphate, multiplied by the manganese equivalent of the solution, will give the amount of manganese in one gram of iron.

The method was tested with solutions containing known amounts of manganese and gave accurate results. The method avoids the evaporation to dryness required by Volhard's method and also gives a very sharp end reaction, while the end reaction of Volhard's method is very difficult to see.

The paper is published in the Jour. Amer. Chem. Soc., *24*, 243.

A New Hydroxy-dihydro-alpha-Campholytic Acid.

W. A. Noyes and A. M. Patterson.

Dihydro-alpha-campholytic acid was prepared by W. M. Blanchard and one of us last year. From this the alpha-brom. derivative, $C_8H_{14}{-CO_2H \atop -Br.}$ and the corresponding hydroxy acid, $C_8H_{14}{-CO_2H \atop -OH}$, have been prepared. When the latter is warmed with lead peroxide and dilute sulphuric acid a ketone is formed which should be identical with the 2–3.3 trimethyl cyclopentanone, prepared synthetically by one of us, if the Perkin-Bouveault formula for camphor is correct. From the melting point of the oximes the two ketones appear to be different, and the formula for camphor referred to seems to be no longer tenable. The rejection of that formula, however, compels us to suppose a transfer of a methyl group from one carbon atom to another in reactions which take place readily at ordinary temperatures under the influence of sulphuric or hydrobromic acid.

Some Drug Adulterants of Note.

John S. Wright.

[Abstract.]

Phytolacca decandra L.—The leaves, inflorescence and young fruiting racemes were found mixed to the extent of about thirty per cent. in bales of belladonna leaves received in Indianapolis from Germany, December, 1898. Since then the writer has not found them as an adulterant, though many other lots have been carefully searched. The presence of Phytolacca was first betrayed by the abundance of young flowering and fruiting racemes. Deprived of these, Phytolacca leaves make a very clever adulterant for belladonna leaves, as the two resemble in many particulars, especially when dried and crushed or compressed in the manner customary for shipment. Critical examination, however, reveals many differences of odor, texture, color, size, shape and other gross characters.

Since this report was made, in December, 1901, the writer has found that Dr. C. Hartwich [Schweitz. Wochensch. f. Chem. u. Pharm., 1901, p. 430] gives an account of a similar discovery. Furthermore, Dr. Hartwich points out some of the histological differences between the two, so that, according to established rules, he deserves the credit of priority.

*Genista tinctoria L.—The flowering and leafy stems of this plant have been recently offered, unmixed and neatly baled, on the American markets as "flowering" Scoparius—Cytissus Scoparius (L.) Link. When baled, Genista bears a superficial resemblance to the official Scoparius; however, the purchaser who accepts it as such is certainly a very careless or incompetent inspector of drugs. The botanical characters of the two are too well known to need mention here. Medicinally they are unrelated.

Rhizome and stipes of fern—species undetermined—are frequently offered for the official *male fern* or *Aspidium*. The official drug should consist of the recent rhizomes and stipes of Dryopteris Filix-mas (L.) Schott, and D. marginalis (L.) Gray, deprived of all non-green tissues. The spurious rhizome is smaller and structurally very unlike the true drug. It has never been observed in the recent state by the writer; contains practically no extractives, and may be regarded as worthless. So far, neither its geographical nor its botanical source has been learned. At times the market offerings would indicate that it constitutes about one-half of the available supply of so-called male fern.

* An examination of the authorities disclosed but one reference to it as an adulterant: "Do not confuse with Scoparius."—King's Am. Disp., Revision by Lloyd and Felter.

Notes on Apple Rusts.

H. H. Whetzel.

The following notes on the apple rusts of Crawfordsville and vicinity are presented with the hope that they may prove helpful to those interested in this group of fungi. The observations recorded here are the results of three years' study of these plants. No systematic classification of our forms has been attempted, but the species studied is probably Tremella Juniperi-Virginianae (Schw.), as listed by Arthur in his Generic Nomenclature of Cedar Apples. This is the most common one in our locality. Special work on the anatomy of the cedar apple and the various forms in which this fungus occurs is now under way and will be ready for presentation soon.

GENERAL PREVALENCE OF THE PARASITE THROUGHOUT THIS DISTRICT.

The general prevalence and abundance of this pest throughout this section of the State is to be attributed to two causes: First, the occurrence of cedars throughout the timbered tracts of this region in such numbers and so generally distributed as to insure a universal infection of the orchards of the district; second, the prevailing ignorance of the farmers and apple growers in regard to the relation of the galls of the cedar to the Roestelia of the apple. Most farmers have planted cedars about their yards, either for ornament or protection, and as the orchards are always in close proximity to the house, the fungus is placed in a position for easy dissemination and perpetuation. One farmer not far from Crawfordsville alternated a row of apple trees with one of cedars throughout his orchard for protection from winds. Another gentleman, in the city, planted a row of cedars through his orchard along either side of the path that led from the street to his house. The result in both cases, of course, is evident. Almost every lawn in the outskirts of the city supports one or more cedars to the detriment of every susceptible apple tree in the neighborhood.

PHENOMENAL ABUNDANCE OF THE FUNGUS DURING 1900 AND ITS MARKED SCARCITY THE FOLLOWING SEASON.

The phenomenal abundance of the cedar apples and the very marked ravages of the rust on the apple trees of the city during 1900 aroused the interest not only of those acquainted with the parasite, but also very generally of the citizens of the city. On a field trip in November, 1899, we noticed the extraordinary abundance and great size of the galls that infested the cedars in yards and pastures. In commenting upon this Prof. Thomas said that never before had he seen them in such numbers and of such large size, some of them being at that time as large as walnuts. The infection was very general. Every cedar from the small seedling to the tall tree was fairly loaded on every twig and branch with the chocolate-brown galls. Just what caused this unusual abundance is not so easily discovered, but perhaps the following record of the weather for July and August and the first days of September, 1899, may throw some light on the matter. From observations made the following year it was found that the aecidiospores began to ripen about July 26. Beginning, then, with July 28, we have the following:

July 28, 1899	Rain
August 2, 1899	Rain
August 5, 1899	Rain
August 8, 1899	Rain
August 25, 1899	Rain
September 6, 1899	Rain

Six heavy rains, followed by intervals of from three to sixteen days of warm, fair weather, as shown by the weather reports kept in the city, the very best conditions for the distribution and germination of the aecidiospores on the cedar. What other factors may have entered into this general infection we are unable to say.

The conditions the following spring (1900) bore out fully the promises of the previous fall. The warm rains of the latter part of April and throughout May brought forth the yellow gelatinous masses of teleutospores in abundance. So numerous and large were the galls that the limbs of the trees bent beneath the burden and the large yellow masses could be seen for long distances. The warm sun of the days following the rain dried up the gelatinous masses, causing the teleutospores to germinate and produce countless numbers of sporidia, which were carried far and near to the apple trees of the city and surrounding country. How perfect the weather conditions of that spring were for the dissemination of this fungus, the following record will show:

April 17, 1900 .... Rain
April 20, 1900 .... Rain
May 6—8, 1900 .... Rain
May 18—19, 1900 .... Rain
May 23, 1900 .... Rain
May 28—29, 1900 .... Rain
May 31, 1900 .... Rain

Here were heavy rains with longer or shorter periods of fair, warm days between them, the thermometer standing on an average at from 68 degrees to 70 degrees F.

Under conditions so favorable to the fungus, infection of the apple trees was very general and the ravages of the Roestelia stage of the rust were most severe. Late in July the aecidiospores began to ripen, the leaves of the infected apple trees, already discolored by the numerous yellow spots that had begun to appear during the latter part of May, now grew brown and dropped off, so that by the middle of August some trees were nearly bare and the ground beneath them was covered with dead leaves. Most of the young trees put forth a second growth of leaves. Many of the old trees, seemingly unable to meet the unusual demand, either made a feeble effort or entirely refused to put out new leaves and remained bare until the following spring. Of course, some perished. We recall several such trees that were cut the next summer. The apple crop suffered accordingly. Almost no fruit was produced and the little that did mature was knotty and worthless. While the farmers of the northern part of the State, where cedars are very scarce, were selling apples at fifty cents to one dollar a bushel, grocers in the city of Crawfordsville sold them "three apples for five cents" and proportionately per bushel. This failure of the apple crop of this vicinity, while perhaps due in part to the dry weather of the latter part of July, August and the first of September, was largely because of the ravages of the apple rust. Comparison of this district with other apple producing sections of the country, where the drought was equally severe but where the cedar does not occur, confirms this statement.

The general scarcity of the apple rust the following year (1901) was as striking as had been its general prevalence the previous season. So scarce were the galls in the spring of 1901 that it was with difficulty that we obtained specimens enough to supply a class of nine students. The tree which the previous year had bent to the ground with its weight of galls now yielded, after careful search, but five or six scrawny specimens. Not only were the galls few in number, they were very small and produced comparatively few spores. In many cases they consisted only of new growths on the sides of the old galls and occasionally, even the old galls bore a second crop of teleutospores. To what, then, shall we attribute this marked decrease in gall production? Certainly not to a deficiency in aecidiospore supply, for we have already seen that the supply of aecidiospores during the summer of 1900 was unusually large; not, indeed, to any mishap that may have befallen the galls during the winter of 1900 and 1901, for upon field trips during October and November, 1900, the general scarcity of the galls was very noticeable. The fact remains, then, that the galls were not formed. To us it seems that the cause is to be found in the weather conditions of the latter part of July, August and early September of 1900, the period during which the large crop of aecidiospores was ripened and disseminated and when under favorable conditions very general infection of the cedars should have occurred. The weather reports for the period indicated are as follows:

July 24, 1900....................................Rain
August 12—15, 1900..............................Rain
August 17—18, 1900..............................Rain

Only three rains, practically only two, with long periods of from eighteen to thirty days of warm, dry weather between (there was no rain after August 18 until September 19), with the thermometer averaging about 80 degrees F. A comparison of the above with conditions during the same period in 1899 shows about one-half the number of rains as occurred during the last mentioned time.

The Roestelia, while not so abundant during the past summer (1901) as in 1900, have still been plentiful enough to aid materially in the destruction of the remaining apple trees of the city and country. The dry weather of the latter part of the past summer (1901) has had its effect on the infection of the cedars. Galls, while present, are not numerous, and a repetition of the ravages of 1900 are not to be expected. Weather conditions for this period are as follows:

July, 1901, no rain; average temperature, 90 degrees F.
August 14, 1901, rain; average temperature, 80 degrees F.
August 18, 1901, rain; average temperature, 80 degrees F.
September 11, 1901, rain; average temperature, 80 degrees F.

AN EXPERIMENT.

For the past three years we have had occasion daily to pass the home of Mayor Elmore, of Crawfordsville. On the lawn in front of his house stands a large cedar and just southeast of it, about three rods distant, is a small apple tree, about seven years old. During the spring of 1900 we noticed the great abundance of the cedar apples which infested this cedar and later in the summer the great number of leaves of this apple tree that were covered with the Roestelia. That the cedar galls were responsible for the attacks on the apple tree seemed quite evident, but we decided to test it by an experiment the following spring, and also to determine if by exclusion of the spores of the cedar galls the apple tree might not be protected from the ravages of the Roestelia. Accordingly on April 24, 1901, one of the limbs of the apple tree was enclosed in a sack of cheesecloth. The apple leaves were just bursting from the buds and the teleutospores had as yet not ripened on the cedars. About May 1, just after a hard rain, the first gelatinous stalks with their teleutospores made their appearance on the cedar apples, and on the following day sporidia in abundance were produced. On May 27 the first indication of the Roestelia, in the form of yellow spots or patches, appeared on the exposed leaves of the tree. Examination of the protected leaves showed only a very few spots. By July 3 no aecidia had ripened, although spermagonia in abundance had been produced. July 27 the first aecidia matured. The sack had been removed June 25 and the protected leaves showed only about one-half as many spots as the unprotected. No more spots appeared on any of the leaves during the remainder of the season. The last crop of sporidia were produced about the last of May, at least a month before the sack had been removed.

It was also observed that the west side of the apple tree, which was directly exposed to the cedar, bore more clusters of aecidia per leaf than the east side. This fact, together with the results in the protected branch, seems to prove conclusively that the sporidia of the teleutospores on the cedar had produced the infection of the apple leaves. The failure of the sack to exclude all of the sporidia was due to their minute size and the openness of the cloth. The experiment will be repeated next spring with cloth of a firmer texture. The fact that infection took place through the cheesecloth proves that the sporidia and not the teleutospores are carried to the apple leaves, since the openings in the cloth were too small to allow the latter spores to pass through. This fact seems to have been overlooked in many published reports on this fungus.

GERMINATION OF TELEUTOSPORES.

Many attempts at the germination of teleutospores were made in the laboratory. Most of these were more or less successful. The only things brought out worthy of note were: First, that in general our results confirmed the work done by H. M. Richards and recorded in his paper in the Botanical Gazette for September, 1889; and second, that best results were obtained when the teleutospores were germinated, not in an abundance of water, but rather on simply moist slides placed in the sunlight under bell jars. This allowed the spores to dry slowly, thus affording natural conditions for sporidia production.

Several gelatinous galls were allowed to dry in the sunlight on the window sill. An abundance of sporidia were produced which covered the sill beneath and about the galls, while wet material showed upon examination no sporidia. This strengthens the statement previously made that the sporidia and not the teleutospores are disseminated by the wind, since evidently the teleutospores never leave the gall before germination.

THE GALLS PERENNIAL.

As already mentioned, it was observed that many of the galls of the spring of 1901 were but outgrowths on the sides of old galls and that in many cases these old galls bore a second crop of teleutospores. Although no further investigation has been made, there appears to be but one solution to the problem, and that is that the mycelium had summered in the old galls, producing the new outgrowths and the second crop of spores in the spring. As far as we have found, no record of such a condition has been made, and while evidence seems to show that the mycelium is perennial, we wish to investigate further before making a definite statement and only offer this observation as a matter for consideration by those who may be working on this fungus.

SUSCEPTIBILITY AND IMMUNITY OF DIFFERENT SPECIES OF APPLES.

Some observations were made in different parts of the city to determine the susceptibility and immunity of different species of apples. In the experiment already described the apple tree infested was of the Milum variety. In the same yard in which this tree stood was another apple tree that was never infected by the rust. It was a fall apple, variety unknown. In another yard in another part of the city stood two apple trees with interlocking branches; one was of the Bellflower variety, a winter apple, the other was a large fall apple, variety unknown. Across the street to the west stood two cedars that usually bore a few galls. The Bellflower always suffered severely from attacks of the pest, while the other tree remained free from it. The difference in the appearance of these two trees by the middle of August was most striking. The Bellflower, with its sickly, yellowish foliage, mottled with the dark clusters of Roestelia, presented a striking contrast to the dark, healthy green of its neighbor's. The effect was also very noticeable in the apples of the two trees. Those of the Bellflower were small, knotty and not numerous, although the branches had been loaded with blossoms during the spring. The apples of the other tree were large, perfect and plentiful. More extended observations regarding this point will be made next spring.

The selection of immune varieties seems to be the only solution of the problem of the extinction of the fungus, at least in this vicinity. Not only do cedars occur in the natural forests of the region, but they have been very generally planted by farmers for protection and decoration so that the only other method, the destruction of the cedars, is quite out of the question, as so many not concerned in apple growing would not destroy their cedars, and the absolute destruction of every red cedar would be necessary to exterminate the fungus.

Notes on the Genus Stemonitis.

H. H. Whetzel.

During the past summer and fall we have made a careful study of the genus Stemonitis, as represented by the species occurring in the vicinity of Crawfordsville, Ind. This study has brought out several striking and interesting conditions regarding the development of some structures of this genus. The study was made in the laboratories of Wabash College.

and the specimens examined represent the collections of three years from this vicinity. Many species were from the campus and the shade trees along the streets of the city.

Great care was taken in collecting. The exact place of its occurrence, the date and other important data were preserved with the material. The best specimens of each species were mounted for future reference, while the remaining material was preserved for study. On each collecting trip every specimen of slime mould was taken and subsequently identified to insure thoroughness in the local work. This was necessary, as many species could be determined only by extended study and comparison with other material. Several species that appear exactly alike to the naked eye vary greatly in minute structure.

Besides this, very careful mounts were made, both in balsam and glycerine jelly, from fresh specimens. The spores were removed from those mounted in balsam, in order to show capillitium structures; others to show spore markings were mounted in jelly, containing a small amount of potassium hydrate to swell the spores. Careful measurements of spores were kept and records preserved of their color *en masse* and under the microscope. Fresh material was always used for color records, as the spores change with age, and the entire sporangium with its spores changes color several times during the process of fruiting. The following record kept of S. maxima will illustrate this:

June 25, 7 p. m., plasmodium, pearly white.
June 26, 6 a. m., fruited (still wet), purple black.
June 26, 10 a. m., brownish, dark.
June 27, 3:30 p. m., lighter brown.
July 20, spores shed, purple brown, pale.

This specimen grew on an old charred stump convenient to the laboratory, and we examined it several times each day to note any changes of color. Records of color variation of species of other genera also show this striking change of color during and after fruiting.

For determination of species, Macbride's North American Slime Moulds were used, while Lister's Mycetozoa was used for reference and comparison.

Before the presentation of the conclusions based upon a study of sporangium and spore structure, the following miscellaneous notes and observations may be of some interest:

The number of species occurring in this vicinity, so far as collections up to the present show, are six of the twelve listed by Macbride. Besides these, a seventh form was found differing quite materially from any other species collected, and not corresponding with any description of species listed by Macbride or any other author consulted. This form is very common, and its distinctive characteristics are so much unlike those of closely related individuals that it is doubtless a new species.

Very hot days following heavy showers seemed to present conditions best suited for the development of the fruiting stage of Stemonitis, and from early in the spring until late in the fall such conditions were sure to bring forth beautiful sporangium clusters in abundance. A hot morning following a thunder shower is particularly favorable. Examination of old trees and stumps early in the morning often revealed the pearly white plasmodia pushing forth upon the surface. As far as we have observed, all plasmodia of this genus are of a pearly white. Repeated attempts to bring these plasmodia to the laboratory to fruit always resulted in their distortion, partial development or decay. In no case were there normal fruits produced, although conditions seemed to be favorable.

A careful review of the particular habitat of each species revealed no special place for each. We have found them almost everywhere, although perhaps most frequently on the decaying trunks and stumps of the Red Maples that line the streets of the city. One stump of Red Maple has produced for three successive years the most beautiful specimens of S. Webberi; several fruitings being produced each season. Three were noted this year. Usually an area six inches in diameter on the side of the stump was completely covered with rich brown tufts. Board piles, posts and sides of old buildings yielded many fine specimens. Some species fruited on grass blades and leaves, which were in close proximity to the old logs in which the plasmodia grew. Some of the best specimens we obtained came from an old charred stump on the campus. The sporangia almost always occur in very exposed places. This, together with their large size and abundance, makes the discovery of them comparatively easy.

Many and careful attempts were made at germinating the spores of the different species. None was successful, although several kinds of media were used. Besides water, concoctions of rotten wood, on which the specimens grew, were tried, but all without success.

CONCLUSIONS DRAWN FROM THE SYSTEMATIC STUDY.

Comparison of this genus with others of the order has lead us to believe that Stemonitis represents the most perfect differentiation and specialization of the Stemonitaceae. Next in order below it stands Comatricha, from which the former is not very easily separated. as its lowest forms are much like the higher forms of Comatricha, only its one characteristic structure, the superficial net, serving to distinguish it.

This superficial net is peculiar in several respects. In the first place, it is almost the only example of such a structure occurring among the slime moulds, although a slight indication of such a structure may be noted in the higher forms of Comatricha. In the second place. its gradual development and perfection in Stemonitis is indeed very remarkable. Besides, this gradual perfecting of net structure is found to correspond with a like perfecting of spore markings, so that in a species presenting the best development of this superficial net we find the most specialized forms of spore marking. Another and almost equally interesting gradation in structural development, parallel to the above, is to be seen in the inner or supporting network of the capillitium. Although presenting some exceptions, this shows on the whole a tendency to a steady reduction in the number of threads of the inner network and a thickening of the resulting ones. In the species we have studied there was noted, corresponding to the differentiation just described, a gradual increase in the height of sporangia. An examination of Macbride's listed species present some interesting exceptions. A wide variation in height of sporangia of the same species is common. But in general we think it may be safely said that the tendency is toward taller and larger sporangia, with the increase in complexity of the contained parts. There are other structures that upon future investigation will probably reveal a like gradation.

Upon the discovery of this gradual and parallel development of certain structures. it occurred to us that a classification of the species of this genus, upon the basis of the development of some of these structures, would not only be the most convenient, but might, at the same time, represent the natural sequence of the species in the genus. Of course that structure which showed this development, and at the same time proved most constant in the different species, was the one to be chosen as the primary basis of classification. Careful investigation of a large number of individuals of each species showed that spore markings primarily, with size and color secondarily, was the structure to be selected.

The specimens were then gone over most carefully, and the following classification prepared, including only the species that have come under our observation, although a review of the remaining six species listed by Macbride showed that they would fit into and complete most perfectly the classification which we had worked out. For convenience, the species have been placed in three groups.

CLASSIFICATION OF THE SPECIES OF STEMONITIS.

Generic character—the superficial net.

Basis of species classification—spores; their markings, size and color.

Other structural characters important in separation of species—inner and outer net structures of capillitium; height of sporangia, and general color.

a. Epispore smooth or only slightly warted, with low, scattered warts. Spores small, light colored or colorless.

1. Stemonitis pallida Wingate.

   Spores nearly or quite smooth, 4-5μ, pale reddish brown; capillitium, inner network dense; outer net meshes small, 6-13μ; height of sporangia, 4 mm., brownish purple, becoming pallid with age.

2. Stemonitis axifera (Bull) Macbr.

   Spores with low, scattered warts, 5-6¼μ, pale reddish brown; capillitium as in S. pallida; height of sporangia 5-10 mm., ferruginous, with purple tinge after spore dispersal.

3. Stemonitis Smithii Macbr.

   Spores minutely warted, 5μ, pale dusky brown; capillitium more open than in S. axifera, outer net meshes 6-15μ; height of sporangia, 5-12 mm., bright yellowish brown, rusty, paler after spore dispersal.

4. Stemonitis ——— 64 (collection number).

   Spores smooth, or nearly so, 5μ, pale dusky brown, not reddish; capillitium, inner network open, outer net with small meshes 10-25μ, height of sporangia 10 mm., dark purple brown, like S. maxima.

b. Epispore distinctly warted. warts spinose; spores larger and darker than in a.

5. Stemonitis Morgani Peck.

Spores densely but minutely warted with spinose warts, 7-8μ, reddish brown, dark with purple tinge; capillitium, inner network loose, few branches, outer net large meshed 15-40μ; height of sporangia, 15-18 mm., rich reddish brown, dark with purple tinge.

6. Stemonitis Webberi Rex.

Spores densely and very distinctly warted. 8-9μ, reddish brown; capillitium, inner net open, outer net large, coarse, irregular meshes 50-125μ; height sporangia 18 mm., rusty brown.

c. Epispore reticulate, large, dark, violaceous never brown.

7. Stemonitis maxima Schw.

Spores reticulate, 7-8μ, dark violaceous; capillitium, inner net of medium density, outer net meshes 8-40μ; height of sporangia 5-10 mm., dark purple brown, becoming pallid with age.

The Vegetation of Abandoned Rock Quarries.

Mel T. Cook.

The study of the encroachment of plants on waste land and the order of their succession becomes especially interesting in the case of the abandoned rock quarries because of the very small amount of soil.

The following observations were made from the study of three limestone quarries in Greencastle, Indiana, and vicinity. It is impossible to give the exact ages of these quarries; a small amount of rock is still taken from them. Rough estimates will be given in the following descriptions:

Quarry A.—A small quarry, about ten or fifteen years old; about two-thirds of the floor covered with water, which drains in from a small area; no natural outlet.

Quarry B.—A much larger quarry, about fifteen or twenty years old; very long and narrow and extending east and west; the first work done in the western end; small stream runs the entire length from east to west; another much smaller stream from a spring enters on the north side, spreads out fan-shaped and joins the main stream. A small marsh in one part of quarry. Heavy woodland on the south.

Quarry C.—Very little larger than B and about twenty or twenty-five years old. Extending north and south; first work at north end; small stream runs through north end; large pond in south end. Almost surrounded by thin woodland.

Fig. 1.

There is no soil in these quarries except the small amount incidentally carried in by the workmen, by the wind, by the streams; and the powdered limestone soil, the result of blasting and crushing.

Although there may be many factors bringing seeds into the quarry, the two principal ones are wind and water.

The order in which the plants appear in these quarries is as follows: Algae, lichens, mosses, scouring rushes, monocotyledons and dicotyledons.

The water naturally brings in the algae, which grow in great variety and abundance. Lichens are not very abundant and are usually found in the higher parts. The peculiar soil formed from powdered limestone forms a muck in which a few species of mosses grow, but not in great abundance. A few very poor specimens of Equisetum arvense were found in quarry B, having come in from the gravel bed of the railroad which runs on the north bluff of this quarry.

Fig. 2.

Of the Spermatophytes the monocotyledons are the first to appear, the hydrophytes leading and invading the ponds. Of these the most showy is the Typha latifolia L. (Fig. 1), which was very abundant in all three quarries. Around the margins of these ponds the sedges were very abundant, gradually giving way to the grasses a little farther back.

Of the dicotyledons, the willows (Salix sp.) and sycamore (Platanus occidentalis L.) were the most conspicuous (Figs. 1 and 2). The willows were always in great abundance along the streams and on the margins of the ponds. The sycamores were by far the most interesting growth and were found abundantly in quarries B and C. They were more abundant and much larger in the old parts of the quarry and seemed especially well adapted to this peculiar soil; in fact, they seemed to be able to grow with little or no soil except the limestone powder in the crevices. Fig. 3 shows a tree about eight inches in diameter growing out of the apparent solid

Fig. 3.

floor of quarry C. Fig. 4 shows a tree of about four inches in diameter growing out of a crevice between strata in the wall of the same quarry.

In the older parts of the quarry and around the margins, where considerable amounts of surface soil has been carried in, the dicotyledonous plants are very abundant.

The common watercress (Roripa nasturtium L.) was abundant in quarry B, having been carried in by the little stream from the north. Its spread, however, was very slow, seemingly dependent on the amount of surface soil carried in by the stream, since it did not thrive in the limestone soil.

A few plants of the button bush (Cephalanthus occidentalis L.) were found around the pond in quarry C.

Fig. 4.

A summary gives the following conclusions: (1) the first plants are the algae in great variety and abundance. (2) A very few lichens. (3) A few mosses. (4) Equisetum very rare; the soil not suited to its growth. (5) Typical hydrophyte societies in the ponds, the Typha latifolia being most conspicuous. The ponds slowly encroached upon by the sedges and grasses: These plants form a soil for the many dicotyledons which are found in the older parts of the quarry. (6) The willows and sycamores are the first trees, both being specially well adapted to the thin soil.

The following census of plants was made from quarry B by Mr. Guy Wilson:

1. Typha latifolia L.
2. Alisma Plantago aquatica L.
3. Panicum dichotomum L.
4. Muhlenbergia sp.
5. Phleum partense L.
6. Agrostis alba L.
7. Cyperus sp——.
8. Carex sp——.
9. Ixophorus glaucus (L.) Nash.
10. Juncus effusus L.
11. Juncus tenuis Willd.
12. Juncus nodosus L.
13. Salix sp——.
14. Ulmus Americana L.
15. Rumex crispus L.
16. Polygonum sp——.
17. Roripa nasturtium (L.) Rusby.
18. Draba Caroliniana Walt.
19. Platanus occidentalis L.
20. Potentilla monspeliensis L.
21. Pyrus sp. (cultivated).
22. Melilotus alba Desv.
23. Trifolium partense L.
24. Trifolium repens L.
25. Acalypha gracilens A. Gray.
26. Euphorbia nutans Lags.
27. Rhus radicans L.
28. Impatiens sp——.
29. Onagra Oakesiana (A. Gray) Britton.
30. Daucus carota L.
31. Asclepias incarnata L.
32. Verbena urticifolia L.
33. Scutellaria lateriflora L.
34. Prunella vulgaris L.

35. Hedeoma pulegioides L.
36. Lycopus rubellus Moench.
37. Mentha piperita L.
38. Mimulus alatus Soland.
39. Plantago major L.
40. Micrampelis lobata (Michx.) Greene.
41. Lactuca Scariola L.
42. Lactuca Canadensis L.
43. Ambrosia trifida L.
44. Xanthium strumarium L.
45. Vernonica sp——.
46. Eupatorium perfoliatum L.
47. Solidago Canadensis L.
48. Erigeron Philadelphicus L.
49. Bidens laevis (L.) B. S. P.
50. Bidens frondosa L.

The Germinative Power of the Conidia of Aspergillus Oryzæ.

Mary F. Hiller.

Former investigations of the mould, Aspergillus oryzae, have resulted in many practical suggestions which have determined this mould to be of interest to the commercial as well as to the scientific public.

In 1876 Ahlburg, the first investigator of the mould, described the fungus and named it Eurotium oryzae. Cohn, in 1883, in his study of moulds as industrial factors, called it Aspergillus oryzae. Büsgen, in 1883, gave the first complete description of this mould, and in 1893 Wehmer attempted a structural study. From this time many investigators were at work in many different laboratories working out the life history of the fungus. It was Takamine, a Japanese chemist, who introduced Aspergillus oryzae into the laboratories of this country.

The careful experiments of many investigators, among whom are Jörgensen, Hansen, Klocher, also Atkinson and Hoffman, who have treated it from the industrial standpoint, have resulted in suggesting for this mould many interesting properties, such as the claims that the mycelium, in developing, secretes a diastatic ferment and that under certain conditions of growth the mould is convertible into yeast. These two properties alone would establish its value to the commercial world aside from its scientific interest.

The object of the following experiments is to study the germinative power of the conidia of Aspergillus oryzae, the plan being to test the conidia of various ages in different media.

This study was suggested by a statement of Wehmer's to the effect that neither the age of the inoculating material, nor the medium upon which it has been grown, affect the germinative power of the conidia.

The material used in these experiments was taken from cultures germinated upon the following media: Wort (obtained from the brewery, unfermented, but after having been hopped), wort-gelatine (wort fortified with ten per cent. gelatine), dextrose, rice, bran, also some of the so-called original material which had been obtained from Takamine. These cultures, which were seventeen in number, covered the dates of March 29, 1897, to November 26, 1898.

A new series of cultures were made from these seventeen cultures, which varied in age from two years and eleven months to four years and seven months, the testing medium being wort. Upon examination of these cultures the following results were obtained: Cultures obtained from the six, grown originally upon wort, and which varied in age from two years and eleven months to three years and seven months, had been germinated and the mould was in a vigorous and advanced stage of growth. Those cultures taken from bran, rice, wort-gelatine and the original material failed to show any signs of germination.

In the second series of cultures the medium of germination used was wort-gelatine. Upon examination of these cultures at various dates, it was found that the six taken from the wort cultures had germinated and the mould had grown vigorously, while those cultures taken from bran, rice, etc., had failed as in series number one.

Pasteur solution was the medium used in the third series of cultures. The results obtained were the same as the results from series one and two, the six cultures taken from wort having germinated and all others having failed.

The fourth series, the testing medium bouillon, gave the following results: Six cultures taken from wort grew, also one taken from bran, which was four years and six months of age, the cultures from wort-gelatine, rice and the original material having failed.

For a fifth series of cultures gelatine was added to beef broth, and the results of these cultures were the six from wort grew, the fungus being in a vigorous state, also one from wort-gelatine, which was three years of age, the growth not being vigorous; cultures from bran, rice, original material and the remaining four of wort-gelatine failed.

The series of moist chambers in which a drop of wort was used was then made, and the following were the results obtained: Germination had taken place in cultures obtained from rice three years and nine months of age, one from wort-gelatine three years of age and the six from wort. Those failed which had been obtained from cultures on bran, dextrose, original material and the remaining four on wort-gelatine.

A series of cultures was also made using Pasteur solution and alcohol to normal solution, but no results at all were obtained, germination having failed in every culture.

New cultures were made in wort from the original cultures which had germinated in just one or two testing media and were as follows: One from wort-gelatine which was three years of age and had germinated in beef broth and gelatine; one from rice three years and eight months of age, which had germinated in the moist chamber, wort having been used; one from bran four years and six months old, which had germinated in bouillon; one from wort-gelatine three years old. It had germinated in the moist chamber. These four cultures failed to give any sign of germination. From this result it is suggested that the cutting off of the air supply had permitted the conidia to germinate in wort in the moist chamber where the test tube cultures in wort failed to promote germination.

A microscopical examination was made of the conidia from cultures of various media and dates, the following being the conidia examined: Those from original cultures in wort, wort-gelatine, dextrose, from cultures of Series I, in which wort was the medium; Series III, Pasteur solution the medium; Series IV, bouillon the medium. In these examinations the conidia showed no apparent difference.

The tabular form of these experiments and the results obtained from them suggests the following conclusions:

First.—The germinative power of the conidia of Aspergillus oryzae is dependent upon the medium upon which the inoculating material has been grown.

Second.—The age of the inoculating material in these experiments varied from two years and eleven months to four years and seven months, and from results obtained the germinative power lessens with age.

Third.—(a) Some media are decidedly favorable to the fungus in retaining its vitality. Example 1: Wort, all cultures from it having germinated in each of the six testing media. (b) Other media are favorable under certain conditions. Example: Wort-gelatine. Out of five cultures one grew in one of the testing media. (c) Still other media are decidedly unfavorable. Example: Dextrose, cultures from it having failed throughout the experiments.

Fourth.—Alcohol is not stimulating to the conidia of Aspergillus oryzae.

LITERATURE.

Büsgen: "Ueber Aspergillus oryzae." Botan. Centralbl. No. 41, p. 62, 1885.

Golden, K. E.: "Aspergillus oryzae," from the proceedings of the Indiana Academy of Science, pp. 189-201, 1898.

Jörgensen, A.: "Micro-Organisms and Fermentation,' pp. 92-93, 1893. "Ueber den Ursprung der Alkoholhefen." Berichte des Gahrungsph., Labor. 1895.

Klocher, A., and Schionning, H.: "Experimentelle Untersuchungen über die vermeintliche Umbildung des Aspergillus oryzae in einen Saccharomyceten." Centr. f. Bakt. u. Par. Bd. I. Nos. 22, 23, pp. 777-782, 1895; "Que savons-nous de 'lorignine des Saccharomyses?" Compte rendu du Labaratoire de Carlsberg, pp. 36-68, .1896.

Takamine, J.: "Diastatic Fungi and Their Utilization." Am. Jour. Phar., vol. 70, No. 3, pp. 137-241, 1898.

Wehmer, C.: "Aspergillus oryzae, der Pilz der japanischen Sake-Brauerei." Centr. f. Bakt. u. Par., Bd. I. Nos. 4, 5, pp. 150-160; Nos. 6, pp. 209-220, 1895. "Sakebrauerei und Pilzverzuckerung." Centr. f. Bakt. u. Par., Bd. I. Nos. 15, 16, pp. 565-581, 1895.

Spore Resistance of Loose Smut of Wheat to Formalin and Hot Water.

William Stuart.

The comparative absence of any definite knowledge of the spore resistance of the loose smut of wheat to formalin and hot water, and the lack of any efficient method of preventing losses to the wheat crop from it, seem to invite some attention to this phase of the question. In a measure the work which has been performed is simply a continuation of some investigations begun during the season of 1898, and reported in the Academy Proceedings for that year, pp. 64-70. At that time work was undertaken with both wheat and oats smut, but on account of the fact that the wheat smut spores did not remain viable under laboratory conditions this portion of the work had to be abandoned. Further opportunity for study of the wheat smut did not present itself till last summer. A considerable quantity of smutted heads was collected from last year's wheat crop just after the grain headed out, and before the spores were blown or washed off the rachis. This material was kept in the laboratory until needed for use. Spores mounted in hanging drop cultures over moist cells showed good germination in distilled or tap water at the time the material was collected, but in the course of two or three weeks failed to germinate. As these results corresponded with those of 1898, it was decided to try germinating them in some nutrient solution. Accordingly a Pasteur sugar solution was substituted for the water, with the result that a vigorous germination was obtained.

In order to insure a uniform lot of spores for the culture experiments, a sufficient quantity of them were jarred from the smutted heads, and after removal of the detritus by screening, they were thoroughly mixed and collected in a receptacle from which fresh supplies were drawn as desired.

Treatment of the spores.—The spores were treated in muslin sacks, one corner of which was weighted with a small quantity of shot in order to carry the sacks down into the solution and maintain them in proper position while being treated.

In treating the spores, especially in the formalin solutions it was found absolutely essential that only a minute quantity of spores be taken, otherwise they were apt to collect in masses, and in this way the solution did not readily permeate the whole mass. Whenever this occurred, in the shorter periods of treatment, spores taken from the interior of these masses would invariably show germination.

Formalin treatment.—The strength of formalin solutions used were .18, .25 and .5 per cent. The periods of treatment to which the spores were subjected in these solutions were one-quarter, one-half, one, and two hours, the four lots of spores being treated at the same time, each being successively removed without in any way disturbing the remaining ones. The treated spores were mounted as soon as possible after removal from the formalin solution, and, after a microscopic examination, were placed in a moist chamber, the moist chamber being used in order to obviate the necessity of using vaseline to cement the cover slips to the glass cell. Better results seemed to be obtained when the culture had free access to moist air.

The data obtained from the formalin treatment which is given in Table I, shows that the quarter-hour treatment in the weaker solutions were apparently not effective. In the .18 per cent. solution with the quarter-hour treatment every culture made showed good germination, while in the .25 per cent. solution eight out of twelve showed germination in the quarter-hour treatment and one out of twelve in the half-hour.

TABLE I.

Germination Tests of Spores Treated With Formalin.

Strength of Solution.	Length of Treatment.	Number of Cultures.	Cultures Showing Germination.	Percentage of Same.
.18	¼ hour.	4	4	100
.18	½ hour.	4	0	.....
.18	1 hour.	4	0	.....
.18	2 hours.	2	0	.....
.25	¼ hour.	12	8	67
.25	½ hour.	12	1	8.3
.25	1 hour.	4	0	.....
.25	2 hours.	4	0	.....
.50	¼ hour.	3	0	.....
.50	½ hour.	3	0	.....
.50	1 hour.	3	0	.....
.50	2 hours.	3	0	.....
Not treated.	....	10	10	100

The latter germination is probably accidental, owing to the fact that the half-hour treatment in the .18 per cent. solution showed no germination. Treatment in the .5 per cent. solution proved effective in all cases.

In order to note the action of the formalin upon the smut after their removal from the solution, cultures were made of the spores at different periods after their removal, varying from a quarter to one and a half hours. The data obtained, which is presented in Table II, shows conclusively that the formalin proved effective in the quarter-hour treatments if given sufficient time to act upon the spores before mounting them in the liquid media. Spores treated a quarter hour in the weakest solution and mounted one hour after showed no germination.

TABLE II.

Germination of Spores Treated 1/4 Hour in Formalin Solution, Mounted Some Time After.

Time elapsed after removal from Formalin Solution.	Strength of Solution.	Number of Cultures.	Cultures Showing Germination.	Percentage of Same.
1 hour.	.18	2	0	....
1½ hours.	.18	2	0	....
¼ hour.	.25	2	2	100
½ hour.	.25	4	2	50
¾ hour.	.25	2	0	....
1 hour.	.25	3	0	....

In the quarter per cent. solution the treatment was effective if the spores were not mounted for three-quarters of an hour after their removal from the formalin. It would appear, therefore, that under ordinary conditions of farm practice in which the seed is allowed to dry before being planted, treatment with either strength of solution should prove effective. In actual practice, however, such a treatment does not prove effective. This has been amply demonstrated by some experiments which were reported by Dr. Arthur in the Thirteenth Annual Report of the Indiana Experiment Station, p. 21, January, 1901, in which seed treated a half hour in a .45 per cent. solution of formalin at an average temperature of

124.5 degrees F., showed over one per cent. of smutted heads in the resultant crop.

Hot water treatment.—Only two periods of treatment were tried with hot water; these were for five and ten minutes. The range of temperature tried was from 130 degrees F. to 100 degrees F. The highest temperature used was considered the lowest point at which the treatment of wheat seed could be expected to prove effective, and it was therefore taken as the starting point in the work. As this temperature proved effective in killing the spores, a lower one was tried and so on until the lower limit of effectiveness was reached. The results of the work, which are presented in Table III, show that the lower limit of effective treatment was 110 degrees F. for five minutes and 105 degrees F. for ten minutes.

TABLE III.

Germination of Spores Treated With Hot Water.

Temperature of Water.	Length of Treatment.	Number of Cultures.	Cultures Showing Germination.	Percentage of Same.
130° F.	5 minutes.	2	0	....
130° F.	10 minutes.	2	0	....
125° F.	5 minutes.	2	0	....
125° F.	10 minutes.	2	0	....
120° F.	5 minutes.	4	0	....
120° F.	10 minutes.	4	0	....
115° F.	5 minutes.	4	0	....
115° F.	10 minutes.	4	0	....
110° F.	5 minutes.	6	0	...
110° F.	10 minutes.	6	0	....
105° F.	5 minutes.	8	4	50
105° F.	10 minutes.	6	0	....
100° F.	5 minutes.	2	2	100
100° F.	10 minutes.	4	4	100
Not treated.	....	19	19	100

The unusually low temperature at which the viability of the spores were impaired seems all the more remarkable when we take into account the fact that a treatment of the seed wheat for ten minutes at a temperature of 130 degrees F. is not effective in removing all the smut from the ensuing crop. The results obtained from both the formalin and hot water treatments would seem to indicate that the spores are easily killed, in weak solutions of formalin and in comparatively low temperatures of water, when brought in direct contact with these agencies.

The lack of success in treating the seed for smut seems to be due to the inability of the agency used to reach all the smut spores. This is probably due to the fact that the seed coat is somewhat impervious to liquid solutions; hence, all spores that are held in the interstices of the seed coat are reached with difficulty, if at all. Assuming this explanation to be correct, it would appear that a different treatment should be accorded wheat than that advocated for oats. Some preliminary treatment should be given with the object of softening the seed coat, to such an extent as to permit of the ready action of whatever disinfecting agency it is desired to employ. With this idea in view a series of experiments were undertaken in which the seed, intended for treatment either with formalin or hot water, was given a preliminary soaking in water at about 70 degrees F. The length of time in which the seed was allowed to soak in water varied somewhat inversely to the time in which it was to be treated in formalin and hot water. For example, in the formalin treatments in which four lots of seed were treated, the first lot was soaked a half hour in the water and two hours in the formalin solution, whereas the fourth lot was soaked three hours in the water and only a quarter-hour in the formalin solution. In the hot water treatment, somewhat the same method was followed, except that a shorter period of treatment was given.

Germination tests were made of the treated seed in a Geneva germinator. The treatment of the seeds and the data obtained from the germinator tests which are presented in Tables IV and V, show that the formalin treatments injured the viability of the seeds somewhat more than that of the hot water. In neither case, however, was the seed appreciably injured.

TABLE IV.

Germination of Seed Wheat Soaked in Water, Then Treated With Formalin.

Soaked in Cold Water.	Treated in .18% Formalin.	Per Cent. of Germination in					Total Per Cent. Germination.
		1 day.	2 days.	3 days.	4 days.	5 days.	
½ hour.	2 hours.	35.5	74	82.5	86.—	87.—	87
1 hour.	1 hour.	22.5	67	80.5	85.5	....	85.5
2 hours.	½ hour.	36	76.5	84.5	87	88	88.—
3 hours.	¼ hour.	34	81	81	85.5	87.5	87.5
Untreated.	....	0	36.5	72.5	81.5	95.—	95.—

TABLE V.

Germination of Seed Wheat Soaked in Water, Then Treated in Hot Water.

Soaked in Cold Water.	Treated in Water at 120° F.	Per Cent. of Germination in					Total Per Cent. Germination.
		1 day.	2 days.	3 days.	4 days.	5 days.	
1 hour.	½ hour.	10.5	64.5	92	....	93	93
2 hours.	¼ hour.	31.5	76	93.5	....	94	94
3 hours.	10 minutes.	45.5	81.5	91.5	....	..	91.5
4 hours.	10 minutes.	46	92	94.5	....	97	97.—
Untreated.	....	....	....	....	....	..	95

The delayed germination of the untreated seed was due to the fact that it had not been soaked in water previous to putting it in the germinator, hence it took some time to absorb sufficient moisture for germination.

In the formalin treatment seed soaked three hours in water and then treated a quarter-hour in an .18 per cent. solution of formalin, was not materially injured, there being but 7.5 per cent. less germination than from the untreated. That soaked one hour in water and one hour in the formalin solution showed slightly more injury than any of the others.

For the hot water treatment a temperature of 120 degrees F. was chosen, on the supposition that though considerably lower than that used in ordinary practice it was nevertheless sufficiently high to insure killing all spores with which it came in contact. Four lots of seed were treated, for periods varying from one to four hours in the cold water and from ten to thirty minutes in the hot water. The highest germination obtained was from seed which had been soaked four hours in cold water and ten minutes in the hot water.

SUMMARY.

A careful consideration of the evidence at hand would seem to indicate that in themselves smut spores are easily destroyed by either formalin or hot water treatments.

Owing to the somewhat impervious nature of the seed coats of wheat, and the not improbable fact that spores find lodgment in the interstices of them, it is difficult to reach and kill all the spores with any ordinary method of treatment.

To render the seed coats of wheat susceptible to such agencies as are commonly employed for the prevention of smut, it appears to be necessary, even imperative, that they should be soaked for some time in cold or tepid water prior to treatment.

A three hours' soaking in cold water and a quarter-hour treatment in an .18 per cent. formalin solution did not materially injure the viability of the seeds.

Seeds soaked four hours in cold water and then treated ten minutes in water at 120 degrees F. gave slightly better germination than the untreated seeds.

Some Additions to the Flora of Indiana.

William Stuart.

The accompanying list of flowering and fungous plants are some which have been collected by the writer during the past two seasons. In the flowering plants, out of a list of five, three are far removed from the range to which they are accredited.

In presenting the list it has been thought desirable to append a few notes under each species, giving the locality and soil in which they were collected, together with such other observations as might be deemed of interest.

FLOWERING PLANTS.

1. Agropyron occidentale Scribn. (A. Spicatum L. & L.) Colorado Bluestem. Tippecanoe County.

This species is not listed in Britton and Brown, but may be found in the revised edition of Bulletin 17 of Division of Agrostology, United States Department of Agriculture, p. 298, 1901. According to Scribner it is found "in dry or moist soil, Wisconsin to Iowa, and westward to Washington, Texas and Arizona." It was found in abundance by the writer along the Wabash and Monon railroads south of Lafayette, in dry, gravelly soil. Its introduction into the State is doubtless due to the railroads.

2. Sporobolus neglectus Nash. (S. vaginaeflorus Vasey.) Small Rushgrass. Tippecanoe County.

Found growing in abundance along sidewalks in West Lafayette. No other station noted.

3. Chenopodium murale L. Nettle-leaved Goosefoot. Tippecanoe County. Collected along sidewalk in Lafayette.

4. Astragalus Tennesseensis Asa Gray. Tennessee Milk Vetch. Tippecanoe County.

This plant was collected in sandy bottom land along the Wea Creek, about four miles south of Lafayette, and some two hundred yards down stream from the Wabash railroad bridge. It is probable that it owes its introduction into the State to the railroad. Not very abundant. Of this plant Britton and Brown say: "On hillsides, Tennessee to Alabama and Missouri, March to May." It was collected in fruit the latter part of May.

5. Psoralea tenuiflora Pursh. Few-flowered Psoralea. Tippecanoe County.

Found growing along the Wabash railroad south of Lafayette. Not abundant. Collected in fruit July 7, 1901. Britton and Brown give the range as follows: "Prairies of Illinois and Minnesota to Texas and Sonora west to Colorado and Montana, May to October."

PLANT RUSTS.

6. Puccinia vexans Farlow. On Bouteloa curtipendula (Michx.) Fon. Tippecanoe County. II, III, collected July 20, 1900.

7. Puccinia panici Dietl. On Panicum virgatum L. Tippecanoe County. III, collected May 30, 1901. (Teleutospores of previous season.) II, collected June 22.

This rust was collected on an isolated clump of Panicum virgatum, in the same region as that in which P. vexans was found. The date of the formation of teleutospores was not obtained owing to the destruction of the grass by fire.

8. Aecidium Pammelii Trelease. On Euphorbia corollata L. Tippecanoe County.

This aecidium was collected June 9, 1901, on plants of E. corollata, which were growing in close proximity to the clump of P. virgatum that was affected with the rust P. panici. The absence of any other aecidium suggested to the writer that possibly this was the aecidial stage of P. panici. Accordingly some of the affected Euphorbia leaves were collected and inoculations made upon potted plants of P. virgatum in the station greenhouse. Leaves of these plants were inoculated June 11 and 14, the latter being made with freshly collected material. In each instance well-developed uredosori were obtained in eight days from the time of infection. As both inoculations were entirely successful, it would appear reasonably certain that A. Pammelii on E. corollata is the aecidial stage of P. panici on P. virgatum.

9. Aecidium physalides Pk. On Physalis heterophylla Nees. Tippecanoe County. Collected May 22, 1901.

The writer wishes to acknowledge his indebtedness to Dr. Arthur for the determination of the rusts.

Effect of the Composition of the Soil Upon the Minute Structure of Plants.*

Herman B. Dorner.

The growth and distribution of plants are dependent upon four factors, namely, light, temperature, moisture and soil. Under moisture are included both that of the soil and that of the atmosphere. Soil and moisture may well be treated together, since the one is greatly dependent upon the other. In the work carried out, the only factor which was varied was that of the soil.

The changes occurring in plant structures, due to the variation of any of these factors, may be divided into two groups. These may be con-

*An abstract from a thesis presented to the Faculty of Purdue University for the degree of Master of Science.

veniently called *permanent* and *temporary* changes. By permanent changes are meant those which have become fixed in the plant and are due to generation after generation being subject to the same conditions. By temporary changes are meant those which have taken place for only a generation or two and which have not become impressed upon the plant to such an extent but that it will again revert to the normal on being placed under the former conditions. To this latter group belong the temporary reduction of leaf surfaces, stunted growths, and other similar changes. It is only this latter group which can possibly figure in the work carried on.

The study of the gross changes, due to the variation of soil conditions, has always been one of great interest to the botanist. These changes may be seen in nature all about us and often the vegetation of a region will give, to the trained eye, the conditions of the soil. The soil is now studied, not by chemical analysis, but by what will grow upon it.

The object of the experiment has been to determine whether these variations in the soil have given other than gross changes. Although the minute differences were the main object in view, all gross changes, which occurred, were noted in order to trace their connection with the minute ones.

The soils used in the experiment were a good, dark loam, a good yellow clay, and a clean pit sand.

The loam used contained only a very small quantity of sand and was taken from a field which had been under cultivation for a number of years, but to which little or no manure had been added for some time. It contained a large amount of silt and humus.

The clay also contained a very small quantity of sand and was secured only a short distance from a brickyard. The soil, however, was a little too light for brick-making.

The sand was a clear pit sand, not over sharp or very coarse. On washing it showed very little silt or foreign substances.

The other three conditions, temperature, light and moisture, were kept, as nearly as possible, uniform for all.

In watering, great care was taken to keep them in the best growing condition. The plants were only given water when they required it, so that in no case were they overwatered or allowed to dry out more than possible.

The plants were grown in a greenhouse with a day temperature of about 21 degrees C., and a night temperature of about 16 degrees C. However, on bright, sunny days, the temperature went as high as 27-30 degrees C.

The plants were arranged upon the bench with enough distance between them to allow them to receive light from all sides. This was necessary in order to avoid distortions due to overcrowding.

In selecting the plants, an attempt was made, as far as possible. to select only those which were representatives of large families. Those used were the carnation, chrysanthemum, geranium, bean, corn, and the onion. At the same time they also represent three modes of reproduction; namely, by seeds, by bulbs, and by the ordinary cutting or slip.

In making a study of the gross difference the following points were noted: The size of the plant, the length of the petiole, size and color of the leaves, diameter of the stems, length of the internodes, and size and abundance of the roots. For the minute differences, the structures of the leaf, stem, and roots were studied.

In counting the number of stomata sections were taken from various parts of the leaves. The sections were then placed under the microscope and a spot chosen at random. Twenty counts were made for each side of the leaf and the average taken.

The bulbs of the onion and the seeds of the corn and bean were planted directly into the five-inch pots in which they were to remain. On the other hand, the rooted cuttings of the carnation, chrysanthemum, and geranium were first planted in two and one-half-inch pots and later transferred to four-inch pots, in which they were allowed to remain.

A close study of the changes in the gross structure, due to the variations in the soil, show that the effect of a heavy clay upon a plant is almost the same as that of a sand. This may be partly explained by the fact that although a clay soil is very rich in plant foods, the roots find such difficulty in penetrating it that the greater part of it is unavailable. Hence, the plant suffers in the same manner as when grown in sand, which is poor in plant foods.

A change in soil was found to result in:

First.—A decrease in size from the loam to the sand. In all cases the sand produced a dwarfed growth.

Second.—A decrease in leaf surface from loam to sand. In no case was the leaf surface in the sand over one-half that of the loam.

Third.—A variation in color. The clay soil gave a very dark green leaf, while that in the sand was always of a sickly, yellowish green.

Fourth.—A decrease in length of petioles from loam to sand.

Fifth.—A decrease in the diameter of the stem from loam to sand.

Sixth.—A decrease in the length of the internodes from loam to sand.

Seventh.—A decrease in the mass of roots from the loam to the sand with the exception in the case of the onion. However, when the size of the plant is taken into consideration, the mass of roots of the plants in sand was always relatively the greatest.

As a result of these numerous variations, the plants in the sand have a stunted growth above soil and an increased growth in the soil. This is also true of the clay, but not to such a great extent as in the sand.

The changes in the histological structure are not so general. Those which do take place are more for specific rather than general cases. The changes which are general may be summed up as follows:

First.—A decrease in the transpiring surface from the loam to the sand.

Second.—A decrease in the relative size of the woody tissues of the root from the loam to the sand. This decrease was due to a variation in the number of cells rather than to their size.

Third.—A larger number of crystals for the clay soil than either of the other two. This was true in the two plants in which the crystals were found, the carnation and the geranium. These crystals were found both in the stems and the leaves.

Fourth.—A greater wood development in the loam than in either of the others. This increase was not due so much to an increase in the size of the cells as to their number.

There was quite a variation in the number of stomata, but these variations were specific and not general. In some cases the loam had the highest average, in others the clay, but in most cases the greatest number were in the sand. In one case, the corn, the loam showed the greatest average for both sides of the leaf. In the bean, the clay gave the greatest average, while in the onion, carnation and geranium the sand gave the most. (See table.)

In five cases out of the six, the loam gave the thickest leaves. In the sixth case, that of the carnation, the clay gave the greatest average. This increase in thickness was caused by a general increase in thickness of all the tissues of the leaf.

In those plants bearing trichomes it was found that those growing in the loam had the smallest number.

An interesting fact was noted in connection with the development of wood in the carnation. The loam here gave the greatest wood development and the clay the least, while on the other hand the clay showed a heavy band of hard-bast. A decrease in the amount of woody tissue seems to have been followed by an increase in the amount of hard-bast. In the clay specimens where there is such a large amount of hard-bast, the wood is merely represented by a few large vessels and a few wood cells.

In conclusion, it may be said that as a result of the variation of soils, there are more marked changes in the gross than in the minute structure. The changes in gross structure are general for all the plants studied, while the changes in the minute structures are more for specific than for general cases.

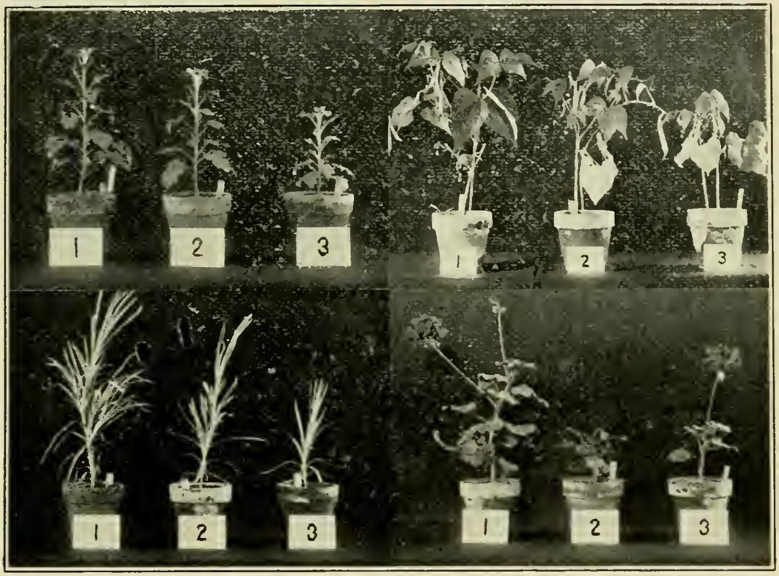
TABLE SHOWING NUMBER OF STOMATA PER SQUARE MM.

	Upper Side.			Lower Side.			Average for Both Sides.		
	Sand.	Clay.	Loam.	Sand.	Clay.	Loam.	Sand.	Clay.	Loam.
Bean	7.2	1.6	3.6	342.8	382.8	162.4	175.0	192.2	133.0
Corn	34.0	32.0	43.6	72.8	63.2	72.0	53.4	47.6	57.8
Onion	....	....	....	85.6	53.2	53.6	.....	.....	.....
Carnation	87.2	88.2	74.6	73.8	69.4	67.6	80.5	78.8	71.1
Geranium	62.4	42.4	35.2	209.8	177.0	195.6	136.1	109.7	115.4
Chrysanthemum*	....	....	....	81.6	97.4	88.2	....	.....	.....

*No count was made for the upper side, as it was impossible to remove the epidermis.

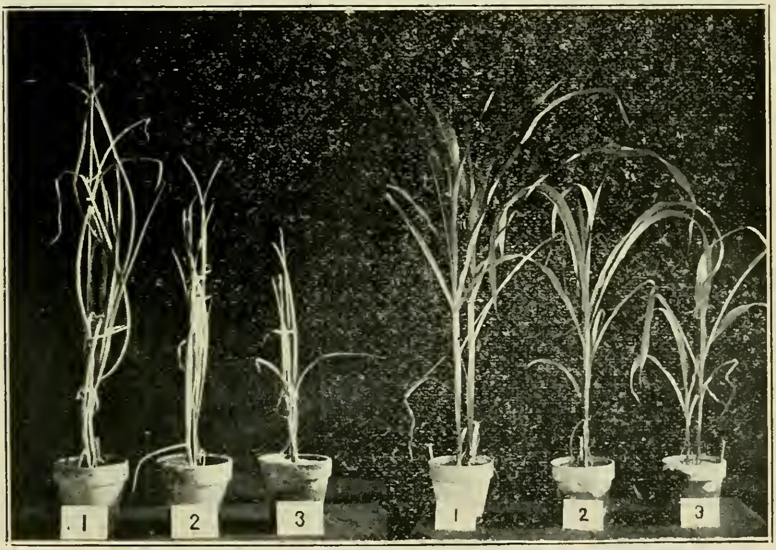
EXPLANATION OF PLATES.

In the illustrations, 1 always represents those plants grown in loam; 2, those in clay; and 3, those in sand.



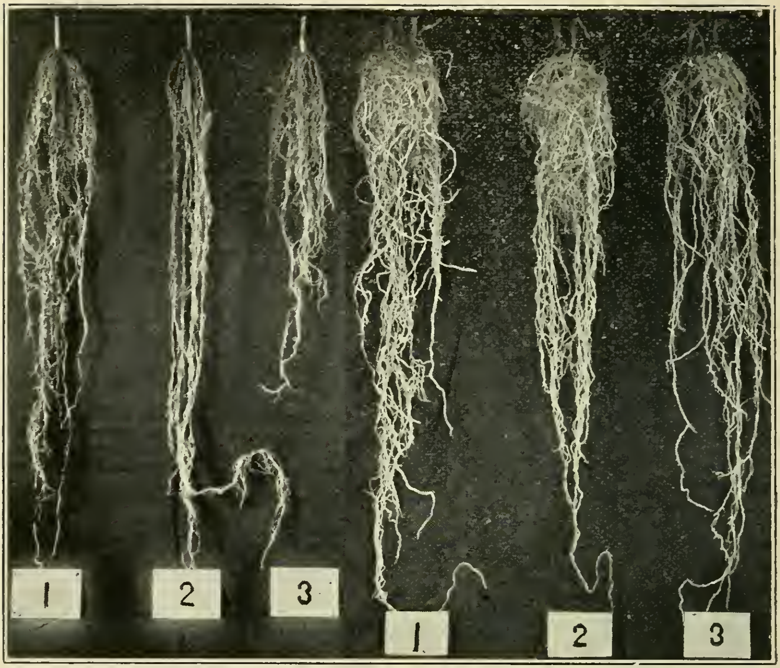
Chrysanthemum. Carnation.

Bean. Geranium.

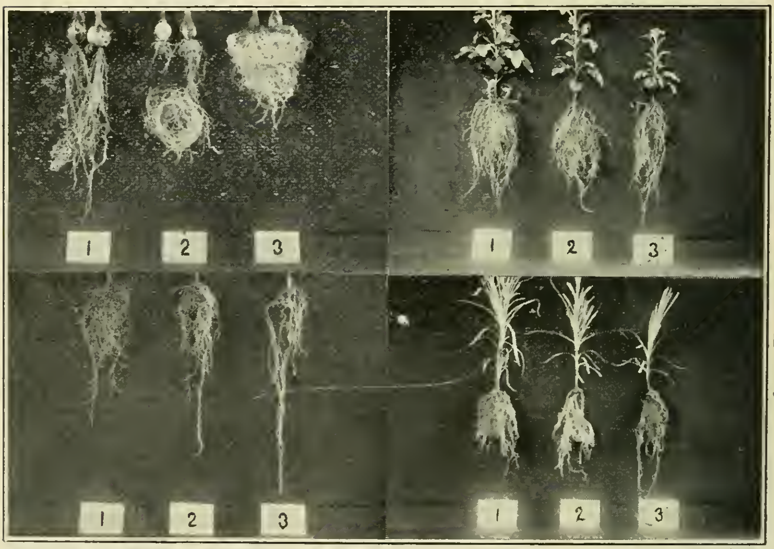


Onion.

Corn.



Bean. Corn.



Onion.
Geranium.

Chrysanthemum.
Carnation.

A Collection of Myxomycetes.

Fred Mutchler.

This collection was made during the month of October, 1901, in the neighborhood of Bloomington, Ind. Lister's "Mycetozoa" was used in classifying them and the names given therein have been observed in this list.

Amaurosporales. (Spores violet.)

I. *Calcarinea.* (Sporangia containing lime.)

Order I. Physoraceae. (Lime in granules.)

4. Fuligo septica Gmelin.

Order II. Didymiaceae. (Lime in crystals.)

12. Didymium nigripes Fries.
Didymium Xanthopus Fries.

II. *Amaurochaetineae.* (Sporangia without lime.)

Order I. Stemonitaceae.

15. Stemonitis splendens Rost.
Stemonitis fusca Rost.
Stemonitis fusca, var. confluens Rost.
Stemonitis ferruginea Ehrenb.

Lamprosporales. (Spores other than violet.)

I. *Anemineae.* (No capillitium.)

Order I. Heterodermaceae.

24. Dictydium umbilicatum Schrader.

II. *Calonemineae.* (Capillitium present.)

Order I. Trichiaceae.

33. Trichia fallax Pers.
Trichia affinis De Bary.
Trichia favoginea Pers.
Trichia contorta Rost.
Trichia persimilis Karst.
Trichia botrytis Pers.
Trichia scabra Pers.
Trichia varia Pers.

34. Oligonema nitens Rost.

35. Hemitrichia rubiformis Lister.
Hemitrichia leocarpa Lister.

Hemitrichia clavata Rost.
Hemitrichia intorta Lister.
Hemitrichia Karstenii Lister.
Hemitrichia stipata Mass.

Order II. Arcyriaceae.

37. Arcyria pucinea Pers.
Arcyria stipata List.
Arcyria digitata McBr.
Arcyria albida Pers.
Arcyria incarnata Pers.
Arcyria nutans (Bull.) Grev.
Arcyria ferruginea Sant.
Arcyria flava Pers.
Arcyria insignis Kalchbr. and Cooke.

39. Perichaena variabilis Rost.
Perichaena chrysosperma List.

Order III. Margaritaceae.

41. Dianema depressum List.

Order IV. Lycogalaceae.

43. Lycogala miniatum Pers.
Lycogala exigium Morg.
Lycogala flavo fuscum Rost.

A Study of the Histology of the Wood of Certain Species of Pines.

Katherine E. Golden.

The conifers grow in thickness similarly to the dicotyledons, but their wood differs very considerably, particularly the secondary wood, in which wood vessels are entirely absent. In the first-year wood a few vessels are developed close to the pith, but the after-growth is composed entirely of tracheides. The tracheides are fibre-like elements with peculiar bordered pits, and are very similar in their appearance in the different species, and yet the wood, taken as a whole, differs very materially, varying from the very soft, light wood of the white pine to the hard, dense wood of the long-leaf pine.

In order to determine, if possible, what peculiarity of structure produced such variations in the wood, since the wood itself is formed entirely of similar elements, and there is not the chance for variations in structure that appear in the dicotyledonous wood, certain species of the pines were examined microscopically, by means of sections and by maceration of the wood, by the latter method separating the elements. Thirteen species were examined. The wood varied in age from seven years in Pinus glabra to over fifty years in Pinus elliottii. In order to compare

Pine Tracheides. X 145.

the elements in the different species, and also the spring and summer wood of the same species, camera lucida drawings were made of the tracheides. These were then measured, so as to determine the actual length, width, and the thickness of the walls of the spring and the summer woods.

The tables give the results of the measurements, the characteristics of the woods as obtained from sections studied with the microscope, and also the properties of the wood in bulk.

NAME.	Length in Mm.		Width in μ.		Ratio Between Length and Width.		Thickness of Walls in μ.		Ratio Between Width and Thickness.	
	Spring.	Summer.	Spring.	Summer.	Spring.	Summer.	Spring.	Summer.	Spring.	Summer.
Pinus strobus	3.7000	3.6000	47.97	21.21	77.11	169.73	5.42	6.81	8.85	3.31
Pinus monticola	4.3330	4.9333	42.95	34.09	100.88	144.71	4.73	8.14	9.08	4.18
Pinus flexilis	2.7333	2.9250	34.09	15.90	80.17	183.96	5.68	6.25	6.00	2.54
Pinus resinosa	2.0250	2.0500	44.69	27.27	45.31	75.17	4.16	6.81	10.74	4.00
Pinus torreyana	3.5333	3.1333	41.66	32.57	84.81	96.20	7.19	11.55	5.78	2.81
Pinus ponderosa	3.2833	3.0222	48.48	35.22	67.72	85.80	3.78	10.03	12.82	3.51
Pinus ponderosa scopulorum.	3.2880	3.0000	25.37	18.18	129.60	164.40	2.46	3.97	10.31	4.57
Pinus contorta	2.9666	3.0333	49.62	35.60	59.78	85.20	4.92	9.46	10.08	3.85
Pinus tæda	6.4444	6.7250	56.06	33.33	114.95	201.77	4.54	10.60	12.35	3.14
Pinus rigida	2.4000	3.0583	42.80	32.95	56.07	92.81	3.03	9.46	14.12	3.48
Pinus glabra	2.2222	2 6055	46.96	26.13	47.32	99.71	4.54	9.84	10.34	2.65
Pinus palustris	4.4555	4.8533	43.56	40.90	102.28	118.66	6.43	13.63	6.77	3.00
Pinus elliottii	5.2590	4.9440	59.09	43.16	89.00	114.55	8.71	16.09	6.78	2.68

NAME.	Spring Wood.	Summer Wood.	Tyloses.	Resin Ducts.	Medullary Rays.
Pinus strobus	Nearly all	Thin ring, indistinct		Single, promiscuous	1 row of cells, obscure.
Pinus monticola	Nearly all	Thin ring, indistinct	Present	Single, pairs, promiscuous	1 row of cells, widens, then narrows, obscure.
Pinus flexilis	Large amount	Small amount, distinct	Present	Single, pairs, promiscuous	1 row of cells, rarely more, conspicuous.
Pinus resinosa	About ⅔	About ⅓, indistinct	Present	Single, promiscuous	1 row of cells, rarely 2 or 3, obscure.
Pinus torreyana	About $\frac{4}{5}$	About $\frac{1}{5}$, distinct	Present	Single, promiscuous	1 row of cells, rarely more, obscure.
Pinus ponderosa	Nearly all	Thin ring, indistinct		Single, pairs, in summer wood	1 row of cells, obscure.
Pinus ponderosa scopulorum	About ¼	About ¾, not dense		Single, pairs, in summer wood	1 row of cells, obscure.
Pinus contorta	About ⅔	About ⅓, distinct	Present	Single pairs, promiscuous	1 row of cells, rarely more, obscure.
Pinus tæda	About ½	About ½, distinct		Single, promiscuous	1 row of cells, widen into more, obscure.
Pinus rigida	About ¾	About ¼, indistinct		Single, in summer wood or close to it	1 row of cells, widen to 3 or 4, obscure.
Pinus glabra	About $\frac{9}{10}$	About $\frac{1}{10}$, distinct		Single, promiscuous	1 row of cells, rarely 2, obscure.
Pinus palustris	About ⅔	About ⅓, distinct		Single, in summer wood, near spring	1 row of cells, rarely more, conspicuous.
Pinus elliottii	About ⅓	About ⅔, distinct	Present	Single, in spring and early summer	1 row of cells, rarely more, conspicuous.

NAME.	Weight.	Strength.	Density.	Grain.
Pinus strobus	Light	Not strong	Soft	Straight, fine.
Pinus monticola	Light	Not strong	Soft, compact	Straight.
Pinus flexilis	Light	Not strong	Soft, compact	Close.
Pinus resinosa	Light	Moderately strong	Hard, compact	Coarse.
Pinus torreyana	Light	Not strong	Soft, compact	Rather close.
Pinus ponderosa	Heavy	Strong	Hard, compact	Not coarse.
Pinus ponderosa scopulorum	Heavy	Strong	Hard, compact	Not coarse.
Pinus contorta	Light	Strong	Hard	Coarse.
Pinus tæda	Light	Not strong	Not hard	Very coarse.
Pinus rigida	Light	Not strong	Soft	Coarse.
Pinus glabra	Light	Not strong	Soft	Very coarse.
Pinus palustris	Heavy	Very strong	Very hard, compact	Coarse.
Pinus elliottii	Heavy	Very strong	Very hard, compact	Coarse.

NAME.	COLOR.		Quality.
	Heartwood.	Sapwood.	
Pinus strobus	Light brown or red	White	Good quality.
Pinus monticola	Light brown or red	Nearly white	Inferior quality, resembles P. strobus.
Pinus flexilis	Light yellow, red on exposure.	Nearly white	Inferior quality.
Pinus resinosa	Yellow	Nearly white	Tough, elastic, does not shrink, warp in seasoning.
Pinus torreyana	Light red	Light yellow	Brittle.
Pinus ponderosa	Light red	White	Brittle, not durable, vary considerably.
Pinus ponderosa scopulorum	Light red	White	Brittle, not durable, vary considerably.
Pinus contorta	Brown, reddish	Nearly white	Brittle.
Pinus tæda	Light brown	Orange to white	Brittle, not durable, inferior.
Pinus rigida	Reddish	Yellow or white	Rigid, durable.
Pinus glabra	Light brown	Nearly white	Brittle, not durable.
Pinus palustris	Light red or orange	Nearly white	Tough, durable.
Pinus elliottii	Dark orange	Light orange	Tough, durable.

In examining the figures obtained it is seen there are six species in which the spring wood tracheides are longer than those of the summer, while seven species have the summer tracheides the longer. The species in each group show variations in hardness and strength, so that taking the length of the tracheides as a factor by itself nothing can be deduced in regard to the quality of the wood, but taking the length and comparing it with the width of the cells, and again comparing the width and the thickness of walls together, and the amount of the spring and summer wood, the strength can be determined within limits in each species.

For instance, in P. ponderosa scopulorum the spring tracheides are 129.6 times as long as they are wide, and the summer tracheides 164.4 times their width, the thickness of their walls is not nearly as great as that of many of the others, but when the thickness is compared with the width of the cells, it is found to be fairly thick, and as about two-thirds of the annual ring is summer wood, we have an explanation of the strength of the wood.

Taking any of these factors alone, it does not mean anything, as the length of the elements may be very considerable, but the width may be also; then, again, the elements may have rather thin walls, if the thickness of the wall alone were considered. But when the size of the cell as a whole is taken into consideration along with the thickness, the proportion of wall may be greater than the figures representing the thickness indicate.

Contributions to the Flora of Indiana.

Stanley Coulter.

The notes included in this contribution are based, partly, upon a critical study of certain species and partly upon reports and materials submitted by those interested in perfecting our knowledge of the flora of the State. They are presented in the hope that they may prove of interest and value to the botanical workers of the State.

Pinus Strobus L. White Pine.

From Mr. C. F. Very, of New Albany, I have received abundant specimens of the leaves and cones of this species with the following notes. The specimens are from trees planted by the father of Mr. Very some seventy years ago, and one of them is about sixty feet in height, with a trunk diameter of eighteen inches: "They came from that native grove of white pine in the northeastern part of Floyd County, near the line of Clark. At the time my father got them, about seventy years ago, there was quite a grove of the white pines there, one of them being quite an old tree, which would throw them back of the time of white men. The Knobs in that region are now covered with old field scrub pine" (P. Virginiana Mill). The note is interesting as extending the local range of the white pine.

Eriophorum gracile Koch, as given in the State Flora, page 655, becomes *E. paucinervium* (Engelm.) A. A. Eaton, as will be seen by reference to Britton's Manual, page 182, and the latter name should replace it.

Eriophorum gracile Koch, of Britton's Manual, but not of the Illustrated Flora, has been collected by Mr. C. C. Deam, of Bluffton, in Wells County. The determination of the form was made by E. S. Steele, Assistant Botanist, Department of Agriculture, Washington.

E. paucinervium, therefore, replaces *E. gracile* of the State Flora, and *E. gracile* of Britton's Manual is to be added to the Flora.

Quercus Texana Buckley.

In Britton's "Manual of the Flora of the Northern States and Canada," page 333, it will be seen that this species becomes *Quercus Schneckii* Britton (*Q. Texana* Sargent, in part, not Buckley). Under the former name it was reported in the "Catalogue of the Flowering Plants and of the Ferns and Their Allies Indigenous to Indiana,"[1] as occurring in Gibson, Posey and Knox Counties, upon the authority of Dr. J. Schneck. The statement was also made that it would be found to extend farther northward along the Wabash River. Specimens have come into my hands since that report from Vermillion County, where it occurs in considerable abundance. While closely allied to *Q. palustris* DuRoi, with which it is doubtless often confused, it is also liable to be mistaken on casual inspection for *Q. rubra* L. In addition to the leaf characters which serve to separate the forms, I have found the shape of the buds and color of the twigs of value. The buds are more sharply conical and apparently much more compactly built than in either *Q. rubra* or *Q. palustris*. The twigs are of a lighter, more definite gray than in the other forms and have in addition a peculiar dusty appearance, because of their being slightly tomentulose. A reference to Britton's Manual as cited above will give leaf and fruit characters. I submit with this specimens in flower and fruit, labelled *Q. Texana* Buckley,

---

[1] Report of State Geologist, p. 710.

which were collected in low bottoms two miles east of Mt. Carmel, Ill., by Dr. J. Schneck. In the Catalogue of the State Flora, therefore, *Q. Schneckii* Britton should replace *Q. Texana* Buckley, and Vermillion County be added to the range there assigned.

Quercus ellipsoidalis E. J. Hill. Hill's Oak.

Mr. Hill informs me that this oak occurs in the northwestern counties of the State. The range as given in Britton's Manual, page 334, is Illinois, Michigan and Minnesota. It is a tall tree with drooping lower branches, close, gray bark, the innermost layer being yellowish. The leaves are oval to obovate-orbicular in outline, from 6-15 cm. long when mature, deeply 5-7 lobed, with rounded sinuses; shining above, glabrous or nearly so beneath; base broadly cuneate to truncate; petioles 2.5-5 cm. long. Acorn ellipsoid to subglobose, 1-2 cm. long, 1-1.5 cm. thick, 1-2 times as long as cup. (Britton's Manual, *loc. cit.*) The species should be added to the flora.

Quercus pagodaefolia (Ell.) Ashe.

It will be recalled that last year[2] I expressed the opinion that the above form was "so well marked in our area as to seem entitled to varietal, if not, indeed, to specific rank." I further stated, after reviewing the history of the species, that in my judgment "it should be written *Q. digitata pagodaefolia* Ell., and given a place in the flora."

In Britton's Manual, page 334, it appears as above, with the following leaf and fruit description:

"Leaves oval to oblong in outline, cuneate to truncate at base, 2-3 dm. long, deeply 5-11 lobed, persistently white-tomentulcse below, dark green above, the lobes narrowly triangular, spreading or somewhat ascending, usually entire; twigs tomentose; petioles 3-6 cm. long; cup sessile, shallow, its bracts appressed; acorn globose, about 1 cm. in diameter; about one-half enclosed in cup."

The tree, which is from 100-110 degrees high in its maximum development, is usually found in wet or moist soil. In the southwestern counties, Dr. J. Schneck. I submit for your inspection specimens collected by Dr. Schneck near East Mt. Carmel, Ind.

Q. pagodaefolia (Ell.) Ashe is, therefore, to be added to the flora, having a place between *Q. digitata* (Marsh) Sudw., and *Q. Marylandica* Muench, being given the range assigned above.

[2] Proceedings Indiana Academy Science, Vol. 11, p. 142.

Quercus Alexanderi Britton. (Manual of the Flora of the Northern States and Canada, page 336.)

To this species is to be referred the forms cited in the State Catalogue, page 713, under *Q. Prinus* L.

Q. Alexanderi is closely allied to *Q. acuminata* (Michx.) Houda, including really what were formerly regarded as broad-leaved forms of the latter species. The description is as follows:

"A tree similar to the preceding species (*Q. acuminata*), but the leaves broadest above the middle, obovate or oblong-obovate; cup cupulate, short-stalked or sessile, shallow; acorn ovoid, 1.5-2 cm. long, 2-3 times as high as the cup; bark; especially that of the old trees, flaky."

Probably fairly distributed throughout the State in the same situations as *Q. acuminata*.

In some respects, notably the venation of the leaf and the acorn, the form closely approaches *Q. Prinus*. The catalogue should, however, be corrected to read as indicated by this paragraph. Specimens of the leaves are herewith presented.

Sisymbrium altissimum L.

This species, adventive from Europe, is reported by Dr. Robert Hessler as growing along the State Line Railroad, east of Lake Cicott, Cass County, June 7, 1901; Lake Maxinkuckee, Marshall County, H. W. Clark. The species is easily distinguished from the other members of the genus by its height, from 6-9 dm.

Vicia angustifolia Roth.

"Growing plentifully along the old Eel River railroad in the northern portion of Logansport. I had not noticed it in former years and it must have been introduced recently." (Robert Hessler.)

Britton, in his manual, page 566, gives the range of the species from Nova Scotia to Florida. This record is a western extension of the range. The inflorescence being axillary, separates it readily from the other members of the genus except *V. sativa* L. and *V. sepium* L.; from both of which it is easily distinguished by the character of the leaflets.

Scrophularia leporella Bicknell.

"Lake Cicott, June 7, 1901, in flower; Lake Maxinkuckee, July 21, 1901, in fruit. Plants are more upright and bloom much earlier than the other species, at least by the end of May." (Robert Hessler.) Also collected at Lake Maxinkuckee by H. W. Clark.

The form is further separated from *S. Marylandica* L. by its leaves being "incised dentate" instead of sharply serrate; the mostly alternate instead of opposite bractlets; the sharply contracted throat of the corolla, and the corolla being dull instead of shining within.

An examination of the specimens in the Purdue Herbarium show that all of the specimens collected in flower in May and June are to be referred to this species, which will probably be found generally distributed throughout the State.

The following additions are also reported by Mr. H. W. Clark, but as specimens have not been seen they are included only tentatively:

Savastana odorata (L.) Scribn. Holy Grass. Seneca Grass.

Lake Maxinkuckee, Marshall County. This locality would be a southward extension of range in the central United States, the recorded range being "south to Wisconsin."

Lilium umbellatum Pursh. Western Red Lily.

Lake Maxinkuckee, Marshall County. The only objection to this reference seems to lie in the fact that it is a dry soil plant, and the further fact that the majority of Mr. Clark's Maxinkuckee collections were in the marginal zones near the lake. The leaf character and arrangement would, however, seem sufficient to separate it readily from any related forms.

The following species are to be added upon the authority of Britton's "Manual of the Flora of the Northern States and Canada." I have not as yet had opportunity to examine Herbarium specimens to verify the references, but have no reason to doubt their accuracy.

Lycopodium porophilum Lloyd and Underw. Rock Club-moss.

Britton's Manual, page 1037. "Differs from *L. lucidulum* in its nearly linear entire leaves and smaller size, and from *L. Selago* in the bases of its leaves, which are flattened. On sandstone rocks, Wisconsin, Indiana and Alabama." The familiarity of Dr. Underwood with the Pteridophytes of the State places this reference beyond question.

Talinum rugospermum Holzinger. Rough-seeded Talinum.

Britton's Manual, page 1047. "Similar to T. teretifolium and confused with that species. * * *T. teretifolium* differs in having short, blunt style-lobes, oblong anthers and smooth, black seeds. In dry soil Indiana to Wisconsin and Minnesota." In *T. rugospermum* the seeds are pale and roughened.

The following additional stations are reported by Dr. Robert Hessler and indicate work of a character that would much simplify the labors of the Biological Survey if it could become more general:

Xyris flexuosa Muhl. Slender Yellow-eyed Grass.

Low places along Lake Cicott, Cass County, August, 1901. Previous reported stations are Laporte, Lake and Kosciusko counties.

Veratrum Woodii Robbins. Wood's False Hellebore.

Found several miles southeast of Logansport, Cass County. No flowers developed, probably on account of the extreme dryness of the season.

Trillium nivale Riddell. Early Wake Robin.

On rocky, shaded hillsides, rare. This species is also found in abundance in Tippecanoe County, on the grounds of the Germania Club south of LaFayette.

Jeffersonia diphylla (L.) Pers. Twin-leaf.

A patch on a shady hillside east of Logansport, Cass County.

Hamamelis Virginiana L. Witch Hazel.

On limestone cliffs along the Wabash River, near Logansport.

Floerkea proserpinacoides Willd. False Mermaid.

In low, moist woods at the Northern Indiana Hospital for Insane, Cass County. A large patch in bloom, May 2, 1901.

Oenothera laciniata Hill. Sinuate-leaved Evening Primrose.

Along the Eel River railroad, about two miles east of Logansport, Cass County. Spreading rapidly along the right of way of the railroad. Previous records for the State are Vigo, Daviess and Fayette counties.

Lysimachia quadrifolia L. Whorled Loosestrife.

In sandy soils about Lake Maxinkuckee, Marshall County.

Naumburgia thyrsiflora (L.) Duby. Tufted Loosestrife.

Wet places about Logansport, Cass County.

Asclepias amplexicaulis J. E. Smith. (*A. obtusifolia* Michx.) Blunt-leaved Milkweed.

A cluster found in a sand field near Lake Cicott, only a short distance from the railroad.

The following forms are spreading with extreme rapidity in locations indicated:

Camelina sativa (L.) Crantz. False Flax.

In Logansport, along the right of way of the Wabash railroad.

Micrampelis lobata (Michx.) Greene. Wild Balsam Apple.

Sicyos angulatus L. Star Cucumber. One-seeded Bur Cucumber.

"These vines, formerly rarely seen in Cass County, are now very common along the margins of the Wabash River, covering shrubs and small trees profusely and often crowding out small plants." (R. Hessler.)

Should the nomenclature of Britton's Manual, 1901, be generally adopted, many new species would be added to the flora of the State, since in that work any recognizable plant segregate is given specific rank. No sweeping changes should be made, however, until there has been sufficient time to judge as to whether the species there announced are possible of recognition except by the comparative methods of a great herbarium.

INDEX, 1901.

Proceedings of the
Indiana Academy
of Science
1902

PROCEEDINGS

OF THE

Indiana Academy of Science

1902.

EDITOR, - - DONALDSON BODINE.

ASSOCIATE EDITORS:

C. A. WALDO,
C. H. EIGENMANN,
V. F. MARSTERS,
M. B. THOMAS,
W. A. NOYES,
STANLEY COULTER,
THOMAS GRAY,
JOHN S. WRIGHT.

INDIANAPOLIS, IND.
1903

INDIANAPOLIS:
Wm. B. Burford, Printer
1903.

TABLE OF CONTENTS.

AN ACT TO PROVIDE FOR THE PUBLICATION OF THE REPORTS AND PAPERS OF THE INDIANA ACADEMY OF SCIENCE.

[Approved March 11, 1895.]

Preamble.

WHEREAS, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory body, assist in the direction and execution of any investigation within its province, without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State, and,

WHEREAS, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form, and,

WHEREAS, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement, therefore,

Publication of the Reports of the Indiana Academy of Science.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana,* That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

Editing Reports.

SEC. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such services, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports, shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less

Number of printed Reports.

than 1,500 nor more than 3,000 copies of each of said reports shall be published, the size of the edition within said limits, to be determined by the concurrent action of the editors and the Commissioners of Public Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894.

Proviso.

Disposition of Reports.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

Emergency.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage.

AN ACT FOR THE PROTECTION OF BIRDS, THEIR NESTS AND EGGS.

[Approved March 5, 1891.]

Birds.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That it shall be unlawful for any person to kill any wild bird other than a game bird, or purchase, offer for sale any such wild bird after it has been killed, or to destroy the nests or the eggs of any wild bird.

Game birds.

SEC. 2. For the purpose of this act the following shall be considered game birds: the Anatidæ, commonly called swans, geese, brant, and river and sea ducks; the Rallidæ, commonly known as rails, coots, mudhens, and gallinules; the Limicolæ, commonly known as shore birds, plovers, surf birds, snipe, woodcock and sandpipers, tattlers and curlews; the Gallinæ, commonly known as wild turkeys, grouse, prairie chickens, quail, and pheasants, all of which are not intended to be affected by this act.

Penalty.

SEC. 3. Any person violating the provisions of Section 1 of this act shall, upon conviction, be fined in a sum not less than ten nor more than fifty dollars, to which may be added imprisonment for not less than five days nor more than thirty days.

Permits.

SEC. 4. Sections 1 and 2 of this act shall not apply to any person holding a permit giving the right to take birds or their nests and eggs for scientific purposes, as provided in Section 5 of this act.

Permits to Science.

SEC. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science to any properly accredited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to said Board written testimonials from two well-known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege and pay to said Board one dollar to defray the necessary expenses atttending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of such permit has killed

Bond.

Bond forfeited.

any bird or taken the nests or eggs of any bird for any other purpose than that named in this section and shall further be subject for each offense to the penalties provided in this act.

Two years. SEC. 6. The permits authorized by this act shall be in force for two years only from the date of their issue, and shall not be transferable.

Birds of prey. SEC. 7. The English or European House Sparrow (Passer domesticus), crows, hawks, and other birds of prey are not included among the birds protected by this act.

Acts repealed. SEC. 8. All acts or parts of acts heretofore passed in conflict with the provisions of this act are hereby repealed.

Emergency. SEC. 9. An emergency is declared to exist for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

OFFICERS, 1902–1903.

PRESIDENT,

WILLIS S. BLATCHLEY.

VICE-PRESIDENT,

CARL L. MEES.

SECRETARY,

JOHN S. WRIGHT.

ASSISTANT SECRETARY,

DONALDSON BODINE.

PRESS SECRETARY,

G. A. ABBOTT.

TREASURER,

W. A. McBETH.

EXECUTIVE COMMITTEE.

W. S. Blatchley,
Carl L. Mees,
John S. Wright,
Donaldson Bodine,
G. A. Abbott,
W. A. McBeth,
Harvey W. Wiley,
M. B. Thomas,
D. W. Dennis,
C. H. Eigenmann,
C. A. Waldo,
Thomas Gray,
Stanley Coulter,
Amos W. Butler,
W. A. Noyes,
J. C. Arthur,
J. L. Campbell,
O. P. Hay,
T. C. Mendenhall,
John C. Branner,
J. P. D. John,
John M. Coulter,
David S. Jordan.

CURATORS.

BOTANY	J. C. Arthur.
ICHTHYOLOGY	C. H. Eigenmann.
HERPETOLOGY, MAMMALOGY, ORNITHOLOGY	Amos W. Butler.
ENTOMOLOGY	W. S. Blatchley.

COMMITTEES, 1902–1903.

PROGRAM.

Mel. T. Cook, Glenn Culbertson.

MEMBERSHIP.

A. W. Butler, Donaldson Bodine, G. A. Abbott.

NOMINATIONS.

Thomas Gray, M. B. Thomas, C. H. Eigenmann.

AUDITING.

W. S. Blatchley, F. M. Webster.

STATE LIBRARY.

A. W. Butler, Stanley Coulter, C. A. Waldo, J. S. Wright.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

Stanley Coulter, John S. Wright, M. B. Thomas.

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, W. S. Blatchley.

EDITOR.

Donaldson Bodine, Wabash College, Crawfordsville.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, Donaldson Bodine, M. B. Thomas, J. C. Arthur, Stanley Coulter.

RELATIONS OF THE ACADEMY TO THE STATE.

C. A. Waldo, W. J. Karslake, R. W. McBride.

GRANTING PERMITS FOR COLLECTING BIRDS AND FISHES.

A. W. Butler, Stanley Coulter, W. S. Blatchley.

DISTRIBUTION OF THE PROCEEDINGS.

A. W. Butler, J. S. Wright, Donaldson Bodine, H. L. Bruner.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

Years.	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885–6	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886–7	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887–8	J. P. D. John	Amos W. Butler			O. P. Jenkins.
1888–9	John C. Branner	Amos W. Butler			O. P. Jenkins.
1889–90	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890–1	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891–2	J. L. Campbell	Amos W. Butler			C. A. Waldo.
1892–3	J. C. Arthur	Amos W. Butler	Stanley Coulter W. W. Norman		C. A. Waldo.
1893–4	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894–5	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895–6	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896–7	Thomas Gray	John S. Wright	A. J. Bigney		W. P. Shannon.
1897–8	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.
1898–9	C. H. Eigenman	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899–1900	D. W. Dennis	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900–1901	M. B. Thomas	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901–1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine	Geo. W. Benton	J. T. Scovell.
1902–1903	W. S. Blatchley	John S. Wright	Donaldson Bodine	G. A. Abbott	W. A. McBeth.

In Memoriam.

JOSEPH EASTMAN,

BORN

Fulton County, New York, January 29, 1842.

DIED

Indianapolis, June 5, 1902.

CONSTITUTION.

ARTICLE I.

SECTION 1. This association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigation and discussions as may further the aims and objects of the Academy as set forth in these articles.

Whereas, the State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or of one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

SECTION 1. Members of this Academy shall be honorary fellows, fellows, non-resident members or active members.

SEC. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and there-

after an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

Sec. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men, and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

Section 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a President, Vice-President, Secretary, Assistant Secretary, Press Secretary, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-Presidents of the Academy, shall constitute an Executive Committee. The President shall, at each annual meeting, appoint two members to be a committee which shall prepare the programs and have charge of the arrangements for all meetings for one year.

Sec. 2. The annual meeting of this Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the

Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past Presidents, together with the officers and Executive Committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not specially provided for in this constitution, in the interim between general meetings.

SEC. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The President shall deliver a public address on the morning of one of the days of the meeting at the expiration of his term of office.

3. The Press Secretary shall attend to the securing of proper newspaper reports of the meetings and assist the Secretary.

4. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

5. No bill against the Academy shall be paid without an order signed by the President and countersigned by the Secretary.

6. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

7. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

FELLOWS.

R. J. Aley	*1898	Bloomington.
J. C. Arthur	1893	Lafayette.
George W. Benton	1896	Indianapolis.
A. J. Bigney	1897	Moore's Hill.
A. W. Bitting	1897	Lafayette.
Donaldson Bodine	1899	Crawfordsville.
W. S. Blatchley	1893	Indianapolis.
H. L. Bruner	1899	Irvington.
Severance Burrage	1898	Lafayette.
A. W. Butler	1893	Indianapolis.
J. L. Campbell	1893	Crawfordsville.
Mel. T. Cook	1902	Greencastle.
John M. Coulter	1893	Chicago, Ill.
Stanley Coulter	1893	Lafayette.
Glenn Culbertson	1899	Hanover.
D. W. Dennis	1895	Richmond.
C. R. Dryer	1897	Terre Haute.
C. H. Eigenmann	1893	Bloomington.
Percy Norton Evans	1901	Lafayette.
A. L. Foley	1897	Bloomington.
Katherine E. Golden	1895	Lafayette.
M. J. Golden	1899	Lafayette.
W. F. M. Goss	1893	Lafayette.
Thomas Gray	1893	Terre Haute.
A. S. Hathaway	1895	Terre Haute.
W. K. Hatt	1902	Lafayette.
Robert Hessler	1899	Logansport.
H. A. Huston	1893	Lafayette.
Arthur Kendrick	1898	Terre Haute.
Robert E. Lyons	1896	Bloomington.
V. F. Marsters	1893	Bloomington.
C. L. Mees	1894	Terre Haute.
W. J. Moenkhaus	1901	Bloomington.

* Date of election.

Joseph Moore	1896	Richmond.
D. M. Mottier	1893	Bloomington.
W. A. Noyes	1893	Terre Haute.
J. H. Ransom	1902	Lafayette.
L. J. Rettger	1896	Terre Haute.
J. T. Scovell	1894	Terre Haute.
Alex. Smith	1893	Chicago, Ill.
W. E. Stone	1893	Lafayette.
Joseph Swain	*1898	Swarthmore, Pa.
M. B. Thomas	1893	Crawfordsville.
C. A. Waldo	1893	Lafayette.
F. M. Webster	1894	Champaign, Ill.
H. W. Wiley	1895	Washington, D. C.
John S. Wright	1894	Indianapolis.

NON-RESIDENT MEMBERS.

George H. Ashley	Charleston, S. C.
M. A. Brannon	Grand Forks, N. D.
J. C. Branner	Stanford University, Cal.
D. H. Campbell	Stanford University, Cal.
A. Wilmer Duff	Worcester, Mass.
B. W. Evermann	Washington, D. C.
Charles H. Gilbert	Stanford University, Cal.
C. W. Green	Stanford University, Cal.
C. W. Hargitt	Syracuse, N. Y.
O. P. Hay	Washington, D. C.
Edward Hughes	Stockton, Cal.
O. P. Jenkins	Stanford University, Cal.
D. S. Jordan	Stanford University, Cal.
J. S. Kingsley	Tufts College, Mass.
D. T. MacDougal	Bronx Park, New York City
T. C. Mendenhall	Worcester, Mass.
Alfred Springer	Cincinnati, Ohio.
L. M. Underwood	New York City.
Robert B. Warder	Washington, D. C.
Ernest Walker	Clemson College, S. C.

* Date of election.

ACTIVE MEMBERS.

G. A. Abbott....................................Indianapolis.
Frederick W. Andrews........................Bloomington.
George C. Ashman............................Frankfort.
Edward Ayres ....Lafayette.
Arthur M. Banta...............................Franklin.
Edwin M. Blake.................................Lafayette.
J. W. Beede......................................Bloomington.
Lee F. Bennett..................................Valparaiso.
William N. Blanchard.........................Greencastle.
Charles S. Bond.................................Richmond.
Fred J. Breeze ....Pittsburg.
E. M. Bruce.......................................Weston, Oregon.
A. Hugh Bryan...................................Indianapolis.
E. J. Chansler....................................Bicknell.
Howard W. Clark...............................Culver.
Otto O. Clayton.................................Pleasant Mills.
George Clements ....Springfield, Ill.
Charles Clickener ....Tangier.
U. O. Cox...Mankato, Minn.
William Clifford Cox..........................Columbus.
J. A. Cragwall....................................Crawfordsville.
Albert B. Crowe.................................Ft. Wayne.
M. E. Crowell....................................Franklin.
Edward Roscoe Cumings...................Bloomington.
Alida M. Cunningham........................Alexandria.
Lorenzo E. Daniels.............................Laporte.
H. J. Davidson...................................Baltimore, Md.
Charles C. Deam................................Bluffton.
Martha Doan ....Westfield.
J. P. Dolan...Syracuse.
Herman B. Dorner..............................Lafayette.
Hans Duden ....Indianapolis.
E. G. Eberhardt..................................Indianapolis.
Frank R. Eldred..................................Indianapolis.
M. N. Elrod...Columbus.
Samuel G. Evans.................................Evansville.

Carlton G. Ferris.............................Big Rapids, Mich.
E. M. Fisher..................................Urmeyville.
Wilbur A. Fiske...............................Richmond.
W. B. Fletcher................................Indianapolis.
Austin Funk...................................New Albany.
Charles W. Garrett............................Logansport.
Robert G. Gillum..............................Terre Haute.
Vernon Gould..................................Rochester.
Walter L. Hahn................................Bascom.
Victor K. Hendricks...........................Indianapolis.
Mary A. Hickman...............................Greencastle.
John E. Higdon................................Indianapolis.
Frank R. Higgins..............................Terre Haute.
John J. Hildebrandt...........................Logansport.
J. D. Hoffman.................................Lafayette.
Allen D. Hole.................................Richmond.
John N. Hurty.................................Indianapolis.
Lucius M. Hubbard.............................South Bend.
Alex. Johnson.................................Ft. Wayne.
Edwin S. Johonnott, Jr........................Terre Haute.
Ernest E. Jones...............................Kokomo.
Chancey Juday.................................Boulder, Col.
O. L. Kelso...................................Terre Haute.
Charles T. Knipp..............................Bloomington.
Henry H. Lane.................................Lebanon.
V. H. Lockwood................................Indianapolis.
Dumont Lotz...................................Indianapolis.
William A. McBeth.............................Terre Haute.
Robert Wesley McBride.........................Indianapolis.
Rousseau McClellan............................Indianapolis.
Richard C. McClaskey..........................Terre Haute.
Lynn B. McMullen..............................Indianapolis.
Edward G. Mahin...............................West Lafayette.
James E. Manchester...........................Vincennes.
W. G. Middleton...............................Richmond.
John A. Miller................................Bloomington.
H. T. Montgomery..............................South Bend.

Walter P. Morgan . . . . Terre Haute.
Fred Mutchler . . . . Terre Haute.
J. P. Naylor . . . . Greencastle.
Charles E. Newlin . . . . Irvington.
John Newlin . . . . West Lafayette.
John F. Newsom . . . . Stanford University, Cal.
R. W. Noble . . . . Chicago, Ill.
D. A. Owen . . . . Franklin.
Rollo J. Peirce . . . . Logansport.
Ralph B. Polk . . . . Greenwood.
James A. Price . . . . Ft. Wayne.
Frank A. Preston . . . . Indianapolis.
A. H. Purdue . . . . Fayetteville, Ark.
Ryland Ratliff . . . . Bloomington.
Albert B. Reagan . . . . Bloomington.
Claude Riddle . . . . Lafayette.
Giles E. Ripley . . . . Decorah, Iowa.
George L. Roberts . . . . Greensburg.
D. A. Rothrock . . . . Bloomington.
John F. Schnaible . . . . Lafayette.
E. A. Schultze . . . . Ft. Wayne.
John W. Shepherd . . . . Terre Haute.
Claude Siebenthal . . . . Indianapolis.
J. R. Slonaker . . . . Bloomington.
Richard A. Smart . . . . Lafayette.
Lillian Snyder . . . . Rockville.
Retta E. Spears . . . . Elkhart.
Charles F. Stegmaier . . . . Greensburg.
William Stewart . . . . Lafayette.
J. M. Stoddard . . . . Indianapolis.
William B. Streeter . . . . Indianapolis.
Frank B. Taylor . . . . Ft. Wayne.
J. F. Thompson . . . . Richmond.
A. L. Treadwell . . . . Oxford, Ohio.
Daniel J. Troyer . . . . Goshen.
A. B. Ulrey . . . . North Manchester.
W. B. VanGorder . . . . Worthington.

Arthur C. Veatch	Rockport.
H. S. Voorhees	Ft. Wayne.
J. H. Voris	Huntington.
B. C. Waldemaier	West Lafayette.
Daniel T. Weir	Indianapolis.
Jacob Westlund	Lafayette.
Fred C. Whitcomb	Delphi.
William M. Whitten	South Bend.
Neil H. Williams	Indianapolis.
William Watson Woollen	Indianapolis.
J. F. Woolsey	Indianapolis.

Fellows	47
Non-resident members	20
Active members	118
Total	185

LIST OF FOREIGN CORRESPONDENTS.

AFRICA.

Dr. J. Medley Wood, Natal Botanical Gardens, Berea, Durban, South Africa.

South African Philosophical Society, Cape Town, South Africa.

ASIA.

China Branch Royal Asiatic Society, Shanghai, China.

Asiatic Society of Bengal, Calcutta, India.

Geological Survey of India, Calcutta, India.

Indian Museum of India, Calcutta, India.

India Survey Department of India, Calcutta, India.

Deutsche Gesellschaft, für Natur- und Völkerkunde Ostasiens, Tokio, Japan.

Imperial University, Tokio, Japan.

Koninklijke Naturkundige Vereeniging in Nederlandsch-Indie, Batavia, Java.

Hon. D. D. Baldwin, Honolulu, Hawaiian Islands.

EUROPE.

V. R. Tschusizu Schmidhoffen, Villa Tannenhof, Halle in Salzburg, Austria.

Herman von Vilas, Innsbruck, Austria.

Ethnologische Mittheilungen aus Ungarn, Budapest, Austro-Hungary.

Mathematische und Naturwissenschaftliche Berichte aus Ungarn, Budapest, Austro-Hungary.

K. K. Geologische Reichsanstalt, Vienna (Wien), Austro-Hungary.

K. U. Naturwissenschaftliche Gesellschaft, Budapest, Austro-Hungary.

Naturwissenschaftlich-Medizinischer Verein in Innsbruck (Tyrol), Austro-Hungary.

Editors "Termeszetrajzi Fuzetk," Hungarian National Museum, Budapest, Austro-Hungary.

Dr. Eugen Dadai, Adj. am. Nat. Mus., Budapest, Austro-Hungary.

Dr. Julius von Madarasz, Budapest, Austro-Hungary.

K. K. Naturhistorisches Hofmuseum, Vienna (Wien), Austro-Hungary.

Ornithological Society of Vienna (Wien), Austro-Hungary.

Zoologische-Botanische Gesellschaft in Wien (Vienna), Austro-Hungary.

Dr. J. von Csato, Nagy Enyed, Austro-Hungary.

Botanic Garden, K. K. Universitat, Wien (Vienna), Austro-Hungary.

Malacological Society of Belgium, Brussels, Belgium.

Royal Academy of Science, Letters and Fine Arts, Brussels, Belgium.

Royal Linnean Society, Brussels, Belgium.

Societé Belge de Geologie, de Paleontologié et Hydrologie, Brussels, Belgium.

Societé Royale de Botanique, Brussels, Belgium.

Societé Geologique de Belgique, Liège, Belgium.

Royal Botanical Gardens, Brussels, Belgium.

Bristol Naturalists' Society, Bristol, England.

Geological Society of London, London, England.

Dr. E. M. Holmes, British Pharm. Soc'y, Bloomsbury Sq., London, W. C., England.

Jenner Institute of Preventive Medicine, London, England.

The Librarian, Linnean Society, Burlington House, Piccadilly, London W., England.

Liverpool Geological Society, Liverpool, England.

Manchester Literary and Philosophical Society, Manchester, England.

"Nature," London, England.

Royal Botanical Society, London, England.

Royal Kew Gardens, London, England.

Royal Geological Society of Cornwall, Penzance, England.

Royal Microscopical Society, London, England.

Zoölogical Society, London, England.

Lieut.-Col. John Biddulph, 43 Charing Cross, London, England.

Dr. G. A. Boulenger, British Mus. (Nat. Hist.), London, England.

F. DuCane Godman, 10 Chandos St., Cavendish Sq., London, England.

Mr. Howard Saunders, 7 Radnor Place, Hyde Park, London W., England.

Phillip L. Sclater, 3 Hanover Sq., London W., England.

Dr. Richard Bowlder Sharpe, British Mus. (Nat. Hist.), London, England.

Prof. Alfred Russell Wallace, Corfe View, Parkstone, Dorset, England.

Botanical Society of France, Paris, France.

Ministérie de l'Agriculture, Paris, France.

Societé Entomologique de France, Paris, France.

L'Institut Grand Ducal de Luxembourg, Luxembourg, Lux., France.

Soc. de Horticulture et de Botan. de Marseille, Marseilles, France.

Societé Linneenne de Bordeaux, Bordeaux, France.

La Soc. Linneenne de Normandie, Caen, France.

Soc. des Naturelles, etc., Nantes, France.

Zoölogical Society of France, Paris, France.

Baron Louis d'Hamonville, Meurthe et Moselle, France.

Pasteur Institute, Lille, France.

Museum d'Histoire Naturelle, Paris, France.

Botanischer Verein der Provinz Brandenburg, Berlin, Germany.

Deutsche Geologische Gesellschaft, Berlin, Germany.

Entomologischer Verein in Berlin, Berlin, Germany.

Journal für Ornithologie, Berlin, Germany.

Prof. Dr. Jean Cabanis, Alte Jacob Strasse, 103 A., Berlin, Germany.

Augsburger Naturhistorischer Verein, Augsburg, Germany.

Count Hans von Berlspsen, Münden, Germany.

Braunschweiger Verein für Naturwissenschaft, Braunschweig, Germany.

Bremer Naturwissenschaftlicher Verein, Bremen, Germany.

Ornithologischer, Verein München, Thierschstrasse, 37½, München, Germany.

Royal Botanical Gardens, Berlin W., Germany.

Kaiserliche Leopoldische-Carolinische Deutsche Akademie der Naturforcher, Halle Saale, Wilhemstrasse 37, Germany.

Königlich-Sächsische Gesellschaft der Wissenschaften. Mathematisch-Physische Classe. Leipzig. Saxony. Germany.

Naturhistorische Gesellschaft zu Hanover. Hanover. Prussia, Germany.

Naturwissenschaftlicher Verein in Hamburg. Hamburg. Germany.

Verein für Erdkunde. Leipzig. Germany.

Verein für Naturkunde. Wiesbaden. Prussia.

Belfast Natural History and Philosophical Society. Belfast. Ireland.

Royal Dublin Society. Dublin.

Royal Botanic Gardens. Glasnevin. County Dublin. Ireland.

Societa Entomologica Italiana. Florence. Italy.

Prof. H. H. Giglioli. Museum Vertebrate Zoölogy. Florence. Italy.

Dr. Alberto Perugia. Museo Civico di Storia Naturale, Genoa, Italy.

Societa Italiana de Scienze Naturali. Milan. Italy.

Societa Africana d' Italia. Naples. Italy.

Dell 'Academia Pontifico de Nuovi Lincei. Rome. Italy.

Minister of Agriculture. Industry and Commerce. Rome. Italy.

Rassegna della Scienze Geologiche in Italia, Rome, Italy.

R. Comitato Geologico d' Italia. Rome. Italy.

Prof. Count Tomasso Salvadori. Zoölog. Museum. Turin. Italy.

Royal Norwegian Society of Sciences. Throndhjem. Norway.

Dr. Robert Collett. Kongl. Frederiks Univ. Christiania. Norway.

Academia Real des Sciencias de Lisboa (Lisbon). Portugal.

Comité Geologique de Russie. St. Petersburg. Russia.

Imperial Academy of Sciences. St. Petersburg. Russia.

Imperial Society of Naturalists. Moscow. Russia.

Jardin Imperial de Botanique, St. Petersburg, Russia.

The Botanical Society of Edinburgh, Edinburgh, Scotland.
John J. Dalgleish, Brankston Grange, Bogside Sta., Sterling, Scotland.
Edinburgh Geological Society, Edinburgh, Scotland.
Geological Society of Glasgow, Scotland.
John A. Harvie-Brown, Duniplace House, Larbert, Sterlingshire, Scotland.
Natural History Society, Glasgow, Scotland.
Philosophical Society of Glasgow, Glasgow, Scotland.
Royal Society of Edinburgh, Edinburgh, Scotland.
Royal Physical Society, Edinburgh, Scotland.
Royal Botanic Garden, Edinburgh, Scotland.

Barcelona Academia de Ciencias y Artes, Barcelona, Spain.
Royal Academy of Sciences, Madrid, Spain.

Institut Royal Geologique de Suéde, Stockholm, Sweden.
Societé Entomologique a Stockholm, Stockholm, Sweden.
Royal Swedish Academy of Science, Stockholm, Sweden.

Naturforschende Gesellschaft, Basel, Switzerland.
Naturforschende Gesellschaft in Berne, Berne, Switzerland.
La Societé Botanique Suisse, Geneva, Switzerland.
Societé Helvetique de Sciences Naturelles, Geneva, Switzerland.
Societé de Physique et d' Historie Naturelle de Geneva, Geneva, Switzerland.
Concilium Bibliographicum, Zürich-Oberstrasse, Switzerland.
Naturforschende Gesellschaft, Zürich, Switzerland.
Schweizerische Botanische Gesellschaft, Zürich, Switzerland.
Prof. Herbert H. Field, Zürich, Switzerland.

AUSTRALIA.

Linnean Society of New South Wales, Sidney, New South Wales.
Royal Society of New South Wales, Sidney, New South Wales.
Prof. Liveridge, F. R. S., Sidney, New South Wales.
Hon. Minister of Mines, Sidney, New South Wales.

Mr. E. P. Ramsey, Sidney, New South Wales.
Royal Society of Queensland, Brisbane, Queensland.
Royal Society of South Australia, Adelaide, South Australia.
Victoria Pub. Library, Museum and Nat. Gallery, Melbourne, Victoria.
Prof. W. L. Buller, Wellington, New Zealand.

NORTH AMERICA.

Natural Hist. Society of British Columbia, Victoria, British Columbia.
Canadian Record of Science, Montreal, Canada.
McGill University, Montreal, Canada.
Natural Society, Montreal, Canada.
Natural History Society, St. Johns, New Brunswick.
Nova Scotia Institute of Science, Halifax, N. S.
Manitoba Historical and Scientific Society, Winnipeg, Manitoba.
Dr. T. McIlwraith, Cairnbrae, Hamilton, Ontario.
The Royal Society of Canada, Ottawa, Ontario.
Natural History Society, Toronto, Ontario.
Hamilton Association Library, Hamilton, Ontario.
Canadian Entomologist, Ottawa, Ontario.
Department of Marine and Fisheries, Ottawa, Ontario.
Ontario Agricultural College, Guelph, Ontario.
Canadian Institute, Toronto.
Ottawa Field Naturalists' Club, Ottawa, Ontario.
University of Toronto, Toronto.
Geological Survey of Canada, Ottawa, Ontario.
La Naturaliste Canadian, Chicontini, Quebec.

La Naturale Za, City of Mexico.
Mexican Society of Natural History, City of Mexicc.
Museo Nacional, City of Mexico.
Sociedad Cientifica Antonio Alzate, City of Mexico.
Sociedad Mexicana de Geographia y Estadistica de la Republica Mexicana, City of Mexico.

WEST INDIES.

Botanical Department, Port of Spain, Trinidad, British West Indies.

Victoria Institute, Trinidad, British West Indies.

Museo Nacional, San Jose, Costa Rica, Central America.

Dr. Anastasia Alfaro, Secy. National Museum, San Jose, Costa Rica.

Rafael Arango, Havana, Cuba.

Jamaica Institute, Kingston, Jamaica, West Indies.

The Hope Gardens, Kingston, Jamaica, West Indies.

SOUTH AMERICA.

Argentina Historia Natural Florentine Amegline, Buenos Ayres, Argentine Republic.

Musée de la Plata, Argentine Republic.

Nacional Academia des Ciencias, Cordoba, Argentine Republic.

Sociedad Cientifica Argentina, Buenos Ayres.

Museo Nacional, Rio de Janeiro, Brazil.

Sociedad de Geographia, Rio de Janeiro, Brazil.

Dr. Herman von Jhering, Dir. Zoöl. Sec. Con. Geog. e Geol. de Sao Paulo, Rio Grande do Sul, Brazil.

Deutscher Wissenschaftlicher Verein in Santiago, Santiago, Chili.

Societé Scientifique du Chili, Santiago, Chili.

Sociedad Guatemalteca de Ciencias, Guatemala, Guatemala.

. . PROGRAM . . .

OF THE

EIGHTEENTH ANNUAL MEETING

OF THE

INDIANA ACADEMY OF SCIENCE,

STATE HOUSE, INDIANAPOLIS,

December 26 and 27, 1902.

EXECUTIVE COMMITTEE.

H. W. WILEY, President. W. S. BLATCHLEY, Vice-President. JOHN S. WRIGHT, Secretary. DONALDSON BODINE, Asst. Secretary. J. T. SCOVELL, Treasurer.

M. B. THOMAS,	THOMAS GRAY,	J. C. ARTHUR,	JOHN C. BRANNER,
D. W. DENNIS,	STANLEY COULTER,	J. L. CAMPBELL,	J. P. D. JOHN,
C. H. EIGENMANN,	AMOS W. BUTLER,	O. P. HAY,	JOHN M. COULTER,
C. A. WALDO,	W. A. NOYES,	T. C. MENDENHALL,	DAVID S. JORDAN.

The sessions of the Academy will be held in the State House, in the rooms of the State Board of Agriculture.

Headquarters will be at the English Hotel. A rate of $2.00 and upwards per day will be made to all persons who make it known at the time of registering that they are members of the Academy.

M. B. THOMAS,
M. E. CROWELL,
Committee.

GENERAL PROGRAM.

FRIDAY, DECEMBER 26.

Meeting of the Executive Committee at Hotel Headquarters .... 10:45 a. m.
General Session, followed by Sectional Meetings........................... 2 p. m. to 5 p. m,
President's Address, Shortridge High School.. 8 p. m.

SATURDAY, DECEMBER 27.

General Session, followed by Sectional Meetings.............................. 9 a. m. to 12 m.

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT.

DR. HARVEY W. WILEY.

At 8 o'clock Friday evening, at Shortridge High School.

Subject: "Ye Shall Know Them by Their Fruits."

The following papers will be read in the order in which they appear on the program, except that certain papers will be presented "*pari passu*" in sectional meetings. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another whose time is approximately the same. Where no time is sent with the papers, they have been uniformly assigned ten minutes. Opportunity will be given after the reading of each paper for a brief discussion.

N. B.—By the order of the Academy, no paper can be read until an abstract of its contents or the written paper has been placed in the hands of the Secretary.

GENERAL.

1. Transmissible Diseases in College Towns, 8 m....Severance Burrage
2. Sewage Disposal at the Indiana State Reformatory at Plainfield, 10 m..........................Severance Burrage
3. Some Recent Mound Investigations in Jefferson County, Indiana, 8 m..............................Glenn Culbertson
4. The Water Supply of Havana, Cuba, 10 m.........C. H. Eigenmann
5. Results of the Indiana University Expedition to Cuba, 15 m..................................C. H. Eigenmann
6. Naezhosh, or the Apache Pole Game, 8 m..........Albert B. Reagan

MATHEMATICS AND PHYSICS.

7. Geodesic Lines on the Syntractrix of Revolution, 8 m..E. L. Hancock
8. Comparison of Gauss' and Cayley's Proofs of the Existence Theorem, 10 m.................................O. E. Glenn
9. Motion of a Bicycle on a Helix Track, 8 m.............O. E. Glenn
10. A Generalization of Fermat's Theorem, 8 m.........Jacob Westlund
11. On the Class Number of the Cyclotomic Numberfield $k\left(\varepsilon^{\frac{2\pi i}{p^n}}\right)$, 8 m..............................Jacob Westlund
12. Photographic Observations of Comet c 1902, 10 m........J. A. Miller

BOTANY AND ZOOLOGY.

13. The Genus Puccinia, 10 m...............................J. C. Arthur
14. Forestry Conditions in Montgomery County, Indiana, 10 m...S. J. Record
15. Notes on the Cleavage Plane in Stems and Falling Leaves, 8 m...................................Mary A. Hickman

16. On the Veins of the Head of the Snake (Tropidonotus), 15 m. . . . . H. L. Bruner
17. On the Maxillary Veins of Lizards, 15 m. . . . . H. L. Bruner
18. Some Rare Indiana Birds, 10 m. . . . . A. W. Butler
19. The Catalpa Sphinx, *Ceratomia catalpæ*, Destroyed by the Yellow-Billed Cuckoo, *Coccyzus americanus*, in Southern Indiana, 10 m. . . . . F. M. Webster
20. Notes on Reared Hymenoptera from Indiana, 10 m. . . . F. M. Webster
21. Preliminary List of Gall-Producing Insects Common to Indiana, 6 m. . . . . Mel T. Cook
22. Notes on Deformed Embryos, 5 m. . . . . Mel T. Cook
23. The Lake Laboratory at Sandusky, Ohio, 12 m. . . . . Mel T. Cook
24. The Individuality of the Maternal and Paternal Chromosomes in the Hybrid between *Fundulus heteroclitus* and *Menidia notata*, 8 m. W. J. Moenkhaus
25. An Extra Pair of Appendages Modified for Copulatory Purpose in *Cambarus viridis*, 8 m. . . . . W. J. Moenkhaus
26. Description of a New Species of Darter from Tippecanoe Lake, 5 m. . . . . W. J. Moenkhaus
27. The Myxomycetes of Winona Lake, 10 m. . . . . Fred Mutchler
28. The Plankton of Winona Lake, 10 m. . . . . Chancy Juday
29. The Birds of Winona Lake, 15 m. . . . . Clarence G. Littell
30. A List of the Dragonflies of Winona Lake, 5 m. . Clarence H. Kennedy
31. A New Diagnostic Character for the Species of the Genus *Argia*, 10 m. . . . . Clarence H. Kennedy

CHEMISTRY AND GEOLOGY.

32. Investigation of the Action between Manganese Dioxide and Potassium Chlorate in the Production of Oxygen, 10 m. . . . . Edward G. Mahin
33. The Action of Heat on Mixtures of Manganese Dioxide with Potassium Nitrate and with Potassium Bichromate, 5 m. . . . . J. H. Ransom
34. Criticism of an Experiment Used to Determine the Combining Ratio of Magnesium and Oxygen, 5 m. . . . . J. H. Ransom
35. An Apparatus for Illustrating Charles's and Boyle's Laws. J. H. Ransom
36. Some $\triangle_2$ Keto-R-Hexene Derivatives, 5 m. . . . . J. B. Garner
37. Action of Hydrogen Peroxide on Cuprous Chloride, 10 m. W. M. Blanchard

THE EIGHTEENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The eighteenth annual meeting of the Indiana Academy of Science was held in Indianapolis, Friday and Saturday, December 26 and 27, 1902.

Friday, 11 a. m., the Executive Committee met in session at hotel headquarters. At 2 o'clock p. m. President Harvey W. Wiley called the Academy to order in general session in the room of the State Board of Agriculture, State House. The transaction of routine and miscellaneous business, occupied the first part of the session. Following this, papers of general interest were read and discussed. On the disposition of these, special technical subjects occupied the time until adjournment at 5 p. m.

The address of the retiring President, Harvey W. Wiley, was delivered in the auditorium of the Shortridge High School at 8 p. m. before the members of the Academy and a number of invited guests; subject, "Ye Shall Know Them by Their Fruits."

Saturday 27, 9 a. m., the Academy met in general session, before which the remaining papers of the program were read and discussed. Following the disposition of the papers unfinished business was considered.

Adjournment, 12 m.

THE FIELD MEETING OF 1902.

The field meeting was appointed for Madison and Hanover, May 22, 23 and 24. The President and some of the members assembled, but owing to the heavy rains and the inclemency of the weather all attempts to do field work were necessarily abandoned.

PRESIDENT'S ADDRESS.

H. W. Wiley.

Ye Shall Know Them by Their Fruits.

Members of the Indiana Academy of Science, Ladies and Gentlemen—It perhaps marks a sad epoch in the history of a man when he deliberately chooses a period of reminiscence for a public address. It is one of the privileges of the old to review the preceding years and draw from them such lessons of wisdom or of folly as may happen to be the case. I have therefore, chosen on this occasion to look back over the scientific history of Indiana during a period of a third of a century. Strange as it may seem, that short period covers practically all the progress which has been made in applied science in this great State. I do not forget the early days of the Owens and their associates, and the great contributions which came to the intellectual and scientific development of our people from the center first established at New Harmony, but I speak of the actual accomplishments for the good of the community from the application of the principles of science to mining, manufacture, commerce, agriculture and public health.

It was my fortune to enter upon the period of my education immediately following the great Civil War. This fratricidal struggle for four years had engaged every energy and consumed every resource of our country. The end of the war left our people in a remarkably susceptible condition—ready for the purpose of re-establishing their industries and of utilizing every available means thereto. In the very midst of the period of the Civil War were laid deep and sure, by wise congressional action, the foundations of the system of agricultural and technical education, which has since grown to be the admiration of the world. I refer to the Morrill Act of 1862, setting apart portions of the public domain for the purpose of promoting instruction in agricultural and mechanical arts and military tactics. Every State in our Union received grants of public lands in proportion to size, population and representation in Congress. It is true that some of the States invested this munificent endowment more wisely than others, but all have received from it substantial aid. This munificent gift to technical education was supplemented twenty years later by the Hatch Act, whereby there was established in each State and

Territory of the Union at least one Agricultural Experiment Station with an annual grant of $15,000. Still later Congress added to the income of each of the agricultural and technical colleges by a money grant which now amounts to $25,000 annually. I recall briefly the condition of scientific instruction in the State of Indiana in the five years immediately following the Civil War. I can illustrate these years by brief allusions to the system of instruction in use in our higher institutions of learning. By these I mean especially the colleges and universities then existing rather than the high schools. Beginning with the oldest institutions of learning, I will say that in the State University during the period noted, instruction in the sciences was given by Professors Owen, Kirkwood and Wylie. These three names are intimately associated with the beginnings of scientific instruction in our State. They were all men of remarkable intellectual power. Professor Owen devoted himself chiefly to the so-called natural sciences (I wonder what are unnatural?), Professor Kirkwood to astronomy and Professor Wylie to physics. It should not be forgotten that Professor Richard Owen was chosen as the first president of Purdue, but never actively entered on the duties of the office. His tastes and training were not in the line of executive work, and in addition, his advancing years precluded the possibility of that strenuous service which even in those early days was looked for, perhaps under another name, in the executive office. As there were beautiful women before the days of Helen, so the lives of these pioneers in scientific work remind us that there were great men in Indiana before the days of Jordan and Coulter.

The next oldest institution is the one I am most familiar with in the State, namely, Hanover College. In that institution instruction in the sciences at the time mentioned was given, with the exception of the mathematics, exclusively by Dr. John W. Scott. Having studied for four years with this illustrious man I can speak with knowledge of the great work which he accomplished; work, I am sure, which was only a type of that done by other teachers of science in colleges at that time. Dr. Scott had never received any special training in science more than was given in the old colleges existing in our country between the years 1820 to 1825. He was born with the beginning of the last century and happily lived almost to its close. He was educated for the ministry and devoted practically his whole life to the church. During the period of his professorship he was pastor of the village church, associating these onerous duties with those of the classroom. Doctor Scott taught many sciences, viz., botany, geology, biology, entomology, chemistry and physics. In addition to these he often had a class in Latin and occasionally other branches. Doctor Scott was a man of wonderful strength of body and mind, and had a capacity for continued work which was nothing less than astonishing. During the day, after the end of the recitation, he would spend the hours in his laboratory preparing for the experiments and recitations for the following day. The lamp in his study window would often be found burning at night up to 12 and even 1 o'clock, preparing for his sermons on Sunday. He was accustomed to have in his preparatory work in his laboratory the assistance of one of his students, and during my time at Hanover I especially remember the enthusiasm with which Mr. M. L. Amick, now a prominent physician in Cincinnati, displayed in the preparation of the lectures. With a laboratory outfit of the most meager description Dr. Scott was able to give in chemistry a series of experimental lectures which would have done credit to many of the elaborate lecture rooms of to-day. There was absolutely no provision for the students' work in the laboratory whereby the fundamental principles of chemistry could be illustrated by appropriate experimental work. Some of these experiments were very difficult, and at least one of them I have never seen performed in an experimental lecture anywhere else in the world, namely, the preparation of the highly explosive chloride of nitrogen. The preparation of this compound is one of such danger that it should only be attempted with those most skilled, yet every year for three years I saw Dr. Scott perform this experiment in a most successful manner. The small quantity of the explosive made was placed in a safe place out of doors and exploded by means of a long stick, the tip of which had been dipped in turpentine oil. By reason of this devotion to his profession and the success attending his efforts, he made chemistry, which was at that time one of the dry book studies, a most attractive science. In like manner he would conduct his classes in botany to the neighboring woods and fields and teach them not only the principles of botanical classifications, but the means of identifying the various species of plants growing in the vicinity. The hills of the Ohio River, rich in magnificent trilobites and other reminiscences of early geological life afforded a magnificent opportunity for teaching the practical principles of geology as illustrated in those lofty hills and deep ravines. Since those days, when I have seen practically all the magnificently equipped laboratories of the world, the wonder grows more and more in my mind at the great work which this great man could accomplish with so few material appliances to help him. I shall never forget the last time he visited my laboratory in Washington. After leaving Hanover he had come to Washington and taken a position as a clerk in the Pension Office. At the time I speak of he was 90 years of age, but still clear of mind and firm of step. It was soon after the inauguration of Benjamin Harrison as President of the United States. One morning Doctor Scott stepped into my office. He seemed uneasy and wore a worried look. When I inquired in regard to his health, he said it was most excellent, but he added, "Strange to say, I have become a victim of the Republican administration. General Harrison has insisted on me coming to the White House to live with him and has dismissed me from my position in the Pension Office." He continued, "I am a gentleman of leisure now, and I think I would like to come and study chemistry with you." It is only when we can look back on a life-work such as that done by Doctor Scott that we can realize the inestimable blessing of his career to humanity. Two years after that the end came peacefully to his existence. I can not help thinking that the feeling of love and interest taken in him by the President, expressing itself in the desire that he should pass his last days in the comfort and honor of the White House, may have shortened his life. If he could have kept at work, which was his normal condition, he might have rounded out the century.

Scientific instruction given during the period I speak of at Wabash College was in charge of Professors Campbell and Hovey. Professor Campbell is still in the harness—possibly almost the only one of the old guard that still wears his armor.

At the present time chemistry, biology, botany, mathematics, physics and astronomy are all separate departments. The change at Wabash has taken place gradually and progressively, so that it is not possible to designate these segregations by any particular period. It will be sufficient to say that it has been the constant effort at Wabash to keep up with the new without disparaging the old. Wabash is another of the so-called small colleges which has established for itself a place and a reputation of the highest character. We have so many illustrations of institutions of this kind in Indiana that the sneering remarks which are often made about the small colleges of Indiana meet with a merited rebuke when one takes the trouble to investigate the great work which has been accomplished by them.

At Earlham College instruction in science was given by Professors

Erastus Test, William B. Morgan and Joseph Moore. In the period from 1865 to 1870 the text-books used at Earlham in chemistry was Stockhardt's; in botany, Gray's Structural. Herschel's work on astronomy was the one used in the classroom, and Dana's was, of course, the one used in geology. Two of these veteran instructors I have had the pleasure of knowing personally, namely, Professor Test and Professor Morgan.

Earlham College enjoys the distinction of having been one of the foremost among the educational institutions of the West in the promotion of advanced practical instruction in science. In the year 1853 it made the first beginning in Indiana toward a permanent collection of material in geology and natural history for purposes of college instruction. The present Earlham College museum, with its more than 14,000 specimens, is the outgrowth of that beginning.

About the same time the first astronomical observatory in the State was established at Earlham. A room in Earlham Hall, adjoining the present quarters of the Christian Associations, was the location of the first chemical laboratory for the use of college students in Indiana.

At present Earlham offers courses in science as follows, a year's high school laboratory work in some one science being required for matriculation:* Chemistry, six terms' work; physics, six terms' work; biology, ten terms' work; geology, four terms' work; astronomy, three terms' work; psychology, two terms' work.

Earlham now has a complete set of laboratories devoted to chemistry, biology, physics and psychology. These laboratories are equipped with all modern appliances, and although not as large as those in many institutions, they are complete in every respect for the prosecution of research and for purposes of instruction.

At Butler College, at that time known as Northwestern Christian University, instruction in science was given by that distinguished geologist and chemist, Dr. R. T. Brown, assisted part of the time by Professor Fairchild. During the years of 1869 and 1870 I learned to know Doctor Brown intimately, for during that period I served as instructor in Latin and Greek in the Northwestern Christian University. Interested, as I was, at that time, in scientific studies, I accompanied Doctor Brown on some of his geological excursions. I remember particularly the trip which was taken in the spring of 1869 down as far as Spencer. It was at the time that the railroad from Indianapolis to Vincennes was building and it was finished practically all the way to Spencer, and part of this trip was made on the railroad, and then the rest on foot, several days being spent in studying the geological formations. Doctor Brown was a man of practically the same type as Doctor Scott, full of enthusiasm, a wonderful capacity for work, a magnificent physique, and a faculty of interesting his students in the subjects under consideration. These two men, whom I knew so well, were typical teachers. They had the genius docentis. Mr. Brown's services to the State are written in its Geological Reports of the coal fields and in the promotion of its industries. Like Doctor Scott, he was also a preacher, and there was rarely a Sunday that he did not deliver at least two sermons. He was particularly fond of walking, and thought nothing, even at the age of seventy, of a tramp of ten or fifteen miles to fill an appointment. I remember a story which he told in regard to one of his trips when he was a young man and soon after he entered the ministry. He was too poor to have a horse and was in the habit of going from one appointment to another on foot, inasmuch as the railroads were then not in vogue. One morning after a long tramp he stopped at a farmhouse with the expectation of being entertained at dinner. The farmer happened to be a quaker, and, of course, devoid of any ceremony. Doctor Brown was a modest young man and was not quite accustomed to the directness of the quakers' hospitality, and when the hour for the meal arrived the host said, "Thy dinner is ready; will thee come in to dine?" He very politely said, expecting to be invited a second time, "I thank you, but I am not very hungry;" to which came the reply, "Very well, thee can sit there until we have finished." Whereupon the dinner was served with all the good things which a quaker farmer can put upon a table, while the young preacher was left to regale himself with all the delicious odors from the table and the thought of what he could do with all the excess of peptic ferments which the odor of the dinner were producing. After that experience he learned never to decline the first invitation from a quaker.

Instruction in Franklin College in science at the time I mention, was given by Professor Hougham. Professor Hougham was also a remarkable man in industry and in ability. I afterward had the good fortune to know him quite intimately when he was one of the professors in the early days of Purdue. In his laboratory work he was the perfection of neatness and order. In fact this was one of the predominating characteristics of his character, and his great success in life was, in a large measure, due to it. Professor Hougham was particularly interested in physics and had charge of that branch of science in the early days of Purdue. He had a happy constructive faculty and could make a very modest collection of appliances serve for extended illustrations. Professor Hougham was a manufacturer of philosophical apparatus, and Franklin College had the benefit of many of the pieces of apparatus which he built. He took post-graduate work at Brown University, and the first chemical laboratory built at Purdue was constructed on the exact plans of the laboratory at Brown. The Civil War had a depressing effect upon Franklin College, and I believe it was the only institution of higher learning which was closed for a period as a result directly or indirectly of that conflict. There was an interregnum at Franklin from 1865 to 1869. When the institution opened again in 1869, President Stott took temporary charge of chemistry, physics, physiology, botany and geology. The text-books used then were Youman's in chemistry; Ganot and Olmsted's in physics; Dana's in geology; Gray's in botany; and Hitchcock's in physiology. At the present time there are four large rooms devoted to chemistry, one to physics, and three to biology. There are two full professors giving instruction in these sciences and the laboratories are well supplied with apparatus and with working libraries. Franklin has also an excellent biological collection, mostly the gift of Mr. Gorby, at one time State Geologist.

DePauw University, in those days, was known as Asbury, and perhaps the only science teacher in the institution was Joseph Tingley. I never had the good fortune to know Professor Tingley very well, but met him on one or two occasions. One of these I should like to recall. It was, I think, in the winter of 1870, when he gave an illustrated lecture on electricity in Indianapolis. This was the first occasion on which I ever saw an electric light produced by the current passing between two carbon points. This current was generated by a battery of a great many cells (I have forgotten just now how many) composed of the elements of carbon and zinc. It was not a very big light, but very intense, and I imagine that none of the audience present, and it was a large one, had ever seen an electric light before. I have no doubt I address some here who were students of Professor Tingley, and they, without question, can say the good things of him which I, from my personal acquaintance, have said of Doctors Scott and Brown. In connection with the exhibition of the electric light which is now so universal in all our cities and towns, I might call attention to the fact that the first electric light generated by a dynamo seen in Indiana was at Purdue University. During the Centennial Exposition of

1876 there were exhibited three or four dynamos manufactured by Gramme, of Paris. One of these was purchased for the physical laboratory of Purdue University and one by Professor Barker for the physical laboratory of the University of Pennsylvania. Professor Barker, doubtless, got his apparatus before Purdue, since it was nearby. As soon as the exposition was over the machine belonging to Purdue was sent to Lafayette and early in November, 1876, the first modern electric light ever seen in Indiana blazed forth from the tower of the Purdue chemical laboratory. It was one of the wonders of the age and was the talk of the newspapers and the town for many weeks. It seems almost incredible to think that twenty-seven years ago one electric light would cause such a commotion in a community. But this fact should fully illustrate to the young people how much more keenly we of advanced age can understand the progress of science in our State. Prof. Joseph Tingley, at Asbury University, had a room 20x30 feet as a lecture room and one 9x12 feet for his store room. At the present time there are four departments of science teaching at DePauw, namely, chemistry, physics, botany and zoölogy. These departments are in charge of Dr. W. M. Blanchard, chemistry; Prof. J. P. Maylor, physics, and Prof. Mel. T. Cook, biology. Each professor has an assistant and their rooms, taken in the aggregate, amount to more floor space than the entire old college building of Asbury University. One of the latest acquisitions at DePauw is the Minshall laboratory, 80x130 feet, three stories, constructed of stone, brick and iron, fireproof, and with the most modern appliances for teaching chemistry and physics. Plans are now practically completed for the departments of botany and zoölogy.

One of the earliest contributions to the material prosperity of Indiana from the sciences was made by geology. I have no time here to review the voluminous geological reports which have been made from time to time in the history of our State. There are a few salient points, however, in the history of economic geology which may prove of interest.

I have already made allusions to the services of Dr. R. T. Brown to the geological development of our State. I have now to speak of a period in our geological development of most remarkable significance. I refer to the services of that distinguished scientist, Prof. E. T. Cox. Trained under the Owens, he had imitated their zeal and their industry, and was active in all his habits, both bodily and mental. He pushed with utmost vigor the investigations of a geological nature into the extent and character of the coal deposits of the State. He early saw the importance of utilizing the assistance of chemistry in this work, and established the first chemical laboratory for research, I suppose, ever built in the State of Indiana. I remember well this laboratory in one of the dingy rooms of the old State House as I first saw it in 1869 or 1870. Professor Cox had associated with him a chemist of skill and great industry, Dr. G. M. Levette. Doctor Levette was not only a skilled chemist, but had also a working knowledge of other sciences, and, therefore, his aid in developing some of the phases of the Geological Survey was of the greatest helpfulness. It was in this laboratory that I first saw a quantitative determination, and I remember the feelings with which I used to watch Doctor Levette, who patiently permitted me to hang around his laboratory and probably greatly interfere with his work without exhibiting any signs of petulance or resentment. All the different varieties of coal which were then known in the State were submitted to the most careful chemical examinations. He also erected and operated a small apparatus by means of which bituminous coal could be heated under pressure, making, as he termed it, an artificial coke or anthracite, illustrating probably some of the methods by which nature has secured the deposits of hard coal from those of a soft or bituminous nature. I shall never cease to be grateful for the interest which these two distinguished men took in my visits to their laboratories, which, I fear, were all too frequent for the even march of official business. The personal friendship which I formed for Professor Cox at that time, I am glad to say, has continued until the present. He is now an old man retired from work and spending the evening of his life in the grateful climate of Florida. The services, however, which he rendered to the economic development of Indiana will be more and more appreciated as the years roll by. It was also my good fortune to know one of the successors of Professor Cox personally and intimately, namely, Mr. John Collett, who was first an assistant to Professor Cox and became State Geologist in 1880. Mr. Collett had a wonderfully keen insight into the nature of scientific problems and great ability in developing them. His chief work toward the economical development of the State was directed to the building-stone industry. He called attention to the remarkable character of the deposits in Lawrence County, and it was during his incumbency of the office that the present State House was constructed of the stone of that locality and the Soldiers' and Sailors' Monument begun. Mr. Collett was chiefly active as a geologist, though contributing in many other ways to the development of applied science in the State. He was the author of the first fertilizer control law which was enacted in this State, a law which did so much to protect the farmers from fraud, and in its application to point out to them the fundamental principle of applying artificial fertilizer. This is another remarkable instance in which the geological development of the State was associated with the chemical. Mr. Collett had a strong personality. His snow-white beard and hair, his bright blue eyes, and his ruddy complexion made him a striking figure everywhere. The end of Mr. Collett's administration of office was followed by a remarkable innovation of a scientific nature. A distinguished poet and novelist, James Maurice Thompson, was elected to succeed Mr. Collett as State Geologist. Mr. Thompson has shown in his writings an intimate acquaintance with nature, but it was a poetic rather than a scientific knowledge which he possessed. Evidently the courses of scientific research were not found compatible with his efforts so signal and successful in the fields of poetry and fiction. After two years he resigned his office. There was perhaps little loss to geology in his resignation, but evidently a marked gain to literature, for had he remained as State Geologist that delightful romance, "Alice of Old Vincennes," would probably not have been written. Mr. Thompson was succeeded by Mr. S. S. Gorby, who held the position until the present incumbent assumed control of the office. We are so familiar with the valuable work which Mr. Blatchley has accomplished that it will not be necessary for me to dwell long upon it. One of the innovations which has been of distinct value in the prosecution of the geological survey of the State by Mr. Blatchley was the abolition of the method of county surveys formerly in vogue. In their stead he adopted the plan of taking up each of the natural resources in detail, and preparing a monograph or special report thereon, accompanied by maps, cuts, engravings and tables of chemical and physical tests. Another successful application of economic science to industry has resulted from a study of the clay deposits in the State. The description of the character of these clays, with their chemical and physical composition, has become valuable to intending investors and more than twenty large factories have been established in Clay, Vigo, Fountain, Vermillion, Parke, Morgan and other counties for the manufacture of clay products. The total value of the output of these factories in 1900 was $3,358,350. Another result of the geological studies of Indiana was the discovery of petroleum oil deposits. The output of oil in the State of Indiana in 1901 was 5,749,-975 barrels, of which the market value was only a little less than $1,00 per barrel. The magnitude of the building-stone industry which has grown as a result of geological investigations, has raised Indiana to the first rank in the States of the Union in the output of limestone for building purposes, as shown by the following statistics: The quantity mined in 1901 was 7,781,320 cubic feet. Five State capitol buildings, namely, those of Indiana, Illinois, Georgia, New Jersey and Kansas, have been constructed wholly or partly from it. Numerous custom houses and public buildings of the United States have also been made of this stone, and twenty-seven court houses in the State of Indiana are built of it. Mr. Blatchley has also taken up again the study of the coal fields of the State, as little has been done in that line since the time of Professor Cox, and the output of coal in Indiana has almost doubled in the last few years, amounting in 1901 to 7,019,203 tons. In conjunction with chemistry the Geological Survey of the State has also developed the resources for the manufacture of marl and cement. As a result of these investigations a large output of cement similar to that known as Portland is now credited to Indiana. It is estimated that the output of this cement for 1902 will be fully equal to 600,000 barrels. The adaptability of the oölitic and other limestones of Indiana as suitable material to be used in the manufacture of cement has been described, and, as a result of this, factories have already been able to make use of these materials. It has been shown that Indiana has the raw materials to supply not only the United States, but the whole world with a first-class article of cement for hundreds of years to come. The mineral waters of our State are justly celebrated for their medicinal and curative properties, and their development is the joint work of geology and chemistry. There are now known in the different parts of the State eighty-six wells and springs whose waters are valued for therapeutic purposes. The natural gas industry has also added hundreds of millions of dollars to the development of the State, and this development is largely associated with the work of the Geological Survey. It is hard in so brief a time to do anything like justice to what geology as a science has done for the industries, and also to recognize the services of the distinguished men who have been connected with this work. It is enough for our purpose here to call attention to the leading characters of the work done by geologists in the development of our industries.

The contributions made by botany, entomology and zoölogy, and animal and vegetable pathology, to the material welfare of the State are no less striking in character, though perhaps less in magnitude, than those which have been rendered by the science of geology. Botanical studies, which have ever been far advanced in Indiana, have disclosed the nature and character of our various forests and have especially been concerned with the improvements of economic plants for agricultural and horitcultural purposes. The study of economic botany is one which lies near to the welfare of many of the fundamental industries, chief among them being agriculture and pharmacy. Especially the study of the development of special characteristics of plants useful in the arts is one of the phases to which botany in this State has made large contributions. Without discriminating against the other botanical laboratories in the State, I can best illustrate the useful character of this work by what has been done at Purdue University, the work of that institution being more familiar to me in applied botanical science than of the other institutions of the State. From the botanical laboratories of Purdue University there have been, from 1884 to 1898, fifty bulletins published on botanical subjects of practical importance to the industries of our State. These were chiefly from the fertile pens of Arthur and Coulter. It will, of course, be impossible to even give a brief review of this magnificent work. I must confine myself merely to quoting the titles of some of these important contributions in order to show how closely allied they are to the industries of the State. Among these titles I might mention the following: "What Is Common Wheat Rust?" "A New Factor in the Improvements of Crops," "Black Knot and Other Excrescences," "Living Plants and Their Properties," "The Forest Trees of Indiana," "Science and the State," "Forest Fruits," "The Flora of Indiana," etc.

If you add to the contributions which have been made from Purdue University those which have been made from other centers of botanical studies and investigations you have a sum total of most important practical results. In general, it may be said, that by reason of the activity of the botanical science in this State and the application thereof to our industries we have a far more accurate knowledge of those plants which are most intimately related to our industries. In the second place, we have a systematic and scientific conception of the methods of treating these plants in order to produce the greatest economic results. Third, we have a more advanced knowledge of the proper distribution of these plants in such a manner as to take advantage of the natural qualities of the soil or topographical features of the State and the meteorological environments. In the fourth place, we have an advanced knowledge of the nature of the diseases which affect the value of plants and the methods of successfully combatting them. What has been said of botany is true, also, to a large extent, of the science of entomology, although perhaps Indiana has not been so prominent in entomological as it has been in botanical studies. Nevertheless, most valuable contributions have been made by the entomologists of our institutions of learning to the general store of knowledge. In regard to animal diseases, we find also that science has been of immense use to our industries. The State has been well mapped in regard to the plague of hog cholera and other animal diseases. Careful studies have been made of the causes of these diseases and their distribution coupled with the regulations for the restriction of these diseases and their suppression. These studies have come largely from Purdue University and the reports issued by Doctor Bitting of that institution upon animal diseases have been of the highest utility. The health of the human animal has also not been neglected in the application of science to the public welfare. The Indiana State Board of Health, which is charged with the general oversight of the hygiene of this commonwealth, has been established on a truly scientific basis. The State Board of Health is composed of eminent physicians in active practice and its executive officer is a chemist and pharmacist of national reputation. You are so familiar with the contributions which this distinguished body has made to the welfare of your people that I can not enlighten you to any extent upon the subject. There is one thing that I ought to say in reference to this work, and that is, it should be supported more generously by the people. What the State Board of Health needs from Indiana is a fund for the enlargement of the activities, and to make its work more useful, a laboratory of hygiene is necessary for the study of the foods and waters and a control of the pathogenic germs therein.

The execution of the pure food law which was enacted, I believe, by the last Legislature or the one before, is of prime importance. No one will doubt the benefit which the pure food law gives to the people and its helpfulness to the prosperity of agriculture and the honesty of commerce in foods. There is perhaps little lacking in the letter of the law which has been carefully prepared and worded. I must say, however, that from a careful study of the facilities at the disposal of the health office I fear the law can not be administered to the full measure of its letter and spirit. The population of Indiana in round numbers is 2,750,000 at the present time. There must be at least 500,000 wage earners in the State, and statistics show that the average amount earned by each wage earner is about eighty cents per day. This enormous sum of from $400,-000 to $500,000 is paid daily in wages to the workers. It is safe to say that fully three-fourths of the wages earned per day are spent for agricultural products, that is, foods and clothing, so that the average amount spent each day for these necessities of which food is the chief, is not far from $350,000. Researches of chemists in all parts of the country show the enormous extent of food adulteration resulting in selling at the high price of the genuine cheaper and inferior articles. The wage earners are the principal victims of these frauds, not perhaps in actual magnitude of expended money, but in proportion to their income. A very conservative estimate would place the magnitude of the financial fraud practiced upon the wage earners of the State in the matter of adulterated foods alone at from $15,000 to $20,000 daily. Not only is this condition of affairs reprehensible by reason of this enormous tax upon the daily wages of hard working men, women and children, but it is a moral crime of a still more heinous nature. Twenty thousand dollars a day for fraudulent foods, mean a tax of 5 per cent. on all wages of all workers. When a fraud of this magnitude is considered it does not seem unreasonable to ask the Legislature for an endowment which will support the hygienic laboratory in its investigations of the nature and character of these fraudulent foods and in order that the evil effects of these can be properly ascertained. Great as have been the contributions of the Board of Health to the welfare of the State in securing immunity from disease, freedom from plagues and from contagious and epidemic diseases, we look forward to a still more useful career of this institution when it is fully equipped for the hygienic work outlined above. An admirable historical sketch of the Indiana State Board of Health and a statement of the benefits it has conferred upon our people is found in a paper contributed to the Indiana State Medical Society by J. N. Hurty, read at the Lafayette meeting, May 6, 1898, and published in the proceedings for that year. In that paper Dr. Hurty gives an admirable summary of the progress of sanitary science in Indiana.

The development of medical education of the State must not be forgotten when speaking of the public health. I attended the first lecture of the Indiana Medical College, given in the Senate Chamber of the old State House. Later I was one of the first students in the laboratory established by Dr. Thaddeus Stevens, where students really worked at the desk.

Doctor Stevens had a real enthusiasm for chemical studies connected with medicine, and I believe supported his laboratory chiefly from his own funds.

You now have in the city at least two, probably more, thoroughly equipped schools of medicine, with commodious and well-appointed laboratories of chemistry, physiology and pathology, and these institutions are doing a great work for the public welfare.

Intimately related with the benefits which could be conferred upon the State of Indiana by its Board of Health are those of a somewhat similar nature which have come from the State Board of Charities. This academy is also honored in having among its leading and most industrious members the Secretary of the State Board of Charities. It is hard to speak in an unbiased manner of any of these contributions to the State because of my intimate personal acquaintance with the men who are most active in the work. It is hard even for scientific men, and one who has lived so long away from the home of his youth, to banish from his heart a very affectionate and praiseworthy prejudice in favor of his friends. For that reason it is pretty difficult for me to find fault with what such men as H. A. Huston, Stanley Coulter, J. N. Hurty, W. F. M. Goss, A. W. Butler *et id omne genus* do. When I know that they have done something I am convinced without further investigation that that something is good for the State. There are some features of the work of the Board of Charities which perhaps are not fully comprehended even by those who have read its reports. They have introduced into the study of the public charities of the State a truly systematic method of investigation. In their studies of causes and effects they have endeavored to use every means of securing accuracy. They have striven to get at the individual and family history of every person who is an inmate of these institutions. The results of these endeavors have been the collection and tabulation of the most accurate and complete set of sociological statistics in this country. Mr. Butler developed one phase of this work in his vice-presidential address before the section of Anthropology of the American Association for the Advancement of Science at its Denver meeting. In this address he took up the study of the heredity effects of feeble-mindedness. This study of feeble-mindedness had been pronounced by competent experts to be one of the most exhaustive and thoroughly scientific of any that has ever appeared. Its excellence has been recognized across the water and it has been reprinted in Great Britain for public distribution.

Another phase of this work is the study of the problems in these records which have been secured in order to determine those conditions which are preventive of dependency, delinquency and degeneracy. The charitable institutions of our State have long been the admiration of the whole country. The great work of the State Board of Charities looking to the prevention of crime will perhaps bring more lasting benefit to our people than the institutions themselves over which this board has control. The successful efforts of this board in bettering the condition of our people has been seen especially in the enactment of the Child Labor Law, the Child Saving Law, the Poor Relief Law, the Indeterminate Sentence and Parole Law, the Compulsory Education Law and the law for the custodial care of feeble-minded women. It is evident, therefore, that in enacting the laws providing for the State Board of Charities by the Legislature, in 1889, Indiana took a great step forward, both in a scientific direction and also from an economic standpoint. There is no institution of our State more worthy of support and encouragement than the State Board of Charities, and no one, if properly supported, will do more for the honor and welfare of our people.

As a direct effect of the establishment of this Academy we may point to the law regarding the protection of birds and game. Birds may be taken for scientific purposes only by persons having permits through the Indiana Academy of Science. The bird law is well supplemented by the game law enacted by the last Legislature. There still remain, however, to be enacted some desirable features of one of these laws, and that is, the enactment of a provision for the taking of fish. The Commissioner of Fish and Game has the oversight of fish and game protection, but it might be well to have the law changed so as to have this official in organic connection with the Academy.

I have already alluded to some of the services of chemistry to the State of Indiana in connection with the development of its geological resources and also in its services to the State Board of Health. The chief value, however, of the science of chemistry to the State of Indiana has been in its application to our agricultural industries. The enactment of the Morrill Law, already referred to, in 1862, resulted in the establishment of Purdue University, an institution devoted to the study of agricultural and mechanical arts and military science. The foundation thus provided was generously increased by a gift of Mr. Purdue, and with the assistance of citizens of Lafayette, a commodious home was secured for the institution, and the work based upon the foundations thus given has been generously sustained by the State by annual appropriations. The enactment of the Hatch Law, already mentioned, about twenty years after the Morrill Act, gave a magnificent impulse to agricultural research. By the terms of the Hatch Law there were established in each State at least one Agricultural Experiment Station charged with the investigation of the problems relating to agriculture, horticulture and forestry. As a result of these generous endowments no other country in the world has a system of agricultural research which can compare in magnificence of endowments, number of workers and practical results obtained, with the agricultural institutions of this country. The services which have been conferred upon the State by these endowments have already been pretty fully exploited in this address.

But I must be permitted still to call attention to the fundamental place which one of the sciences, viz., Chemistry, holds in these investigations relating to the progress of agriculture. Before the establishment of the Agricultural Experiment Station of Indiana Mr. John Collett, State Geologist, as previously mentioned, secured the enactment of a law by the Legislature establishing the office of State Chemist. I, as most of you know, had the honor of being the first incumbent of that office. A peculiar feature in the history of the enactment of this law is the way in which Mr. Collett secured it. He did not consult, in so far as I know, any of the officials connected with Purdue University. The first intimation that I had of the enactment of the law was a commission signed by the Governor sent by the Secretary of State appointing me to the place. On looking into the law I found that the duties of the State Chemist were particularly confined to the fertilizer control, and thus there was established in 1882 at Purdue the first laboratory for the control of fertilizing products sold in the State. The laws before this were crude and powerless to protect the farmers of our State against barefaced frauds. At that time any kind of mixture could be sold as a fertilizer for a fancy price and there was no official method of detecting a fraud and no provision for its punishment. Under the provisions of the law the farmer is now completely protected in the character of the goods which he buys. This has been a saving in hard cash to our farmers in sums difficult to estimate, but this is not the most valuable result which has been obtained by the establishment of this office. In addition to analyzing the fertilizers offered for sale the State Chemist commenced a study of their effects upon the crops to which they were applied. This led naturally to an examination also of the soils for the purpose of determining their needs in fertilizing materials. The result of all this is that the farmer at the present day is enabled not only to purchase his fertilizers in a fair and honest market, but also to have them so balanced in respect of the plant food they contain as to give the most economic results in the crops. If the farmer of Indiana at the present day adds phosphoric acid, nitrogen or potash to the soil when it is not needed, he simply does so because he does not take advantage of the facilities which the State affords him of learning the true method of fertilizing his farm. Thus the contributions which chemistry has made with the assistance of the sister science of geology, and through the medium of the Board of Health to the welfare of our people have been vastly increased by its solution of some of the agricultural problems which confront us. With this aid and the efforts of agricultural chemistry the exhaustion of the virgin soils of our State, which are among the most fertile of our country, has been checked, and a start has been made on the up-grade toward the restoration of that fertility which our early settlers found. It would have been glory enough to have checked the deterioration of our soils, but it is an additional glory to our science when it has commenced to build them up again. We can consistently look forward to the near future when fields and farms which have been practically abandoned by reason of exhausted fertility will be again brought into cultivation and made to produce abundant and profitable crops. The investigations which chemistry has made have also shown to a large extent, how our agricultural crops could be distributed with the greatest advantage. In this respect chemistry collaborates with her sister science, botany, which study I have already referred to. As a marked illustration are seen the investigations which have pointed out the fact that the beet sugar industry in Indiana could only prove profitable in its northern part and that it would be economic waste to try to establish it, for instance, in the southern third of our State. Similar studies in connection with botanical science will aid in marking the areas most suitable for other agricultural crops, such as Indian corn, tobacco, etc.

As a final result of all these scientific investigations, the farmers of our State will eventually grow only those agricultural crops which are best suited to the environment and therefore most profitable. Thus agriculture will be made more productive and profitable by such specializations as render great manufacturing industries most useful. As the skilled worker in a great manufacturing establishment is placed at that task which he can do best, so the farmer will utilize the field for that which it can best produce.

These brief surveys of the contributions which science has made to the industries of our State would be incomplete without some tribute to the wonderful work which technical education has accomplished. I mean by technical education, that instruction in the mechanic arts which was practically unknown a third of a century ago, and which has now advanced to such a degree as to place Indiana in the front rank of states in developing this branch of applied science. We have in this State two great centers of technical education, namely, the Mechanical and Engineering Laboratories of Purdue University and the Rose Polytechnic Institute. In addition to these, attention should be called to the splendid courses given in manual training in many of our high schools and other institutions of learning. The Hoosier of fifty years ago was the butt of every jibe. His agricultural skill was supposed to be confined to the growth of pumpkins, and his mechanical genius was occupied with the manufacture of the svelt hoop pole, but his State is now the home of the most famous poets, novelists, statesmen, engineers and scientists.

My friends from other institutions will, of course, pardon me if I speak particularly of the wonderful work at Purdue developed first of all by Professor Goss, who is now assisted by a large corps of mechanical and electrical engineers. It is evident from the activities of Purdue and other institutions that we are in the progress of educating as engineers at least 1,000 of the sons of the State. During the past five years from 50 to 100 have been graduated each year from the engineering classes of Purdue University, and this great influx of men has been absorbed by the industries of this and other states. Purdue has already a thousand graduates in engineering. Without stating in detail the influence of this great institution upon the material prosperity of Indiana, the fact that so many of its young men have been prepared for this useful life work is in itself significant.

The whole industrial activities of the State of Indiana have derived their life and vitality from the instruction which I have outlined. It would increase to an undue size an address of this kind to go into a minute detail. This technical instruction of our State is touching every branch of our industries. Without speaking specifically of what it may be doing for each of the industrial interests of the State, we may say that wherever there are waterworks recently designed, or street railway lines, or electric lighting stations, or a manufacturing plant of any kind, and in general, wherever the people are enjoying the benefits of modern engineering, mechanics and electrical development, there you will find the representatives of the technical education of which I have spoken. The graduates of these technical schools are everywhere. Whatever progress the State is making in industrial lines they are instigating and conducting it. They are in charge, or assisting in the management, of the great manufacturing plants of the State. They are superintendents of motive powers and machine shops. They are found in smaller corporations in charge of the machinery or of the technical processes. Wherever industry is progressing and where manufacturing is growing and where technical skill is adding to the prosperity and welfare of the people, the graduates of these technical schools are found.

It is a good old proverb that you should judge the tree by its fruits. In this free land of ours we judge a man for what he is and from what he does, and therefore, we are justified in applying this same rule in estimating the value of the sciences in the material development of our State by what they have accomplished. I have given in merest outlines some idea of the services of science to our industrial development. Industrial development is always intimately associated with intellectual advancement, moral welfare and spiritual well-being. The first stone in the foundation of a national edifice is material prosperity. No nation, no matter how perfect its ancestry may be and how lofty its purposes, could flourish in a desert, or on an iceberg. The insistent demands of humanity are for food and clothing and comfort. He who would elevate his State must begin by ministering to these primeval wants. It is useless to try to educate the boy who is starving and to preach religion to a man who is shivering. The inventions which increase the power of man to do things, along mechanical lines, the development of those forces of nature which give power such as heat and electricity, the discovery of laws which increase the fertility of soil such as are disclosed by chemistry and botany, the mastery of those sciences which reveal the wealth of the earth, such as geology, mineralogy, and mining, the utilization of those sciences which prevent disease, such as serum therapy and inoculations, the application of the principles of biology to the common affairs of life, as in economic entomology and zoölogy, all these underlie and sustain not only our industrial life but form the basis on which to build our magnificent systems of education, morality and politics. As human knowledge advances the realm of superstition and bigotry contracts because there can be no superstition where knowledge is and no bigotry where broad views of things exist. Science shows that all processes of nature are based on immutable laws. Many of these are known, others are foreshadowed by the brilliant conceptions of the scientific imagination, while some are still unknown and belong to the category which was once regarded as supernatural, but which is now relegated to the undiscovered. If science in its comparative infancy has thus been able to make such magnificent contributions to those elements which make life worth living, what may we not expect of the future years, when the knowledge which we have to-day will seem only as ignorance to our descendants? We judge science by what it has already accomplished. We know it by its results. When these wonderful contributions to human welfare shall have been made in the future, the words of our text will be no less true: "Ye Shall Know Them by Their Fruits."

Transmissible Diseases in College Towns.

Severance Burrage.

The college town of moderate size is unique in some respects, unique in the possession of certain opportunities for the contraction and dissemination of various diseases. College students, as a class, are looked upon as healthy to an unusual degree, and in many respects this view is a correct one; and yet when looked at from the standpoint of sanitary science, we find them exposed to many dangers that are oftentimes overlooked. Many of these dangers do not exist in other communities.

The herding together of a lot of men or boys into unhygienic quarters in unsanitary dormitories is one of the features of the student's life that must be looked upon as a danger. It is also an added responsibility to the college authorities. When the dormitory fulfills all the requirements of the rules of hygiene and sanitary science; and when there are good hospital facilities for students living in the dormitory who may become ill with a contagious or an infectious disease, then the above statements might be somewhat modified.

But when the dormitory system does not exist, and the students are distributed about the community in private and fraternity boarding houses, then dangers to the students as a mass are greatly reduced, while on the other hand there are dangers added to the community at large.

In many of the college towns as we find them in Indiana, there is no such thing as a detention hospital or a pest-house, and under these conditions the question arises as to the disposition of the sick student, and of the other occupants of the same house. If the whole house is quarantined, as the rules of the Board of Health require, and I believe rightly so, then the inmates are or seem to be needlessly exposed to the disease unless extraordinary precautions be taken by each one who finds himself at that time a member of the unfortunate household. And under such conditions, it is difficult not to be in sympathy with the student or students who break quarantine and go to their homes. I am not giving my sanction to any such actions, however, unless every preventive measure be taken before each one departs. I refer to such measures as vaccination, disinfection of body, clothing, and any articles taken away as baggage.

Another feature that is of vital interest to the student is the matter of procuring food. The usual method when there is no general dining hall for the students, is to form clubs, the main feature of which in most cases is to get the meals for very little money. The consequence is that by paying their $1.50 to $3.00 per week the students are fed three times a day on something. It is possible that we have here in our college towns some experiments on adulterated foods and improper dietaries on a larger scale than our President Wiley is conducting at Washington, but we have no one to keep record of them.

Now there are two features about this food that I desire to call attention to:

First. Are not the students who are subjected to such diet—I can not go into the details of the diet here,—are not the students who are subjected to this diet, more prone to come down with a transmissible disease than those who get a more wholesome diet?

And second. Is there not a greater chance of coming in contact with infected food at these low-priced boarding tables? Certainly these two factors working together, form a feature of student life that is worth consideration, as one of the dangers existing in a college community. To emphasize this last point, I take this opportunity to describe a recent epidemic of scarlet fever among the students at Purdue University, and it is this that I consider the feature of this paper.

About the first of December, 1902, it was reported to the authorities of Purdue University, that there were a few cases of suspicious sickness among the students. One instructor, also, was found to be quite ill, and during the illness had a well defined rash, and later had the characteristic "peeling" of scarlet fever. This case was not reported at first as being scarlet fever.

Six cases were confined in the hospital (St. Elizabeth's) and twenty-nine others, most of which were not well defined cases, were at large among the other students. Some few cases were purposely concealed by students and physicians, so that other students rooming in the same houses would not be quarantined, and thus lose time from their classes. At first, no common source of infection could be traced, the boys not eating at the same places, and in some cases not even knowing the other patients. The thirty-five cases, it was found, were fed at eleven different boarding houses or clubs, all of which were supplied with milk from the same dairyman.

Interesting, too, in this connection was the fact that the boy who assisted in delivering the milk, came down with a severe case of "tonsilitis" at the same time as the students, and had to give up his work temporarily. Five private families, supplied with milk from this same man, had one or more cases of genuine scarlet fever among their children at the same time. It is not likely that the boy who delivered the milk spread the disease, but that he contracted it by drinking the milk as did the students.

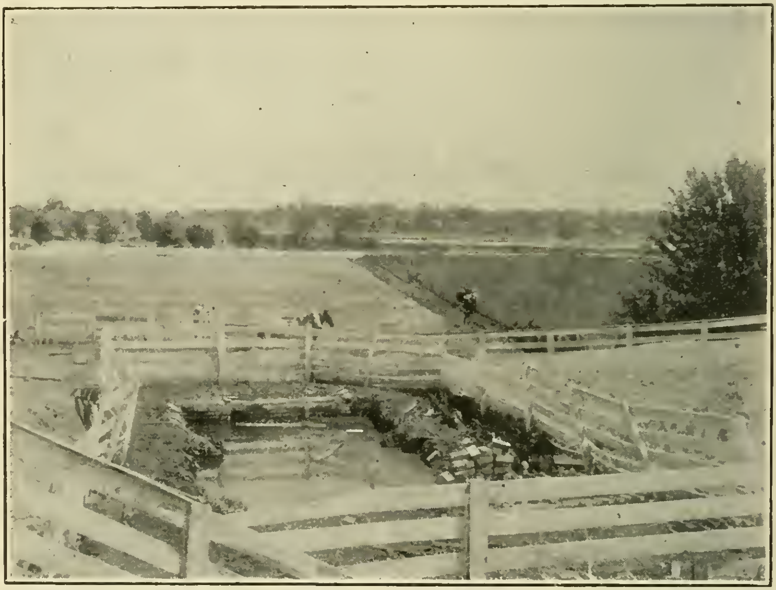
An investigation of the dairy, and the dairyman's family, did not reveal anything that could have caused the epidemic. There was no sickness in the family, nor in either of the other two families that supplied the dairyman with additional milk. The probable explanation of the source of infection lies in the fact that last March the dairyman's family ran through a course of scarlet fever, and this being about the time that the winter clothing was abandoned for the thin summer clothing, that winter clothing would again have to be put on but a short time prior to the outbreak among the students at Purdue. As it is known that the scarlet fever infection may remain virulent for a considerable time in clothing, it is not unlikely that it was through this means that the milk was infected. There is one other possibility, viz., that there might have been another family supplying the dairyman with milk in addition to the two families that he named, and he might have concealed this fact, knowing there was some sickness there. In this case the dairyman would be far more culpable.

This is one of the few scarlet fever epidemics traced to infected milk that have been reported in this country.

Sewage Disposal at the Indiana State Reformatory at Plainfield.

Severance Burrage.

The problem which recently presented itself to the authorities at the State Reformatory, at Plainfield, was a pretty one. An appropriation of $6,500 was available for the purpose of securing a certain amount of



Old Cesspool, showing method of disposal of sewage prior to new system.

plumbing in each of the so-called "family" buildings and to install a system of sewage disposal that first, would be sanitary, and second, would be of use in fertilizing and irrigating the fields on which crops are raised. Until the present year the sewage from the large out-building had been carried in a southeasterly direction to an open settling tank or cesspool, situated on the edge of the river bottoms. This cesspool in the summer time became a mass of fermenting filth, obnoxious and unhealthful. Moreover, it could not be utilized in any way. Now, with the introduction of plumbing into many of the buildings there would arise an appreciable

Site of Septic Tank north of the grounds, looking toward field to be irrigated and fertilized by the effluent from the tank.

increase in the amount of sewage and it would be out of the question to continue the old method of disposal. Up to this time practically all of the sewage came from one large out-building, which was nothing but a combination of closets and urinals, and while this made a considerable amount of sewage, both solid and liquid, there would be a considerable increase with the introduction of plumbing into all of the "family" buildings. This plumbing, including water-closets, wash-basins, and perhaps an occasional bath-tub.

There were two possible methods of sewage disposal that could be considered as practical in this instance, one being the system called "irrigation," which simply depends upon the distribution of the sewage directly on the fields (in this case on the river bottoms) that are being cultivated, and the other method was the septic tank system. After a very careful consideration of all the conditions, it was finally concluded to adopt a system which was a combination of both the septic tank and irrigation. This conclusion was arrived at because, should the raw sewage

Site of the Septic Tank north of grounds, as seen from main drive.

be thrown directly upon the fields in question it was feared by some that the odor from this raw sewage would be offensive, if not unhealthful, at certain times, and in view of the fact that these fields were adjacent to the main drive to the Reformatory, should any obnoxious odors arise, they would be noticed by everybody, and might be the cause for critical comment. In all probability there would not have been sufficient sewage at any one time to cause anything that would be called a nuisance in the manner just described, but it was thought better to err on the side of safety, and consequently the present plan includes a septic tank in which the sewage receives preliminary treatment before being distributed on the fields.

A casual survey of the Reformatory grounds showed at once that the lay of the land was so favorably arranged that the sewage could be collected and distributed by gravity. At no point would there need be any pumping; and yet when it came to make an accurate survey, including the levels, it was found that there were a number of quite difficult points to settle as to the best lines for the sewers to take in order to collect the

Field to be irrigated and fertilized by effluent from Septic Tank, as seen from main drive.

material from all the family buildings, and it was finally thought advisable to make two main lines of sewers, one leading to the fields northeast of the Reformatory, and the other following in general the line of the old sewer from the out-building in a southeasterly direction. Each one of these sewers ends in a septic tank in which the sewage undergoes a certain fermentation, and only the clear, or comparatively clear effluent passes out of the septic tank as an inoffensive liquid, very useful in irrigating the fields. Of course, this effluent from the septic tank is not as rich in fertilizing properties as the raw sewage would be, but it is free from any of the objections which might arise should the raw sewage be distributed upon the fields. The main problem in connection with the designing of the sewage disposal plant, furnished the material for the graduation thesis of two students of Purdue University, Messrs. Beuhler and Armstrong, who graduated in 1902. Their thesis work was done

Agar Plate, showing colonies of bacteria in 1-500 cu. centimeter of sewage as entering Septic Tank.

under the direction of Mr. C. V. Seastone of the Civil Engineering Department of the University, and the writer. The lines for the sewers were laid by another student of the University, Mr. Alva Baynes, who spent a large part of his summer vacation on the grounds. When it came to actually do the work it was found advisable, for one reason and another, to depart somewhat from the lines as designed by the gentlemen mentioned above in their thesis work, and it was also found advisable to depart somewhat from certain points in the specifications as set down by these same gentlemen. For example, the original thesis design called for but one main sewer collecting the material from all the family buildings

Agar Plate, showing colonies of bacteria in 1-500 cu. centimeter of effluent from Septic Tank.

and the hospital, etc., leading in a northeasterly direction toward the so-called garden, but the system as now existing includes the two main sewer lines as described above, one leading in a northeasterly direction, and the other in a southeasterly direction, and each ending in a septic tank.

All of the work of laying the pipes and building the septic tanks, etc., was done by the boys of the Reformatory, and thus the expense of the whole system was very much smaller than it would ordinarily be. The trenches for the pipes vary in depth from two to seventeen feet, and at many points considerable difficulty was encountered by running across springs or currents of underground water, which interfered very materially with the progress of the work. At the time of writing the paper, the sewer and septic tanks were all ready for reception of the material. The plumbing, however, has not yet been completed, but as soon as this is done the sewage can be turned into the pipes and the result of the method of disposal installed will be watched with much interest. It is practically the first experiment of this kind attempted by any institution in this State; and if successful, and there is no reason why it should not be, it should serve as a type or an example for many of the State institutions, and even for many of the smaller towns of the State.

Some Recent Mound Investigations in Jefferson County, Indiana.

Glenn Culbertson.

During the summer of 1902, through the interest, and under the direction, of Miss D. L. Cravens, of Madison, Indiana, several mounds located in Jefferson County were examined, and two were explored. The writer was asked to assist in the investigation.

The purpose of this paper is, in part, to give a record of the contents of the mounds opened, and in part to call attention to the fact that, in many parts of our State, and especially along the Ohio River and its larger tributaries, there are mounds and other evidences of the existence of a prehistoric people of which no record has been made, and which should be of great interest to science. Many of the mounds have been opened by curiosity or treasure seekers, or destroyed by cultivation, and the contents scattered or lost, and no record has been, or can be made.

As an example of the ruthless destruction of valuable anthropological material, a case may be cited of a Jefferson County farmer, who, in grading a plot of ground for building purposes, ploughed up at least twenty skeletons, many of which were said to be in a fair state of preservation, Some of the bones were carried off by neighbors, others were scattered about, and no record whatever preserved. This occurred some six or seven years ago, and similar cases probably occur every year in different parts of the State.

The first mound opened in Jefferson County, in 1902, is known locally as the "Lawson Mound." It is situated in Milton Township, T. 4, R. 11, Section 14, one mile east of Manville, on the narrow ridge between Brushy Fork and Indian Kentucky creeks, and approximately 300 feet above the level of the latter stream. The mound has been, until recently, covered with forest or underbrush growth, and is well preserved. It is essentially circular, sixty-five feet in diameter, and approximately nine feet high. The materials of which the mound was made are of local origin, and are made up of the ordinary surface soil of the vicinity. They include a few limestones, burnt and unburnt, and a few pebbles and pieces of chert. A thorough investigation of the contents of the mound could not be made, since the central portion was preoccupied by graves of the former owners of the property. When these graves were dug a skeleton was found some three feet below the surface of the mound. Along with the human bones nine arrow heads, placed in a circle, and a stone ax were found so situated as to lead to the opinion that they had been placed on the breast of the buried body. These articles were not preserved, according to Mr. Frank Wolf, who was present when the graves were dug and whose statements I have recorded above.

The excavation of this mound consisted in opening a ditch four feet wide and to the depth of the original soil, from the east side toward the center, and surface excavations to the depth of three feet on the north, west and south of the graves mentioned. At a point some five feet east of the center of the mound, and three feet below the surface, an unglazed earthenware vessel of approximately one and one-half gallons capacity was found. In shape, this vessel was similar to the ordinary Chinese rice pot, and was without markings of any kind. It contained two mussel shells, such as could be obtained from the surrounding streams. The vessel was cracked and had probably seen considerable service before being placed in the mound, as the lower portion showed the reddening influence of the fire.

Within a foot or fifteen inches of the earthenware vessel, and to the east, there were obtained the fragments of a skull and the larger bones of the arms and lower extremities, and one rib. All were greatly decayed. The position of the bones might indicate burial of the body on its side with arms and legs folded together, but this could not be decided definitely. The skull was so badly decayed that no definite idea of its shape could be obtained. The bones were those of a medium-sized person.

On the west side of the mound, in line with the two skeletons already mentioned, and at about the same depth as the others, another deposit of human bones was obtained. This deposit consisted of a skull and the larger bones of the upper and lower extremities. These were also greatly decayed. The position of these bones precludes the idea of their being the result of an ordinary burial. The long bones had the appearance of having been piled in, very much as a bundle of sticks or stove wood would be placed. The skull was placed directly on top of the other bones. These bones were those of one body of large but not unusual stature. The relics obtained from this mound are at present in the Hanover College Museum.

The reputed "Indian Mound" in the village of Lancaster, in Lancester Township, T. 5, R. 9, Section 33, was next examined. It was found to give every evidence of being a natural formation. The so-called "Indian Mound" on the Wainscott Place, near Middle Fork Station on the P. C. C. & St. L. R. R., was also closely examined. Evidence of its human origin, however, was entirely wanting. This peculiar mound is, in all probability, the result of stream erosion.

A mound situated on the second bottom of the Ohio River, a short distance below Hanover Landing, in Hanover Township, T. 3, R. 10, Section 18, was next excavated. This mound had been explored in part by Messrs. G. S. Taylor and W. W. Walker, some fifteen years ago. As reported by Mr. G. S. Taylor, now Superintendent of Schools of Jefferson County, this mound was then some twelve or fourteen feet high and of conical shape. At a depth of about three feet from the original top of the mound these gentlemen found five copper beads from one-half inch to three-quarter inch in diameter and of rough finish, arranged in a circle, as though originally forming a necklace. A considerable quantity of charcoal and ashes was also found, but no human bones.

Last July a trench eight feet wide was opened through the mound from east to west, and extending to the depth of the mound. All the excavated material was closely searched. At a point approximately three feet above the bottom of the mound two stones, each about 15x7x1½ inches, were found in an erect position and about four feet apart. Two and a half feet to one side of these stones a copper bead one-half inch in diameter and thickly encrusted with the green carbonate of copper was found. No bones were found at this level. On the original soil, at the bottom of the mound, a large quantity of charcoal and ashes, and one or two bone fragments, probably non-human, were obtained. With these there were fragments of burnt limestone. The failure to find human bones in this mound may be due to its great age, or it may be accounted for by the partial destruction of the mound by cultivation, since such material may have been ploughed out and no record made of the fact.

The Water Supply of Havana, Cuba.

C. H. Eigenmann.

Until recent years the water supply of Havana came from the Almendares River. During the nineties the present waterworks, deriving the entire supply from a large spring at Vento, on the south bank of the Almendares River, was completed. The Vento Springs and the covered aqueduct leading its waters under the Almendares River and into Havana are the pride of the city of Havana, which has erected an imposing monument to the engineer by whom the work was conceived. The Vento Springs are surrounded by masonry with walls sloping outward from the springs, except on the side nearest the Almendares River, where they are vertical. The surface water running down the slopes of the masonry are caught in a gutter which discharges it into the Almendares. At the top of the masonry, and some distance removed from its margin, another gutter catches the surface water of the region sloping toward the springs, and discharges this also into the Almendares. The spring water flows direct from the basin into the covered aqueduct. The provisions for maintaining the water in its original purity from the time it issues from the ground till it is discharged either into the reservoirs near the city, or direct from the faucets in the city, seem ideal.

There has been some speculation as to the origin of the water issuing from the spring at Vento. The water is beautifully clear and rather warm, having a temperature of 26°C. at the time of our visit. The Almendares River, flowing but a few feet away, also has clear water except after heavy rains, and its water at the time of our visit was slightly colder than that of the springs. It is possible that the Vento Springs derive their water from the upper courses of the Almendares, though this is so highly improbable that the suggestion may be left out of consideration. The springs being situated on the south side of the lower course of the Almendares the region across the river—that is the region north of the river—may be excluded as a possible contributing source of the supply of the Vento Springs. The region about the springs is composed of corralline rock. In such porous material conditions under which territory on one side of a river may contribute to springs located on the opposite side of a river are impossible.

The most probable origin of the Vento water supply can best be understood after a general statement of the conditions of the surrounding region.

The southern slope of the provinces Guanajai, Havana and Matanzas is largely drained by underground streams. The streams arising in the hills and mountains, forming the watershed between north and south drainage, run above ground for a distance and then disappear underground. The Ariguanabo River thus runs into a bank at San Antonio de los Baños and disappears among fallen rocks. A few yards away from its "sumidero" the water can be seen running in its underground channel through an opening in the thin roof of the channel. A few yards further on a dry cave leads down to the water, which, at the end of the dry cave disappears among fallen rocks. Other rivers disappear in a similar manner. They can not be followed in their underground courses because they completely fill them. The underground waters and the channels in which they run can, however, be reached in places through sink-holes. The streams reappear, in part, at least, in a number of "ojos de agua," some near the coast south of San Antonio. The region drained by underground streams is comparatively flat with frequently no indications of surface streams and their erosion, and extends westward to near San Cristobal, where the first permanent surface stream is observed. At Artimisa and Candalaria stream beds contained pools of water at the time of my visit.

From San Cristobal to Pinar del Rio there are many small perennial streams. Eastward from San Cristobal the cave region has an unknown extent. Poey limited it to the jurisdiction of Guanajay, but it certainly extends as far east as the meridian of Matanzas, and from reports probably beyond Cienfuegos. East of Rincon there are, however, frequent river beds, all but one of which were dry during the time of our visit. This main cave region belonging to the southern slope sends a tongue northward from Rincon to Vento on the Almendares River in the northern watershed. Aside from the "ojos de agua" along the edge of the cienegas skirting the southern coast there are two notable places where underground rivers find an exit. The one at Vento, as already mentioned, supplies the entire city of Havana with its water, the other serves to make the region about Guines a garden, its waters being used for irrigation. Other subterranean rivers in all probability have a sub-aqueous exit to the south.

The large spring at Vento is the only one on the northern slope as far as I know. The origin of the supply issuing from the Vento Spring has not been traced. But the region north of the Almendares River, being shut out from a possible contributing source, it undoubtedly derives its water from the tongue of the system of underground streams thrust into the northern slope. An examination of the best available map and the levels of the Western and United Havana Railroads make it seem quite certain that the Vento Springs derive their water from the region immediately south of Vento and north of Rincon and Bejucal. This region contains various sinks, without surface outlets, as well as dry sink-holes. A notable sink-hole in this region is that at Aquada on the United Havana Railroad. This is very broad, shallow and dry during the dry season, but the water rises to stand over ten feet deep on the railroad track during some of the wet seasons. All of these probably drain into the Vento Spring.

It behooves the health authorities of the city of Havana to exercise the strictest guard over the region between Vento on the north and Rincon and Bejucal on the south. Any contamination of sink-holes in these regions is sure, during the wet season at least, to contaminate the underground streams leading to Vento. An examination of the underground channels in the Lost River region of Indiana has shown the main underground channels to be provided with numerous smaller tributary channels which in ordinary weather do not carry water but which do carry water into the main stream after a long rain. At such a time any filth that may have accumulated in any of the sink-holes over one of the tributary streams is sure to find its way into the main stream. The same is very probably true of the Vento supply, although on account of the nature of the region it is not possible to follow the underground channels. At present some of the sink-holes between Rincon and Vento are used as cesspools and receivers of sewage.

Naëzhosh; or, The Apache Pole Game.

Albert B. Reagan.

[Abstract. Original in possession of Bureau of American Ethnology. Illustrations used by permission of Bureau.]

Naëzhosh is the Apache tribal game. It is played most every day from early morning till late in the afternoon by the men; in fact they do but little else, except hunt horses in the hills and drink Indian whiskey. This game is sometimes played to pass time; but most always for gain. The Indians often bet all they have on its outcome, and then having suffered reverses, they brood over their losses in sullen silence. Below is a description of the game; and the requisites—the pole-stick, the pole-hoop, and the pole-ground:

Fig. 1.

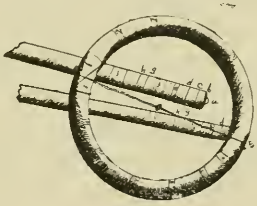


Fig. 2.

Diagram of Pole Sticks and Pole Hoop.
Fig. 1. Pole Stick. The grooves b, c, d, g, h; the spaces e, f, i, and the point a are points used in the game.
Fig. 2. The Pole Hoop, etc. The spaces 1–4 and 6–11 and the gr ove 5 are the points on the hoop used in the game.

The Pole-Stick.—The pole-stick is a willow pole one and one-half inches in diameter at the larger end. It tapers to a point at its smaller end. Its length is about fifteen feet. It is made in three sections, the sections being spliced together with sinew. The larger end of this pole is called the counting end. On it are several transverse grooves. These grooves together with some of the intervening spaces are the points on the pole used in the game.

The Pole-hoop.—The pole-hoop is about a foot in diameter. It is made of a willow withe, the ends of which are tied together with sinew. A buckskin cord forms a diameter to it. On this cord are strung one hundred and one beads, one large center bead and fifty smaller ones on each side of it. These beads are counts used in the game. In addition to the bead counts, the hoop rim has several counts on it. They are its transverse grooves, together with certain intervening spaces.

The Pole-ground.—The pole-ground is a leveled spot thirty-six yards in length, by six yards in width, laid off in a north and south direction. At its center is the base, usually a rock, from which the pole-hoop is rolled and the poles, two in number, are hurled. Nine yards both to the north and also to the south of this base, are three hay ridges, the center ridge being on the north and south center line of the pole-ground. These ridges are three yards long and the distance from the outer edge of the east ridge to the outer edge of the west ridge is five feet. The furrows between the ridges are narrow. It is into one of these furrows that the hoop rolls, under which the poles are slid before the points are counted.

Rolling the Pool-hoop.—In rolling the pole-hoop it is held with rim vertical between thumb and second finger of the right hand, it resting on the extended front finger over which it rolls when sent on its mission of chance. If the hoop, when rolled, fails to enter either of the furrows, a break in the game is declared, and it is brought back and rolled again. On entering one of the furrows, the loose hay retards its speed, and it soon falls, to be slid under by the well guided poles. The hoop is always rolled twice to the south and once to the north, and so on for hours, till the game is finished.

Hurling the Pole-stick.—The pole-stick, when being hurled, is held so as to slide through the left hand. The propelling power is the right hand, the index finger being placed against the rear end. The pole being dexteriously hurled, slides into the furrow, and stops with the larger end beneath the hoop. The counting then begins.

Counting the Points.—All points on each pole that fall on or within the rim of the hoop are counted as are also all points on the hoop-rim, and all the beads on the transverse cord which fall within the edges of either pole. The points being counted, the players again proceed to the base and play again as before. This playing is continued for hours till one of the contestants gets the number of points agreed upon by the players to constitute a game. A transfer of the staked property follows. Then the betting begins for a new game.

The pole field.

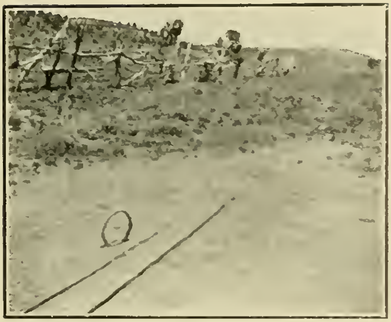
Starting the pole hoop. The beginning of the game.

Hurling the poles.

Hurling the poles.

The poles speeding on their way.

The hoop rolls wide of the counting field. A break in the game.



Hoop and poles entering the counting field.

Hoop and poles after motion has ceased. The hoop overlies the counting ends of the poles. The counting now begins.

Counting the points in the pole game.

Picking up the poles in the counting field.

Returning to the base.

The game begins anew.

Geodesic Lines on the Syntractrix of Revolution.

E. L. Hancock.

The syntractrix is defined as a curve formed by taking a constant length, d upon the tangent c to the tractrix*. The surface formed by revolving this curve about its asymptote is the one under consideration. We shall call it S.

Being a surface of revolution it is represented by the equations

$$x = u \cos v$$
$$y = u \sin v$$
$$z = -\sqrt{d^2 - u^2} + \frac{c}{2} \log \frac{d + \sqrt{d^2 - u^2}}{d - \sqrt{d^2 - u^2}}$$

Using the Gaussian notation† we find:

$$E = \frac{u^2(d^2 - 2cd) + c^2d^2}{u^2(d^2 - u^2)},\ F = o,\ G = u^2,\ A = -\frac{u^2 - cd}{u\sqrt{d^2 - u^2}} u \cos v,\ B = -\frac{u^2 - cd}{u\sqrt{d^2 - u^2}} u \sin v\ C = u,\ D = \frac{u^2(d^2 - 2cd) + cd^3}{u(d^2 - u^2)^{\frac{3}{2}}},\ D' = o,\ D'' = \frac{u(u^2 - cd)}{\sqrt{d^2 - u^2}}$$

$$K = \frac{1}{R_1R_2} = \frac{DD'' - D'^2}{EG - F^2} = \frac{(u^2 - cd)[u^2(d - 2c) + cd^2]}{(d^2 - u^2)[u^2(d - 2c) + c^2d}$$

In the particular surface given by $d = 2c$ the Gaussian curvature becomes

$$\frac{2\left(u^2 - \frac{d^2}{2}\right)}{d^2 - u^2}$$

Here d is positive, and since $d > u$, the denominator is always positive. We get the character of the curvature of different parts of the surface by considering the numerator. When $u^2 = d^2/2$, $K = O$, i. e., the circle $u = d/2$ $\frac{d}{\sqrt{2}}$ is made up of points having zero-curvature. When $u^2 > d^2/2$, $K > O$, and when $u^2 < d^2/2$, $K < O$.

For this particular surface

$$E = \frac{d^4}{4u^2(d^2 - u^2)},\ F = o,\ G = u^2,\ A = -\frac{2u^2 - d^2}{2u\sqrt{d^2 - u^2}} u \cos v,\ B = -\frac{2u^2 - d^2}{2u\sqrt{d^2 - u^2}} u \sin v\ C = o,\ D = \frac{d^4}{2u(d^2 - u^2)^{\frac{3}{2}}},\ D' = o,\ D'' = \frac{u(2u^2 - d^2}{2\sqrt{d^2 - u^2}}$$

To get the geodesic lines of the surface we make use of the method of the calculus of variations according Weierstrass§. This requires that we minimize the integral:

* Peacock, p. 175.

† Bianchi, Differential Geometrie, pp. 61, 87, 105.

§ Osgood, Annals of Mathematics, Vol. II (1901), p. 105.

$$I = \int_{t^2}^{t^1} \sqrt{E\,du^2 + 2F\,du\,dv + G\,dv^2}.dt$$

Denote $\sqrt{E\,u'^2 + 2\,F\,u'\,v' + G\,v'^2}$ by F. Then the first condition for a minimum of I is $Fv - \frac{d}{dt}\,Fv' = o$||

Now, in this case $Fv = o$, so that $\frac{d}{dt}\,Fv' = o$

Hence $Fv' = \delta$, or substituting the values E, F and G this becomes

$$\frac{u^2\,v^1}{\sqrt{\frac{d^4\,u'^2}{4\,u^2(d^2 - u_2)} + u^2\,v'^2}} = \delta$$

When $\delta = o$, $v' = o$, hence $v =$ constant, i. e., the meridians are geodesic lines.

When $\delta = o$

(1) $$v = \int \frac{\delta\,d^2\,u^1}{2\,u^2\sqrt{(d^2 - u^2)\,(u^2 - \delta^2)}} + \delta'$$

Making the substitution $u = 1\ t$, (1) becomes

(2) $$v = \int \frac{-\delta\,d^2\,t^2\,dt}{2\sqrt{(t^2\,d^2 - 1)\,(1 - \delta^2\,t^2)}} + \delta'$$

We have for the reduction of the general elliptic integral

*$R(x) = A\,x^4 + 4\,B\,x^3 + 6\,C\,x^2 + 4\,B'\,x + A'$

$g_2 = AA' - 4\,BB' + 3\,C^2$

$g_3 = AcA' + 2\,BcB' - A'B^2 - AB'^2 - c^3.$

These become in the present case

$R(t) = (t^2d^2 - 1)(1 - \delta^2t^2) = -\delta^2d^2t^4 + (d^2 + \delta^2)t^2 - 1$

$$g_2 = \delta^2d^2 + \frac{(d^2 + \delta^2)}{12}$$

$$g_3 = \frac{\delta^2\,d^2(d^2 + \delta^2)}{6} - \left(\frac{d^2 + \delta^2}{6}\right)^3$$

We get also

$R'(t) = -4\,\delta^2d^2t^3 + 2\,(d^2 + \delta^2)\,t$

$R'(t) = -12\,\delta^2d^2t^2 + 2\,(d^2 + \delta^2)$

Making the substitution

(3) $$t = a + \frac{\frac{1}{4}\,R'(a)}{p\,u - \frac{1}{24}\,R''(a)}\dagger$$

Where a is one of the roots of R(t), say 1 d, we get

$$t = \frac{1}{d} + \frac{\frac{\frac{1}{2}(d^2 - \delta^2)}{d}}{p\,u - p\,v} \quad \text{where } p\,v = \tfrac{1}{12}(d^2 - 5\delta^2)$$

|| Kneser, Variationsrechnung. Fv denotes function v.

* Klein, Ellip. Mod. Functionen, Vol. I, p. 15.

† Enneper, Ellip. Functionen, 1890, p. 30.

Now, since $\frac{dt}{du} = \sqrt{R(t)}$ we get from (2)

(4) $$v = -\frac{\delta d}{2}\int t^2 du + \delta' = \frac{1}{2\delta}\int\left[-\delta^2 - \frac{\delta^2(d^2-\delta^2)}{pu - pv} - \frac{\frac{\delta^2}{4}(d^2-\delta^2)^2}{(pu-pv)^2}\right]du + \delta'$$

Noting that in the present case

$$(p'v)^2 = -\frac{\delta^2}{4}(d^2-\delta^2)^2$$

$$p''v = -\delta^2(d^2-\delta^2)$$

and remembering that

$$\frac{(p'v)^2}{pu - pv)^2} = p(u+v) - p)u - v) - 2\,pv - \frac{p''v}{pu - pv}$$

(4) becomes

$$v = \frac{1}{2\delta}\int[-\delta^2 + p(u+v) - p(u-v) - 2\,pv]du + \delta'$$

$$= \frac{1}{2\delta}\left[-\frac{1}{6}(d^2+\delta^2)u + \xi'(u-v) - \xi'(u+v)\right] + \delta'$$

The functions ξ' may be expressed in power series. We have then the geodesic lines given by the equations

$$v = f(t) + \delta'$$

$$u = \frac{1}{t}$$

The constant δ' being additive has no effect upon the nature of the geodesics. It determines their position. All lines given by δ' may be made to coincide by a revolution about the z-axis. The curves may be completely discussed when $\delta' = o$.

Since the parameter lines of the surface consist of geodesic lines through a point and their orthogonal trajectories E may be taken equal to unity.* $E\,du^2 = du'^2$

Hence $-\frac{d}{2}\log\left\{\frac{d+\sqrt{d^2-u^2}}{u}\right\} = u'$, or $u = d\ \mathrm{sech}\,\frac{2u'}{d}$

Because of the relations of the surface to the pseudo-sphere it may be represented upon the upper part of the Cartesian plane†. The relation between the surfaces is given by the equations

$$v = v'$$

$$u = \frac{c}{d}u'$$

---

* Knoblauch, Krummen Flächen, p. 49.

† Bianchi, Differential Geometrie, p. 419.

where u and v are co-ordinates of points on the pseudo-sphere and u′ and v′ co-ordinates of points on S. The equations of transformation from S to the plane are

$$v = x$$

$$c\,e^{-\frac{u}{d}} = y$$

The real part of the surface being represented on the strip included between $y = c$ and $y = c/e$.

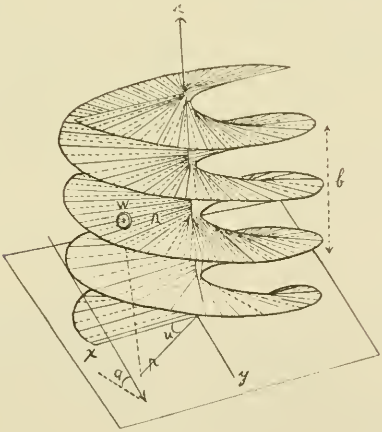
Comparison of Gauss' and Cayley's Proofs of the Existence Theorem.

O. E. Glenn.

[By title.]

Motion of a Bicycle on a Helix Track.

O. E. Glenn.



The equation of the helix surface may be conveniently expressed in surface co-ordinates, thus:

$$x = r\cos u \equiv f_1(ru)$$

$$y = r\sin u \equiv f_2(ru)$$

$$z = \frac{bu}{2\pi} \equiv f_3(ru)$$

in which r represents the distance of a point from the z axis, and u the angle between the x axis and the projection of r upon the (xy) plane; b being a constant.

It will be assumed here that there is a force of friction equal and opposite to the centrifugal force, of a particle (or wheel) moving down the surface, under the action of gravity (g). If these equal and opposite vectors be introduced, the problem reduces to that of determining the motion of a particle (or wheel) on a fixed smooth surface.

The general equation of kinetic energy* is,

$$(1)\quad d\left(\tfrac{1}{2}mv^2\right) = \left\{X\frac{{}^{\dagger}df_1}{dr} + Y\frac{df_2}{dr} + Z\frac{df_3}{dr}\right\}dr + \left\{X\frac{df_1}{du} + Y\frac{df_2}{du} + Z\frac{df_3}{du}\right\}du,$$

where m represents the mass, v the velocity and X, Y and Z the axial components of the impressed forces.

Denoting the angle between the [xy] plane and the tangent plane of the surface by a there results:

$$(2)\quad X = mg\sin a\cos a\cos u = mg\frac{\sin 2a}{2}\cos u.$$

$$Y = mg\sin a\cos a\sin u = mg\frac{\sin 2a}{2}\sin u.$$

$$Z = mg.$$

And equation (1) reduces to

$$d\left(\tfrac{1}{2}mv^2\right) = \left[g\frac{\sin 2a}{2}\cos^2 u + g\frac{\sin 2a}{2}\sin^2 u\right]m\,dr.$$

$$+\left[-g\frac{\sin 2a}{2}r\sin u\cos u + g\frac{\sin 2a}{2}r\sin u\cos u + \frac{gb}{2\pi}\right]m\,du\text{; or,}$$

$$(3)\quad d\left(\tfrac{1}{2}mv^2\right) = m\left\{g\frac{\sin 2a}{2}\right\}dr + \frac{mgb}{2\pi}du.$$

But the angle a equals,

$$a = \cos^{-1}\frac{2\pi r}{\sqrt{4\pi^2 r^2 + b^2}}$$

Whence $\frac{\sin 2a}{2} = \sin a\cos a = \frac{2\pi r b}{4\pi^2 r^2 + b^2}$ and from (3).

$$(4)\quad d\left(\tfrac{1}{2}mv^2\right) = \left\{\frac{2\pi b\,mgr}{4\pi^2 r^2 + b^2}\right\}dr + \left\{\frac{mgb}{2\pi}\right\}du.$$

This, upon integration, gives,

$$(5)\quad v^2 = \frac{gb}{2\pi}\log\left[\frac{r^2 + \frac{b^2}{4\pi^2}}{r_0^2 + \frac{b^2}{4\pi^2}}\right] + \frac{gb}{\pi}u,$$ the initial conditions being $v = 0$ and $r = r_0$ when $u = 0$.

---

* Ziwet Mechanics, p. 103, Vol. III.

† These are partial derivatives.

Now $v^2 = \left\{ \frac{*df_1}{dr}\frac{dr}{dt} + \frac{df_1}{du}\frac{du}{dt} \right\}^2 + \left\{ \frac{df_2}{dr}\frac{dr}{dt} + \frac{df_2}{du}\frac{du}{dt} \right\}^2 + \left\{ \frac{df_3}{dr}\frac{dr}{dt} + \frac{df_3}{du}\frac{du}{dt} \right\}^2$

in which t represents the time and v the velocity. Therefore,

$$(6) \quad v^2 = \left\{ \cos u \frac{dr}{dt} - r \sin u \frac{du}{dt} \right\}^2 + \left\{ \sin u \frac{dr}{dt} + r \cos u \frac{du}{dt} \right\}^2 + \left\{ \frac{b}{2\pi}\frac{du}{dt} \right\}^2$$

$$= \left\{ \frac{dr}{dt} \right\}^2 + \left\{ r^2 + \frac{b^2}{4\pi^2} \right\} \left\{ \frac{du}{dt} \right\}^2.$$

From (5) and (6).

$$(7) \quad \frac{gb}{2\pi} \log \left| \frac{r^2 + \frac{b^2}{4\pi^2}}{r_0^2 + \frac{b^2}{4\pi^2}} \right| + \frac{gb}{\pi} u = \left\{ \frac{dr}{dt} \right\}^2 + \left\{ r^2 + \frac{b^2}{4\pi^2} \right\} \left\{ \frac{du}{dt} \right\}^2$$

This is the differential equation of the motion.

Its integral furnishes solutions of the following:

1. What is the time of descent?
2. What is the equation of the curve of quickest descent?
3. What is the space passed over in a given time?
4. What is the velocity at any instant?
5. What is the normal pressure on the surface?

Problem: A wheelman rides down a helix surface along the line of pitch 30°, keeping his wheel at a constant radial distance of 30 feet. Find the time of descent and his velocity upon reaching the ground; the helix making one complete turn.

Since r is constant and equal to r_0, we have:

$$(8) \quad r = r_0 = 30.$$

$$b = 2\pi r \tan 30^0 = 3{,}1416 \times 60 + \tfrac{1}{3}\sqrt{3} = 108.824.$$

$$g = 32.$$

Equation (7) now becomes,

$$\left\{ r_0 + \frac{b^2}{4\pi^2} \right\} \left\{ \frac{du}{dt} \right\}^2 = \frac{gb}{\pi} u$$

Substituting from (8)

$$\frac{du}{dt} = \left\{ \frac{32 \times 108.82}{3.1416 \times 1199.982} \right\}^{\frac{1}{2}} \sqrt{u} = .96 \sqrt{u}.$$

$$\therefore t = \frac{2}{.96} \sqrt{u} \Big]_0^{2\pi} = \frac{200}{96} \sqrt{2 \times 3.1416} = 5.2 \text{ seconds} = \text{time of descent.}$$

From equation (4).

$$v = \sqrt{\frac{32 \times 108.824}{3.1416}} \sqrt{u} = \sqrt{64 \times 108.824} = 83.4 \text{ ft. per second} = \text{velocity}$$

at bottom.

---

* Partials.

It may be observed that the velocity is the same as that acquired by a body falling through the height h, and is independent of the radial distance, r. The time of descent is directly proportional to r; and both are independent of the weights. That is, we have the theorem:

Motion on the helix surface is equivalent to that on the incline plane, when r is constant.

A Generalization of Fermat's Theorem.

Jacob Westlund.

Consider the function

$$(1)\quad F(\alpha,\ A) = \alpha^{n(A)} - \left(\alpha^{\frac{n(A)}{n(P_1)}} + \ldots + \alpha^{\frac{n(A)}{n(P_i)}}\right) + \left(\alpha^{\frac{n(A)}{n(P_1P_2)}} + \ldots\right) - \ldots + (-1)^i\, \alpha^{\frac{n(A)}{n(P_1P_2\ldots P_i)}},$$

where α is any algebraic integer and A any ideal in a given algebraic number field, $P_1, \ldots P_i$ are the distinct prime factors of A, and n(A) denotes the norm of A. The theorem which we shall prove is that $F(\alpha, A)$ is always divisible by A.

For the case when α and A are rational integers several proofs of the divisibility of $F(\alpha, A)$ by A have been given*.

When A is a prime ideal the function $F(\alpha, A)$ reduces to $\alpha^{n(A)} - \alpha$, which, as we know, is divisible by A.

Let us first consider the case when $A = P_1^{S_1}$, where P_1 is a prime ideal of degree f, and p_1 the rational prime divisible by P_1. Then

$$F(\alpha,\ P_1^{S_1}) = \alpha^{p_1^{fs_1}} - \alpha^{p_1^{f(s_1-1)}}.$$

But

$$\alpha^{p_1^{f(s_1-1)}(p_1^f-1)} \equiv 1, \text{ mod } P_1^{S_1}$$

and

$$\alpha^{p_1^{fs_1}} \equiv \alpha^{p_1^{f(s_1-1)}}, \text{ mod } P_1^{S_1}$$

hence

$$(2)\quad F(\alpha,\ P_1^{S_1}) \equiv 0, \text{ mod } P_1^{S}.$$

Now, suppose $A = B\,.\,P_1^{S_1}$ where B is any ideal not divisible by P_1. Then we can easily derive the following relation:

$$F(\alpha^{p_1^{fs_1}},\ B) - F(\alpha,\ B\,.\,P_1^{S_1}) = F(\alpha^{p_1^{f(s_1-1)}},\ B),$$

---

* Dickson, Annals of Mathematics, 2d Series, Vol. 1, 1899, p. 31.

or

(3) $F(\alpha, BP_1^{S_1}) = F(\alpha^{p_1^{fs_1}}, B) - F(\alpha^{p_1^{f(s_1-1)}}, B)$.

If we let $B = P_2^{S_2}$ we get from (3)

$$F(\alpha, P_2^{S_2}P_1^{S_1}) = F(\alpha^{p_1^{fs_1}}, P_2^{S_2}) - F(\alpha^{p_1^{f(s_1-1)}}, P_2^{S_2})$$

and hence by (2)

(4) $F(\alpha, P_2^{S_2}P_1^{S_1}) \equiv 0, \text{ mod } P_2^S$

By a similar reasoning we also get,

(5) $F\left(\alpha, P_2^{S_2} P_1^S\right) \equiv 0 \text{ mod } P_1^{S_1}$ and hence by (4) and (5).

(6) $F\left(\alpha, P_2^S P_1^{S_1}\right) \equiv 0 \text{ mod } P_2^{S_2} P_1^{S_1}$.

We now assume that for an arbitrary α the function $F(\alpha, A)$ is divisible by A, then if P be any prime ideal not contained in A we have by (3)

$F(\alpha, AP^s) = F(\alpha^{p^{fs}}, A) - F(\alpha^{p^{f(s-1)}}, A)$ and hence,

(7) $F(\alpha, AP^s) \equiv 0 \text{ mod } A$.

Now let $A = CQ^t$ where Q is a prime ideal and C prime to Q. Then,

$F(\alpha, AP^s) = F(\alpha^{q^{f't}}, CP^s) - F(\alpha^{q^{f'(t-1)}}, CP^s)$ where q is the rational prime divisible by Q and t the degree of Q, and since by our assumption the two terms on the right side are divisible by CP^s it follows that,

(8) $F(\alpha, AP^s) \equiv 0 \text{ mod } CP^s$, and hence,

(9) $F(\alpha, AP^s) \equiv 0 \text{ mod } AP^s$.

Hence if $F(\alpha, A)$ is divisible by A when A contains n distinct prime factors it is also divisible by A when A contains n+1 distinct prime factors. Making use of (4) we then find that $F(\alpha, A)$ is divisible by A for any A.

On the Class Number of the Cyclotomic Numberfield

$$K\left(e^{\frac{2\pi i}{p^n}}\right)$$

Jacob Westlund.

[By title.]

[Will appear in Transactions American Mathematical Society, Vol. IV; 2.]

Photographic Observations of Comet C, 1902.

John A. Miller.

Comet c (Perrine) 1902, was photographed here on every clear night from October 5 to October 22, clouds preventing either earlier or later ones. With few exceptions two photographs were made on each night. One photograph being made with a portrait lens built on the Petzval system, but afterward refigured by Brashear. This lens had an aperture of twelve centimeters and a focal length of fifty-five centimeters. The other photograph was made with an old "tintype" lens which Mr. W. A. Cogshall rescued from a photograph gallery here and which performs surprisingly well. This lens has an aperture of 5.5 centimeters and a focal length of twenty-two centimeters.

The tail of this comet was exceedingly faint, so faint that it was with difficulty that it could be photographed at all. Each of the photographs showed two streamers, a long one nearly straight and a shorter one more sharply curved. The greatest length of the short tail was shown on the photograph of October 6. It was then 1.°8 long, while on October 22 it did not exceed one-half degree in length. On October 5 the long streamer subtended 3.°2. Each succeeding photograph showed the streamer longer until on October 22 it subtended an angle of 8.°4. In the following table I have shown the results obtained by measuring five of the photographs, which represents fairly well the behavior of the comet.

In this table T is the central time of exposure; L, the length of the long tail in degrees; S, the length of the short tail in degrees; N, the number which when multiplied by the cosine of the angle between the direction of the comet's tail and the radius vector from the sun to the comet gives the length of the long streamer in terms of the mean distance of the earth from the sun:

T.	L.	S.	N.
h. m. h. m.			
October 5, 8:10 — 9:00	3.2	1.0	.0294
October 6, 8:00 — 11:45	3.2	1.8	.0383
October 7, 6:00 — 7:20	3.8	1.5	.0323
October 20, 6:00 — 7:20	6.1	1.2	.0686
October 22, 6:15 — 7:45	8.4	...	.0966

The Genus Puccinia.

J. C. Arthur.

The present paper is a continuation of two previous attempts to bring to the notice of this society something of the efforts that are being made to devise a workable method that will eventually lead to a stable nomenclature for plants. The necessity for having one authoritative name for each species and genus of plants is conceded by all botanists. The methods proposed for arriving at this desirable state are various. It is evident that nomenclature will never become stable if left to itself, that is, to the judgment of the individual. There must be rules of procedure which most botanists, if not all, will feel bound to respect.

The wise formulation of such rules and the impress of authority, which they must necessarily bear, are difficult to secure. Were there an international organization of recognized competency to take up the matter, the way would seem easy. In the absence of such a body, suggestions and attempts must be expected from various sources, which may finally crystallize into a form which the botanical world at large will accept.

American botanists, acting through the American Association for the Advancement of Science, promulgated the Rochester-Madison rules of nomenclature in 1892-93. These rules, after the test of a decade, have been somewhat modified and extended, and today represent the most carefully considered and most practical scheme for securing uniformity of procedure in naming plants that has yet been brought forward. Whatever may be thought of these rules, or of any other, it is certainly the part of wisdom to test their applicability, and lend a hand to their improvement.

In order to illustrate the American rules I propose to take the very interesting case of the genus *Puccinia*. As the name is generally used it embraces about one thousand species of plant rusts, which are characterized by having free, two-celled telentospores. In my paper* of four years ago I pointed out, that according to the Kuntzean rules of nomenclature this generic name should be transferred to the cedar apple rusts, to replace *Gymnosporangium*, a name that has been in use since 1805. In my second paper,† presented two years later, I showed that if we accept the

* Indiana plant rusts, listed in accordance with latest nomenclature. Proceedings Indiana Academy of Science for 1898:174-186.

† Generic nomenclature of cedar apples. Proceedings Indiana Academy of Science for 1900:131-136.

first species published under a new genus as the type species to which the genus is to be invariably anchored, and from which its essential characters are to be drawn, the cedar apples must be listed under the Linnæan genus *Tremella*, while the fate of the name *Puccinia* was left in doubt.

In the meantime the amended rules of nomenclature by the American Committee have been distributed, and although these recognize the great value of types, a specimen used by the author as type of the species, and a species as type of the genus, they provide other ways of determining the type of a genus than always taking the first species named under it. The new rules require that the intent of the author, or if that is not ascertainable, the usage of his followers, shall be respected.

If we examine the status of the three genera, *Tremella*, *Gymnosporangium* and *Puccinia*, under the present rules, we will find that the first becomes a genus of algae, not longer to be included among the fungi, the second is restored to the position it has long occupied, while the third is well nigh lost in the toils.

The name *Puccinia* was introduced into botanical literature by Micheli in 1729, and is consequently pre-Linnæan. It was employed by Haller in two different works prior to 1753, the initial date for the operation of the law of priority, and by the same author in his *Historia stirpium indigenarum Helvetiæ inchoata* (Vol. III, p. 126) of 1768. The last work, however, does not employ binomial names, and is not to be used in establishing modern nomenclature. Another early author, who cites the name *Puccinia*, is Adanson in his *Familles des Plantes* (Vol. II, p. 8) of 1763. He adopts both the name and the description of the genus from Micheli, but does not mention any species. There is a failure, therefore, to establish the genus on account of the lack of a type species.

The next oldst author to employ the name is Willdenow in his *Floræ Berolinensis*, of 1787. Willdenow characterizes his genus *Puccinia* as follows: "*Corpus cylindraceum seminibus caudatis radiatim positis, elastice exsilientibus farctum.*" Under this genus he places a single species, *Puccinia simplex*, which is described as "*P. corpore cylindrico simplicissimo obtuso.*" It is said to occur on the trunks of plum trees *(Prunus armeniaca)* in autumn, and to be rare in the vicinity of Berlin. Although reference is made to Micheli, yet careful comparison shows conclusively that Willdenow's plant was different from that of the Italian author. Moreover, it could not have been one of the cedar apples

(Gymnosporangium), as pointed out by Magnus,* for they neither grow upon the plum nor produce their spores in autumn. Further confirmation of this is found in Roth's *Floræ Germanicæ*, the first volume of which was issued the year following the appearance of Willdenow's work. In this volume (p. 547) *Puccinia simplex* is given, and credited to Willdenow, with no reference to Micheli, while a few pages farther on in the volume the common cedar apple of Europe is listed as *Tremella juniperina*. The two were evidently considered by the author to be distinct fungi.

There seems to be no doubt, that according to our present form of procedure, we must consider that the genus *Puccinia* was established by Willdenow in 1787, with the single species, *P. simplex*, a species that does not belong to the *Uredineæ*. What fungus Willdenow had in hand, I am not prepared to say. The description fairly well applies to *Cornularia Persicæ* (Schw.) Sacc., but that is a North American fungus, common in America but not yet reported from Europe. So far as our present purpose is concerned, however, it is enough to know that the type of the genus *Puccinia* is not uredineous. Therefore, the largest and best known genus of plant rusts, the one that includes the chief economic species, drops entirely out of the extensive family of the *Uredineæ*. Probably Doctor Kuntze is to be followed in placing under Dicaeoma the species that have heretofore been listed under *Puccinia*, as I have already pointed out in my preceding paper before the Academy.

Whether this is the final word regarding the genus *Puccinia*, and the fungi which it has been used to cover, yet remains to be seen. It may appear foolish to some to relegate to obscurity a well known and long established name, upon what seem to be technical grounds. But the loss of a familiar name should not stand in the way of the introduction of definite rules which will lead to a reasonably permanent nomenclature. What is most desired is that the period of trial and transition shall be as short as possible, and to assist in bringing this about the study of the genus Puccinia is herewith presented.

---

* Bot. Centr., Vol. LXXVII, p. 5.

Forestry Conditions in Montgomery County, Indiana.

Samuel J. Record.

The recent interest in forests and forestry problems in Indiana makes it very important that every one collecting accurate information regarding the forestry conditions in any part of our commonwealth, present in as complete a manner as possible everything that may be of general importance in arousing public interest and at the same time serve as a basis for intelligent work in that particular part of the State.

The writer has studied with some degree of thoroughness the conditions in Montgomery County, which conditions, as revealed by the following facts, demonstrate the very serious nature of the problems we are confronting and the lines for future work.

Montgomery County is located in the middle western part of the State and contains 504 square miles, or 322,560 acres. Owing to its large size, its prominent location and the diversity of its surface and soil it may well be considered as a typical section of the central part of Indiana. Hence, what may be said of the forestry conditions and the plans and possibilities of its reforestation may in a general way be considered true of the whole central portion of the State.

The surface of the county is pleasantly diversified. The western and central part near the principal streams is hilly and broken, in the north central it is gently undulating and at the east and southeast flat and level. The northern part of the county is notably a prairie region, level or gently rolling.

The drainage takes direction from the dip of the underlying rocks generally a little west of southwest. The main stream is Rock River or Sugar Creek, which enters south of the northeast corner and traversing the central area, passes out six miles north of the west corner of the county. Its tributaries from the north are Black and Lye creeks; from the south, Offield, Walnut and Indian creeks. The southern and southeastern parts are drained by Big and Little Raccoon creeks and at the southwest by Coal Creek, which flows directly into the Wabash.

The early settlers found the county one vast forest, broken only by the wind swept streak of the cyclones or the marshy land of the prairies. So dense was the wilderness that their way had to be cut with the axe. Trees and saplings were cut and their trunks made into corduroy roads.

Everywhere were the most valuable varieties of forest growth, such as the oak, walnut, ash, poplar, cherry, maple. elm, hickory, beech, mulberry, buckeye, locust, willow, sycamore, cedar, and some hemlock, each towering and climbing and ever contesting for the necessary light of the sun. The lower branches were of little use in the shade and soon died away, thus by the natural pruning leaving the stem of the tree smooth and unbranched.

To appreciate something of the size of these giants of the forest we need but note the following:

Common Name.	*Diameter.*	*Height to First Limbs.*	*Total.*
Burr Oak	7	72	160
White Oak	6	60	150
Black Oak	6.5	75	165
Red Oak	7	94	181
Black Walnut	7	74	155
Poplar	8	91	190
Sugar Maple	5	62	120

All the ground was covered with underbrush and litter which had been accumulating for ages, producing a deep, rich loam which is still evident in the richness of the cultivated fields. Here were myriads of birds making their homes in the kindly shelter of the trees, and in turn destroying the multitude of insects which threatened the life of the forest. Thus when we closely examine the natural conditions we find the forest is a unit, a natural community in which each factor plays its part. An equilibrium is established, the result of the adaptation of each element to its environment; and when this equilibrium is disturbed the result is an undue development of one factor and consequent suppression of others. In this instance thoughtless man has destroyed the equilibrium, and the drying up of the wells and streams, the decrease in fertility of the fields and loss to our crops are a few of the disastrous results.

Now but little remains to remind us of the luxuriant forests of this county sixty years ago. Here and there are scattered patches of woodland standing like islands in a wide sea of clearing, and most of these so thinned and mutilated that they can scarcely be called forests at all. To the student of such affairs the destruction of this once mighty forest has all the features of a long continued tragedy. It is a crime against the past, present and future, a crime which may never be forgiven nor forgotten. Though undoubtedly required by the necessities of civilization and population, it has been carried too far, and future generations may have to curse the wanton waste of the past. Our fathers had a constant grudge against trees. The best were cut into rails or hewed into sills, or used for firewood. Regular logging bees were held and tree after tree was cut, rolled together and burned. There is not a farm in the county today but would, if left in timber, have been worth six times its present value. And worst of all, this same policy is being continued. Every year forest owners, either through carelessness or ignorance, are wasting valuable property. Concerning the market value of the various crops which the farm produces the farmer is usually posted, but concerning the market value of the various trees making up his timberland he is usually ignorant. The amount of timber that has been allowed to go to utter waste in the past history of the county, because of the failure to appreciate the true value of forests, would have been sufficient, had it been preserved and sold at current prices, to have paid for every acre of land in the county. Save for occasional groves, almost all the black walnut has been removed because of its great value, and yet on every farm in the county, rows of rail fences built of black walnut and poplar, puncheon floors, rafters of old barns and sheds attest to its reckless use in the past.

In this country where all the land is in the hands of private owners, nothing can be done save through the intelligent co-operation of land owners.

No land in the county has been reforested by artificial means. A number of farmers, however, maintain groves of catalpa and black locust which furnishes material for posts and poles. Numerous instances could be cited where a few acres of black locust furnish a constant supply of posts for the fencing of farms containing hundreds of acres each. Such groves are easy to propagate and furnish the best of posts, which can not be purchased on the market for less than thirty cents each line post. The catalpa groves have not proved so successful, owing in some instances to the planting of catalpa bignonoides which is of small growth, crooked and seldom forming a well-shaped tree. The valuable variety to plant is C. speciosa, which is a very rapid grower and furnishes wood valuable for posts, ties, telegraph poles and lumber.

Not only has there been no planting of forest tracts, but there has been a constant cutting off of the remaining timberland. The following figures from the statistician's report shows this condition:

1881	67,574 acres timberland.
1882	62,983 acres timberland.
1883	69,390 acres timberland.
1884	69,451 acres timberland.
1885	46,508 acres timberland.
1886	44,183 acres timberland.
1900	7,184 acres timberland.

The discrepancies in the early returns are due to inaccurate data; the later reports are more reliable. They are sufficient to show the vast decrease in our forest area. In fifteen years 39,324 acres of timber was removed at the rate of 2,621 acres per year. If this rate were kept up all the remaining timberland would be deforested in 2.7 years, but, of course, the decrease in the amount and value of the timber would tend to lessen the annual rate of removal.

The census report for 1900 states that the number of acres in timber but not in pasture land in Union Township is 2,240. Much of this, however, is in small lots or groves and has had most of its best timber removed. This 2,240 acres is but 3.1 per cent. of total area of the township and is divided into 103 tracts or lots, only thirty-seven of which contain twenty acres or more. Of this latter number only eighteen contain as much as forty acres, and only one of 100 acres.

Ripley Township is rugged and broken toward the south and has remaining a larger proportionate acreage of forest. There are twenty-six tracts of twenty or more acres reported, making a total of 1,273 acres, comprising 59 per cent. of the total area. Much of this land is covered with beech, which, however, is not a very profitable timber. The soil, especially toward the southern part, is generally poor clay, and if stocked with young trees would soon bring much more than can be realized from the same ground at present.

Brown Township is also much broken along the course of Sugar Creek. Only fifteen tracts of over twenty acres were reported, but most of these areas are large, giving a total of 950 acres or 2.7 per cent. Much of this timber is beech, though white oak is also abundant. The region near the mouth of Indian Creek, known as Pine Hills, is covered with pine and hemlock. Some of these trees are very large with straight, towering stems reaching to lofty heights. Hundreds of seedlings are growing everywhere and if left alone will perpetuate the excellent forest condition now prevailing. Farther down the stream are the "Shades of Death," an area of 200 acres in virgin forest, especially noted for its beautiful scenery. The sides and slopes of the sharp hills and promontories are covered with a thick growth of evergreen hemlocks and cedars and the tip-top heights with pines which lift their foliage 200 feet above the brook, averting the sun's rays and filling the deep chasm with a gloom typical of the "Valley of the Shades." Here one sees typical forest conditions, the forest litter holding the moisture and feeding gradually the many pure, cold springs. This land, if deforested, would be worth practically nothing, but under proper management a large return could be secured annually from the timber growing there. This area, however, has been recommended by the State Forester as a forest reserve with the purpose of increasing its efficiency as a park. Dr. Henry Moore, of Irvington, Indiana, was chosen president of the board of control. No other recommendations have been made.

Walnut Township reports fifty-eight forest tracts containing a total acreage of 4,493 acres of 20 per cent. whole area. These forest tracts are comparatively large, thirteen of them containing 100 acres or over.

Franklin Township reports eleven forest tracts, of twenty acres or over, making a total of 420 acres, or 2 per cent. The areas are small and most of the good timber has been removed. The boulder trail passes through the western portion of the township and the land in its vicinity would be worth much more if properly covered with timber than it is in its present condition; the large number of boulders making cultivation of crops very difficult.

Sugar Creek Township reports seven tracts or 302 acres, 1.4 per cent. of total area. Most of the region is black prairie land and the timber is mostly in groves which have grown since the settlement of the country. The prevailing species are shellbark hickory and white oak.

Madison is also a prairie region and its condition of soil and forest closely resembles Sugar Creek. Seven tracts are reported, giving a total of 458 acres, though the total acreage of the township, including smaller tracts, is reported as 501 acres or 21 per cent.

Coal Creek reports but two tracts of more than twenty acres, though the total acreage amounts to 201 acres or .6 per cent. of the total area of the township.

Clark Township returns indicate four forest tracts containing over twenty acres. Only one tract contains over forty acres. The total area is 135 acres or .6 per cent.

Wayne has but eleven forest tracts, making a total of 399 acres or 2 per cent. of the total area. The tracts are small, only one containing as much as sixty acres.

Scott Township reports no forest tract containing as much as twenty acres. The total area of the timberland in the township does not exceed ninety-five acres or .4 per cent.

From this glance at the townships it will appear that the amount of available timber is very limited and most of the forests now remaining are so small, open and scattered, that the benefit derived from them is but a small per cent. of that accruing from well regulated forest areas.

The General Assembly of the State of Indiana enacted, in 1899, a forest reservation law, whereby upon any tracts of land a portion, not exceeding one-eighth of the total area, could be selected as a permanent forest reservation which should be appraised for taxation at one dollar per acre. The land to be exempted must contain 170 trees per acre, either naturally or artificially propagated. The act makes further specifications as to the maintenance of the tract, and designates what trees shall be known as forest trees within the meaning of the act. The law was a step in the right direction and has resulted in 284 exemptions covering a total area of 5,312 acres in the State. In Montgomery County, however, not a single exemption has been filed. This condition in this county is largely due to the lack of information on the subject, and succeeding years will no doubt witness a large number of exemptions.

Deforestation of the headwaters has produced a marked effect in the size and value of the county's streams. In its early history Sugar Creek was navigable for good-sized boats and was much used as a means of transportation. In 1824 William Nicholson came from Maysville, Kentucky, to Crawfordsville in a keel boat of ten tons burden which landed at the mouth of Whitlock's Spring branch. It floated down the Ohio to the mouth of the Wabash and thence was rowed up to the mouth of Sugar Creek, finally, after a long voyage, reaching its destination. Afterward two men took the same boat down to Terre Haute for a load of corn. Other instances could be cited, but these are sufficient to show the extent of the navigability of the stream which at present would scarcely float an old time flatboat. Much of this is due to the filling in of the channel with the products of the denuded fields above.

Records show that Sugar Creek has furnished a motive power for at least nineteen mills situated along its course in Montgomery County. At the present time the number does not exceed four and these are obliged to use steam during most of the summer season. As is well known, a constant water supply furnishes a most economical and reliable motive power which would tend to lessen the cost of any manufactured products. The owner of the Sperry Mill, at Crawfordsville, asserts that the cost of running the mill one day by steam power, including coal, fireman and all expenses, is $5; while the total cost of water power for *one year*, including repairs to the dam and wheel, is $40. In other words, the amount required to run the mill one day by steam would pay the cost of running the same mill by water for nearly forty days.

The amount of power exerted by the stream in its course would, if utilized, be sufficient to turn every wheel in every factory within the county. This would be of especial importance in furnishing an economical motive power for concerns under municipal ownership, thereby greatly reducing the expense of operating. But while the volume of water carried by Sugar Creek in a year has probably remained constant since the county was discovered, yet the flow is so irregular and uncertain that it is no longer of great economical importance.

Deforestation has also had a very disastrous effect upon the fish supply of our streams. In the early settlement of the country Sugar Creek was full of edible fish. It is related by an old settler that during one night in 1824, 900 fish, consisting of pike, salmon, bass and perch, were caught in a large fish trap. The settler often carried them by skiff loads from the fish trap and placed them in a pond to be retaken later and sold or used for food. Now this condition has entirely changed and but few food fishes remain in our streams. It is true that stream pollution and illegal fishing are responsible for much of this, but the decrease in the volume of water, rendering it stagnant during the summer months, is almost directly the result of deforestation of the headwaters. The unusually high water at the season of spawning seriously interferes with the reproduction of the species. This sudden rise of the stream is prevented by the forest. The litter receives the rain, and, owing to its looseness and lack of capillarity, prevents rapid evaporation. The relatively low temperature of the forest is also a factor in lessening the rate of evaporation. The unevenness of the forest floor, with sunken logs and piles of debris, prevents the formation of gullies and consequently the water sinks into the ground instead of running off on the surface. It can not wear away the soil upon steep slopes, nor form sudden and disastrous freshets as in a naked and treeless region. The streams rising in woodlands may swell after a rain, but more gradually, and they will subside again more slowly. If they rise in woodland swamps, they are scarcely liable to floods at any season and tend to an even flow throughout the year.

The soil of Montgomery County is generally very rich and the disastrous effect of the removal of the forest will not be evident for many years. The land is especially adapted for agricultural pursuits, and rational farming and rotation of crops is doing much to maintain its productiveness. Yet some tracts have been cleared which are of very little use for farming purposes, and fail to yield a profit for the labor exerted upon them. We have seen large areas of good timber cut down, much of it wasted and destroyed, merely to add to the farm land an area almost worthless for cultivation. Such land should be immediately reforested with the most profitable kinds of timber, since by this means the most profitable returns can be secured.

An examination of our corn crop yields since 1873 shows the following gains:

1873-1877	24 bushels per acre.
1878-1882	31 bushels per acre.
1883-1888	37 bushels per acre.
1889-1893	32 bushels per acre.
1894-1900	42 bushels per acre.

In considering these figures we must remember that much newly cleared land, rich from forest litter, has been added yearly and tends to increase the average yield per acre.

Our wheat crops have not fared so fortunately and the averages for five year periods since 1872 show the following decrease:

1872-1876	21.18 bushels per acre.
1877-1881	15.45 bushels per acre.
1882-1886	14.21 bushels per acre.
1887-1891	13.10 bushels per acre.
1892-1896	13.30 bushels per acre.
1897-1900	11.60 bushels per acre.

The exact cause of this decrease is not known, but to the student of forestry conditions, it seems that deforestation is, in part at least, responsible.

By far the most susceptible of our crops to the changed condition is the apple. Though our statistics on this subject are very limited, yet the memory of every person of mature years will testify to the great decrease in our apple crop. The raising of perfect apples in this county is very difficult and yields such poor financial returns that the growers have almost entirely abandoned the pursuit. However, the decline in yield is by no means proportional to the decline in the number of trees. The following figures are taken from the statistician's reports for Indiana and express approximately this condition:

1879	42,007 bushels apples.
1880	37,781 bushels apples.
1881	20,476 bushels apples.
1885	14,544 bushels apples.
1886	98,933 bushels apples.
1897	3,084 bushels apples.

The yield has so decreased that at the present time we are compelled to import almost all of our apples. The immoderate ravages of hordes of insect pests is mainly responsible for this condition, though the apple rust is also very injurious. The disastrous effect of the latter, however, is probably no greater now than at previous times and will not account for the remarkable decrease in our apple crop.

Besides a decrease in our soil productiveness, the county has also lost many valuable wood industries. Until recently there was located at Crawfordsville a heading and stave factory which used large quantities of timber and furnished employment to many men. The scarcity of available timber made further operation unprofitable and the concern was moved to Arkansas. At one time the county was liberally dotted with sawmills, but now scarce a half dozen remain, and these are compelled to import a large proportion of their logs, in some cases nearly one-half.

Crawfordsville at present has but two important wood industries. The Indiana Match Company uses large quantities of cottonwood and basswood and the supply of this county was soon exhausted. For some time past the company has purchased these woods in different districts, chiefly in lower Illinois, but the new Chicago drainage canal has flooded so much of the timber country that the wood can not be gotten out. The company is in a difficult position and the scarcity of any material may cause it to close down or to be removed. The Casket Company uses annually $38,000 worth of material, turning out a finished product worth $58,500. The factory furnishes employment to forty persons, paying annually in wages, $18,000. Most of the material is shipped here. There are prospects of another industry for the manufacture of wooden novelties for which there is claimed an excellent market. In order to have the desired capacity, about thirty men would be employed at first and if the venture proved successful the capacity and working force of the plant would be doubled. The principal woods used are the maple and beech, and the county still has a good supply of the latter.

Such industries contribute largely to prosperity of the county and whatever would tend to foster them in a proper way is promoting the general welfare. The reforestation of a sufficient area would make good timber available and not only prevent the removal of our present industries but invite new ones as well.

Notes on the Cleavage Plane in Stems and Falling Leaves.

Mary A. Hickman.

Adaptation to climate and environment is nowhere better illustrated than in the forest. Especially is this true of the temperate regions where adaptation is in response to the winter cold. The deciduous trees, instead of protecting their delicate leaf structures from the severe cold of winter, have formed the habit of dropping them and again putting out new leaves when the warm season returns. The deciduous trees have developed the working powers of their leaves to such an extent that the great surface exposure and delicacy of structure make it impossible to carry them through the winter, therefore, the necessity of the deciduous habit.

However, this habit of shedding is not confined to the leaves only, for many trees annually shed twigs and branches. The dropping of twigs and branches is probably to prevent too great a density of foliage. This last habit is not restricted wholly to the deciduous trees, for some of the conifers have the same trait.

This dropping is due, not to breaking, but to growing off by the formation of a cleavage plane between both the twig, petiole and the parent stem. Thus the reason for the scars left by the shedding.

In the shedding of stems, the cleavage plane is gradually developed across the fibro-vascular system separating the stem from the parent stem with the exception of the bark and a few layers of wood cells which are easily broken. The scar is virtually formed before the falling of the stem. Marked illustrations of this habit from the deciduous trees are

found in the family Salicaceæ L. The branches and twigs begin to fall before the shedding of the leaves and continue throughout the period of leaf fall. The twigs shed are green, many bearing large winter buds upon their tips. Of the conifers, the *Tsuga Canadensis* Carr., illustrates this habit very markedly. However, their twigs, when shed, are dead.*

In the shedding of leaves, we find the formation of the cleavage plane the same as in the stem. The most common method is that of a separation between the petiole and stem, as shown by the scars on the stems.

* The Self-pruning of Woody Plants.—John H. Schaffner, Ohio Nat. I., 1902, pp. 171-147

This fall the attention of the writer was called to a peculiar case of variation found in the vine *Ampelopsis veitchie* L., native of Japan, but which has been introduced into America for ornamental purposes. It clings to the walls by its very numerous disk-tipped tendrils. The leaves on the younger branches of the vine are small and entire with dentate margins, but those on the older branches are sharply three-lobed or sometimes three divided.

In this plant we find a second cleavage plane formed between the petiole and leaf blade so that instead of the leaves falling in the usual way the blade is shed and the petiole remains attached to the stem until late in the winter.

Due to the difference in density of structure in the stem and petiole, it is difficult to secure satisfactory results in the formation and structure of the cleavage plane of that region. But when, as in this plant, there is a second cleavage plane formed between the petiole and blade, it is comparatively easy to trace. There is a breaking down and spreading of the tracheary tissue and the formation of a layer of small cells, causing a complete disconnection between the tracheary tissue of the leaf and petiole, as is demonstrated by the illustration.

Some Rare Indiana Birds.

Amos W. Butler.

The following notes are supplemental to those presented at the meeting of the Academy in 1899, which were printed in the proceedings for that year:

PHALACROCORAX DILOPHUS FLORIDANUS (Aud.).

Florida Cormorant.—A bird of this species was killed September 28, 1902, at Morris Street bridge over White River, in the city of Indianapolis. It was obtained by Fletcher M. Noe.

PELECANUS ERYTHRORHYNCHOS Gmel.

White Pelican.—Two were killed on White River April 25, 1902, by Harry Sappenfield. The locality is given as between the farms of Frank C. Lory and A. H. Taylor, in Knox County. It is reported the birds will be mounted. (E. J. Chansler.)

Fletcher M. Noe informs me he saw a specimen which was killed October 12, 1902, near Martinsville, but was unable to obtain it.

C. K. Muchmore wrote me that a flock of thirty-seven White Pelicans "stopped over" at the pond of the Cincinnati Ice Company, two miles south of Laurel, September 29, 1902. Two of them were killed by a boy, Earl Masters, who brought them to my informant. The next morning he received a third specimen from Earl Bossert, of Brookville.

From another source I learn that the bird last mentioned was one of two, possibly from the same flock previously noted near Laurel.

TANTALUS LOCULATOR (Linn.).

Wood Ibis.—Though the Wood Ibises were formerly found irregularly in some numbers in southern Indiana, and doubtless were summer residents and bred, they have not been reported for several years. These peculiar birds, sometimes called "gourd heads" from their odd, naked heads and long heavy bills, were formerly found in the lower part of the White Water and Wabash valleys. To the latter they occasionally recur. With the increasing warfare upon our larger birds especially and the rapidly diminishing area of suitable range, they lessened in numbers for years, and more recently none have been observed by any one who noted them. Through the most of August and September last they were found in considerable numbers in suitable places in the lower Wabash Valley. The earliest date reported was August 10, near Montezuma, Indiana, when a single specimen was seen. The latest occurrence was from the same vicinity September 28.

The following data from Mr. D. W. Overman, of Montezuma, is interesting:

"On August 10 I saw a single specimen in a dead elm at the Goose Pond about two miles north of this place, in the Wabash bottoms. On 12th saw ten or twelve more. The 17th an old fisherman brought me a specimen, and another the 18th. From the 14th they were of daily occurrence and were seen passing north along the Wabash in flocks varying in number from four to 150 or 200. The one whose head I sent you was taken the 18th, by Mr. Chas. Doss, from a flock of twenty-five or thirty, and was 'using' along the Wabash just south of town. The specimen brought me by Mr. Tombs, of Arcadia, was taken the 18th near the town.

"I killed one August 24 at Goose Pond from a flock of thirty-five or forty. They were last reported as being seen September 28."

So we have it summed up: First seen August 10, became common about 14th, last seen September 28, stragglers from the 20th to 28th.

Wood Ibises were also reported as numerous along the Wabash River in Posey County. Paul J. Hartman, New Harmony, has very kindly reported to me such information as he has been able to collect in that county. He says: "In regard to the Wood Ibis, I will say that I have seen it. On August 12 about sundown, I saw ten. I was positive of their identity. They came down the river flying rather low, and alighting in a large willow thicket, went to roost. The next evening I saw another at the same place, but it flew on down the river. On the 15th I saw twenty. They went down the river. On the 16th, at the same place, I saw more than I could count, certainly more than a hundred. I saw all at the same point of observation, and at the same time of day, about sunset. With the exception of the first ones, they did not stop.

I find the Wood Ibises were quite common at Hodge's Landing, about six miles below New Harmony, during the middle of August. They were very tame and a number were killed. The skins were not preserved.

FLORIDA CÆRULEA Linn.

Little Blue Heron.—A specimen of this southern species which as been known to breed in suitable restricted localities in southwestern Indiana, has been received by the State Museum. It is an immature bird in the white plumage, and was killed by John Michaels near Bainbridge, Putnam County, Indiana, August 10, 1902. A few other white herons have been reported from different localities, including Posey, Knox and Kosciusko counties. Possibly some of these were of this species, but the chances are they were American Egrets, *Herodias egretta* (Gmel.) or perhaps some of them Snowy Herons, *Egretta candidissima* (Gmel.).

PHALAROPUS LOBATUS (Linn.).

Northern Phalarope.—A specimen of this rare bird was taken at Millers, Indiana, September 1, 1900, by R. S. Turtle, according to information recently received from Mr. Frank M. Woodruff, of the Chicago Academy of Sciences. This is the fourth specimen reported as taken in the State.

The gathering of peculiarly maritime species of birds along our great lakes each fall is a very interesting fact. They begin to appear about the commencement of the second quarter of August, are most numerous between the middle of that month and mid-September, and generally are scarce after October 1. Some, however, occasionally linger until cold weather. Reference has elsewhere been made to this but attention is called to it again because of information received of the occurrence of some rare species since the last report.

NUMENIUS HUDSONICUS Lath.

Hudsonian Curlew.—Mr. F. M. Woodruff states a fine Hudsonian Curlew was taken at Calumet Heights, Indiana, August 3, 1902, by R. S. Turtle. It is a very rare migrant in Indiana.

TRINGA CANUTUS Linn.

Knot.—Mr. F. M. Woodruff reports the capture of a specimen of this world-wide sea-side wanderer near Millers, Indiana, in 1901. He has kindly placed in my collection a specimen taken at the same place to verify the Indiana record.

ARENARIA INTERPRES (Linn.).

Turnstone.—Mr. Woodruff also obtained one of these birds near the same place August 9, 1902. This is early for these seashore species. They are said to be in exceptionally rich plumage.

MICROPALAMA HIMANTOPUS (Bp.).

Stilt Sandpiper.—A specimen of this rare Sandpiper was taken at Mill Pond, near Greencastle, April 19, 1899, by Alexander Black. This is the second record of which I know for Indiana. Mr. Black has kindly deposited the specimen in my collection to verify the record.

ECTOPISTES MIGRATORIUS (Linn.).

Passenger Pigeon.—The only record of the Wild Pigeon I have been able to obtain since that of June 10, 1899, was received last spring through the kindness of Mr. Fletcher M. Noe of this city. From him I learned that Mr. Chas. K. Muchmore, of Laurel, Indiana, had obtained a specimen of this very interesting bird which was taken near that place last spring, April 3, 1902. Of this Mr. Muchmore says:

"The bird, which is a beautiful male, was taken by a young man named Crowell, near his home, about two and one-half miles southwest of this place. He reported that there were two. He heard the bird cooing and shot it and brought it to me, having concluded that it was something new. You can imagine how we almost took it away from him when he unrolled it out of a bloody old newspaper and began to inquire if we knew what it was. I was convinced that I saw a flock of five Passenger Pigeons one day in the spring of 1901, but had never said much about it as I only saw them flying and at a distance and it seemed rather improbable. I used to see them occasionally in Iowa about 1882-3, and although I was then very small, the specimen was not new to me, and I, of course, at once recognized the same."

Mr. Muchmore in a recent letter says he heard of a small flock near Laurel last fall (1902).

The Catalpa Sphinx (Ceratomia Catalpæ) Destroyed by the Yellow-Billed Cuckoo (Coccyzus Americanus) in Southern Indiana.

F. M. Webster.

This paper was suggested by the receipt of a letter from Mr. A. W. Butler, calling attention to a statement made by Mr. John B. Elliott, a very observing farmer of New Harmony, Indiana, who stated that the catalpa trees in his neighborhood had, until recently, been defoliated by a large worm, but, recently, this worm had nearly disappeared, having been eaten by the Cuckoo or Rain Crow, as they are termed in the South.

There did not appear to be any doubt about the food habit of the bird, though there is but one other similar observation on record, the only question being as to the identity of the worms. Now, the catalpa, like the ailanthus, and the China tree of the Gulf States, has very few enemies, and there is no chance of mistaking the larvæ of the catalpa sphinx for any other insect. On the other hand, there is no data whatever in possession of the division of Biological Survey of the United States Department of Agriculture, showing that this bird ever attacks the catalpa sphinx, though the stomachs of ninety birds have been examined. Several other species of Sphingidæ do not fare so well. Two, *Deilephila lineata* and *Phlegethontius sexta*, are frequently taken by these birds. There hardly seems a doubt about the correctness of Mr. Elliott's observations, and I give these facts in order to show their value. The catalpa is planted as far north as extreme northern Indiana and Illinois, but the catalpa sphinx does not occur north of about the latitude of Vincennes, in this State, Flora, in Illinois and extreme southern Lawrence County, in Ohio. On the Atlantic Coast it is steadily working its way northward, being now seriously abundant about Philadelphia, which is in the latitude of Columbus, Ohio, and almost that of Urbana, Illinois. It was abundant at Flora, Illinois, as far back as 1875, but seems to have progressed no farther northward. The insect has this peculiarity: The female will deposit to the number of 1,000 eggs in a mass on a single leaf and the young are for a considerable time after hatching thoroughly gregarious, so that while a single tree or a row of trees may be defoliated by the larvæ, other trees in the neighborhood may entirely escape. This gives the enemies of the larvæ an opportunity to literally exterminate a colony in short order. Mr. W. H. Edwards, a lepidopterist of Coalburgh, West Virginia, some years ago, recorded the sudden appearance of this insect in his locality for the first in 1896, and the as sudden disappearance the following year.

The catalpa sphinx is like its food plant, a southern species; the Sphingidæ are a tropical family for that matter, and it is interesting to note that Judge Lawrence Johnson observed the attacks of the Cuckoos, both species, on these larvæ in 1883, in Alabama. The Cat Bird and the Baltimore Oriole are both known to feed upon them.

Besides the birds there are several insect enemies of the catalpa sphinx, two being species of Tachinid flies, *Euphorocera claripennis* and *Frontina frenchii*. A Hymenopter, *Apanteles congregatus* also destroys a large number of the larvæ. As I found many of these caterpillars on catalpa trees about Princeton, Indiana, late in August, 1902, with numerous eggs of the Tachinid flies attached to their bodies, there is no doubt but what they are doing their full share in keeping the insect in check.

I might say, in addition to the foregoing, that this Cuckoo is exceedingly fond of another caterpillar, *Datana angusii*, which so frequently defoliates the walnut and hickory trees in midsummer. Here, too, we have the work of the Tachinid flies previously mentioned, and while at Purdue University, several years ago, I observed a case of excessive parasitism, on the larvæ of a closely allied species, *Datana contracta*. On four of the caterpillars of the latter species I counted respectively, 115, 131, 213 and 228 eggs of these parasites. I mention this, seemingly disconnected circumstances, because the same species of Cuckoo is fond of all these caterpillars, and we are met with that perpetual puzzle to economic entomologists, viz., to determine the exact economic value of an organism. If the bird ate only the unparasitized caterpillars, it would be wholly beneficial, but, on the other hand, if it devours parasitized caterpillars, it has done no good, because these would have died in any case, and has done actual harm, because it has destroyed beneficial insects.

Notes on Reared Hymenoptera from Indiana.

F. M. Webster.

The material upon which this list is based was obtained during two trips to southern Indiana, the first late in August and the last late in October, 1902, while in the employ of the United States Department of Agriculture, and making some special investigations of certain insects attacking growing wheat. My first intention was to present a paper that would include only such species as were new to science, but I have in addition to such, found so many forms that are new to the State, and others discovered by me about Lafayette, years ago, but of whose habits nothing was known, have been farther investigated, throwing new light on their life history and habits, that I later decided to include all of the Hymenoptera reared by me, but not previously reported as inhabiting Indiana. I may add that the nature of my investigations required that considerable quantities of wheat stubble, and the stems of *Elymus canadensis* and *E. virginicus*, *Tricuspis sesleroides* and *Bromus secalinus*, the latter being the common cheat of the wheatfields, be collected and the *Isosoma* and other insects inhabiting these stems secured. The stems of these grasses and the wheat stubble were collected and placed in pasteboard boxes so that everything developing within them was thus secured. It will be observed, then, that the prime object of my rearings was to determine the food plants of the *Isosoma*, the parasitic species, though of much importance, were of secondary signification in these studies.

Isosoma grande, which I reared about Lafayette, during the years 1884 to 1886, and established the fact of a dimorphism and alternation of generations before unknown among these insects in this country, was represented in my rearings from wheat stubble, collected from about New Harmony and Princeton, by the spring form *minutum*.

Isosoma tritici Fitch was also reared from wheat straw from these localities. Specimens of the latter occurring among the former are quite strongly contrasted, the latter being quite large for these insects and possessing fully developed wings, whereas the former are much smaller and wingless. Reared also from *Elymus virginicus*, an entirely new food plant for the species.

Isosoma maculatum Howard was reared in considerable numbers from the stems of cheat, *Bromus secalinus*. The species was described from individuals collected by me about Lafayette during June, 1885, and May, 1886, but the food plant has up to this time remained unknown.

Isosoma albomaculatus Ashmead, originally described from West Virginia, was reared from *Bromus secalinus* in great numbers, also to a lesser extent from the stems of *Elymus virginicus*.

Isosoma elymi French was reared in profusion from *Elymus*. This species, at one time supposed to be a wheat insect, confines itself strictly to the grasses. I have never reared it from wheat straws and have never reared *Isosoma grande* from anything else except wheat.

Isosoma (flavipes) hordei Harris was reared from stems of *Elymus canadensis* and in such numbers as to give economic importance to the fact. The rearing of the Joint Worm species, *I. hordei*, and one of the wheat straw worm species, *I. tritici*, from *Elymus*, both of which are wheat insects, shows very plainly that though the farmer may overcome these in his cultivated fields, unless he is careful to destroy these grasses growing along roadsides and in uncultivated fields, a continual reinfestation will be going on, and he must fight his foes in the grasses as well as in his cultivated grains. Besides these, there is a species of Isosoma, of which I have only been able to rear the male, but the larvæ of which infest the stems of *Tricuspis sesleroides*, and I have reared these from stems collected near Orleans, Indiana. There is probably still another species of *Isosoma*, at present not distinguishable from *I. hirtifrons* Howard. This last had until now been known only from rye straw in California. I did not rear this from Indiana, but in Illinois the common cheat, *Bromus secalinus*, appears to be its sole food plant. The larvæ are found in the stems, and as the stems of cheat in Indiana contain an abundance of larvæ it is not unlikely that those of this species are among them. It is not unlikely to be found infesting rye also.

Torymus sp? This is parasitic on the Isosoma larvæ infesting the stems of *Tricuspis*.

Another species of parasitic Hymenoptera has been determined as a new species of a new genus of the family *Encyrtidæ*.

Eurytoma nov. sp. This was reared from the stems of *Elymus canadensis*, the adults emerging in late August.

Parapteromalus isosomatis Ashmead, nov. gen. et. sp. This is parasitic on a cell inhabiting *Isosoma*, affecting *Elymus*. The adults appear in late summer and at once proceed to oviposit in the occupied cells of the Isosomas. That is to say, they have developed in the bodies of their hosts while the latter have been in the process of development and, now, oviposit in the fully grown larvæ, there being thus two broods of the parasite to one of the host.

Coccidencyrtus flavus Ashmead, nov. sp. This is doubtless connected in some manner with a coccid that inhabits the stems of *Elymus*.

Oligosita americana Ashmead, nov. sp. This is an egg parasite and belongs to a genus not before reported from America. A single species is known from Europe and three from the island of Ceylon.

Elasmus websteri Ashmead, nov. sp. Reared from either the stems of Elymus or from the stubble of wheat, in either case it is probably in some way connected with some species of Isosoma.

Xanthoencyrtus nigroclavus Ashmead, nov. gen. et. sp. Reared from stems of *Elymus*, but not probably in connection with the Isosomas.

The following were reared in considerable numbers from leaves and stems of grasses about Champaign and Urbana, Illinois, within which the host insects were feeding, and doubtless are to be found in Indiana also.

Polyneura citripes Ashmead, nov. sp. Reared from stems of *Eragrostis poaoides*, an egg parasite whose exact host is unknown.

Pedobius websteri Ashmead, nov. sp. Parasitic on a dipterous leaf miner affecting *Panicum proliform* by mining in the tips of the leaves. As I have found the same leaf attack in various localities in Indiana, presumably done by the same dipterous insect, it is not at all unlikely that the parasite is also found in Indiana, as I have reared them in great numbers from about Urbana, Illinois. Only one other species of this genus is known, and it is also a dipterous parasite.

Preliminary List of Gall-Producing Insects Common to Indiana.

Mel T. Cook.

For the past two years the writer has been very much interested in gall-producing insects and in the structures produced by them. Among other very interesting phases of this problem is the question of distribution. We know very little of the distribution throughout the country and nothing of the distribution in Indiana.

My collection of galls includes over 200 species, collected in the states of Illinois, Indiana and Ohio. Those collected in Indiana are all from Putnam County and about seventy species are included. Of this number, I have accurately determined forty species. These forty species represent five orders (including Acarina) and eighteen genera. The host plants represent ten orders, twelve families and fourteen genera.

The order and families of the host plants are the following:

Orders.	*Families.*
Salicales,	Salicaceae.
Juglandales,	Juglandaceae.
Fagales,	Fagaceae.
Urticales,	Ulmaceae.
Rosales,	Hamamelidaceae.
	Rosaceae.
	Caesalpinaceae.
Sapindales,	Aceraceae.
Rhamnales,	Vitaceae.
Malvales,	Tiliaceae.
Gentianales,	Oleaceae.
Campanulales,	Compositeae.

The following is a list of the insects and host plants known positively to occur in Indiana:

HEMIPTERA.

1. Hormaphis hamamelis, Fitch—Hamamelis Virginiana L.
2. Colopha ulmicola, Fitch—Ulmus Americana L.
3. Pemphigus ulmi-fusus, Walsh—Ulmus Americana L.
4. Schizoneura Americana, Riley—Ulmus Americana L.

5. Phylloxera caryae-avenae, Fitch—Hicoria alba (L) Britton.
6. Phylloxera caryae-globuli, Walsh—Hicoria alba (L) Britton.
7. Phylloxera caryae-fallax, Riley—Hicoria alba (L) Britton.
8. Phylloxera caryae-caulis, Fitch—Hicoria alba (L) Britton.
9. Phylloxera caryae-depressa, Shimer—Hicoria alba (L) Britton.
10. Phylloxera vastatrix, Planchon—{ (Vitis vulpina L. / (Vitis bicolor LeConte.
11. Pachypsylla celtidis-mammae, Riley—Celtis occidentalis L.

LEPIDOPTERA.

12. Trypeta solidaginis, Fitch—Solidago Canadensis L.
13. Gelechia gallae-solidaginis—Solidago Canadensis L.

DIPTERA.

14. Cecidomyia verrucicola, O. S.—Tilia Americana L.
15. Cecidomyia pilulae, Walsh—Quercus sp. (many species).
16. Cecidomyia salicis-strobiloides, Walsh—Salix sp——.
17. Cecidomyia salicis-semen, Walsh—Salix sp——.
18. Cecidomyia salicis-siliqua, Walsh—Salix sp——.
19. Cecidomyia salicis-aenigma, Walsh—Salix sp——.
20. Cecidomyia gleditschae, O. S.—Gleditsia triacanthos L.
21. Cecidomyia solidaginis, Loew—Solidago Canadensis L.
22. Cecidomyia pellex, O. S.—Fraxinus Americana L.

HYMENOPTERA.

23. Andricus seminator, Harris—Quercus alba L.
24. Andricus petiolicola, Bassett—Quercus sp——.
25. Andricus palustris, O. S.—Quercus palustris Du Roi.
26. Andricus clavula, O. S.—Quercus alba L.
27. Andricus papillatus, O. S.—Quercus sp——.
28. Amphibolips inanis, O. S.—Quercus rubra L.
29. Amphibolips confluentus, Harris—Quercus sp——.
30. Callirhytis tumifica, O. S.—Quercus alba L.
31. Holcaspis centricola, O. S.—Quercus palustris Du Roi.
32. Holcaspis globulus, Fitch—Quercus alba L.
33. Biorhiza forticornis, Walsh—Quercus alba L.
34. Acraspis erinaceae, Walsh—Quercus alba L.
35. Rhodites bicolor, Harris—Rosa sp——.

ACARINA.

36. Phytoptus abnormis, Garman—Tilia Americana L.
37. Phytoptus acericola, Garman—Acer saccharinum L.
38. Phytoptus quadripes, Shimer—Acer saccharinum L.
39. Phytoptus ulmi, Garman—Ulmus Americana L.
40. Erineum anomalum—Juglans nigra L.

From the above lists it will be seen that we have representatives from every order of insects which produce galls, except Coleoptera.

Doubtless the number of gall-producing insects in Indiana will far exceed 300 species. I should be very glad if members of the Academy will send specimens to me. Specimens may be sent either fresh or dry or in formalin. Always send enough of the host plant to enable determination.

Notes on Deformed Embryos.

Mel T. Cook.

It is well known that extremes of temperature will produce malformed embryos, but it is also probable that malformations may result from other causes.

Last spring the students in my class in embryology found a very large number of deformed chick embryos. The most common malformation was two or more blastoderms, but in many cases the embryos did not

develop beyond the formation of the primitive streak. The farthest developed and most remarkable deformity was in the case of two embryos so placed that anterior ends were joined and the posterior ends extending in opposite directions. Judging from the mesoblastic somites, the embryos were about forty-eight hours of incubation, there being eleven well-defined somites in one and sixteen in the other. The neural canal was partially closed, but only one brain vesicle in each case was developed. Between the two anterior ends was a mass of much distorted structures and apparently including several gill arches.

The eggs were secured from reliable parties, and I have every reason to consider them fresh and that they had been properly cared for. My assistant assures me that the temperature of the incubator was regular and that all conditions were normal.

The slide from which the drawing was made was prepared by Mr. Charles Sudranski.

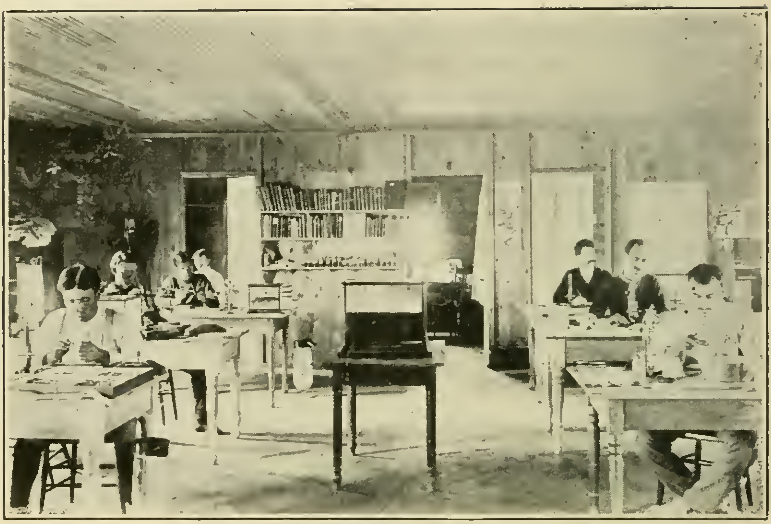
The Lake Laboratory at Sandusky, Ohio.

Mel T. Cook.

The past few years has witnessed a wonderful increase in facilities for biological work. Among the most noticeable features has been the establishment of summer laboratories especially adapted for biological research until we now have six marine and a larger number of inland laboratories. Since the character of biological work is so dependent upon the locality, and since each locality presents certain problems peculiar to itself, each of these laboratories has certain advantages over its friendly rivals and the itinerant biologist has the opportunity of reaping the benefits from all. He meets his fellow-worker and studies the varied fauna and flora under the most favorable conditions.

Among the earliest of these laboratories was the Lake Laboratory at Sandusky, Ohio, which was first opened in 1895, under the direction of Professor Kellicott, of the Ohio State University. In 1898 Professor Kellicott died and the laboratory came under the direction of his successor, Prof. Herbert Osborn, the present director.

The laboratory was at first intended for investigation only, and for the first four seasons was used by only three or four workers. In 1899 there were fourteen investigators and it was then decided to offer regular courses; this was done in 1900 and each succeeding year. For the past three seasons the increase in interest has been very pronounced. In 1902 there were twenty-four students and six instructors; of the twenty-four



Upper Floor, Lake Laboratory.

Proposed Site.

students, sixteen were graduates and eight of these were engaged in investigations.

The laboratory is under the control of the Ohio State University and under the direct management of the President of the University and of the director. The equipment consists of three boats and the necessary dredges for working on the aquatic fauna and flora. The microscopes, microtomes, other apparatus and library are supplied from the Ohio State University laboratories.

Thus far the work has been conducted in the building of the Ohio

Cedar Point Beach, Looking West.

State Fish Commission, but appropriations have been made for the erection of a new building especially for this work. It is expected that this building will be ready for use in 1903. This will give more and better facilities to meet the increasing demands. Ample arrangements will be made for the general courses, both for students and for teachers in the secondary schools. Special efforts will be made to accommodate advanced students in graduate courses and to provide opportunities for independent research by investigators in the many fields of biology.

While the control of the laboratory will probably remain with the Ohio State University, other institutions will be invited to coöperate and every effort will be made to make the laboratory of special service to the biologist of the inland states.

The location is accessible from all parts of the Central West. The climate is healthful and conducive to summer work.

The flora is one of the richest in the country. According to Mosely's "Sandusky Flora" it contains 300 more species than have been reported from any other locality of like dimensions in the State of Ohio. The flora is also more extensive than that reported from other parts of North America. Most plants native to Ohio, with the exception of those characteristic of the Ohio River counties and Sphagnum swamps, are found within the range of the Sandusky Flora. It also includes 165 species not reported in the Canadian catalogue and sixty-seven species not known in Michigan, and many species characteristic of western and southern regions.

This wonderful flora is due largely to the climate and geology, the lake protecting the south shore from the cold winds of the north and thus allowing many southern plants to extend their northern limits.

The lake, the bays, the marshes, the rivers, the deep ravines, the rocky shore line, the mud and sand beaches, the sand dunes, the various kinds of soil, the prairie, and the woods, all tend to give desirable conditions for this very rich and striking flora.

All of the above conditions, together with the varied food supply furnished by the rich flora, give an equally varied and remarkable fauna.

REPORTS FROM THE INDIANA UNIVERSITY BIOLOGICAL STATION AT WINONA LAKE.*

a. The Individuality of the Maternal and Paternal Chromosomes in the Hybrid Between Fundulus Heteroclitus and Menidia Notata.

W. J. Moenkhaus.

[Abstract.]

In the hybrid between *Fundulus heteroclitus* and *Menidia notata* it is possible to distinguish the chromosomes that come from each parent. The chromosomes of *Fundulus heteroclitus* are long and straight while those of *Menidia notata* are short and slightly curved. This difference they maintain in the hybrids. They can best be distinguished during the anaphases. They can not be distinguished in the resting stage. During the first two cleavages each kind of chromosome remains grouped bilatterally upon the spindle. After the second cleavage they become mingled upon the spindle, but the two kinds still retain their individuality and can readily be identified They have been thus traced to a late cleavage stage, as far as was attempted.

b. An Extra Pair of Appendages Modified for Copulatory Purposes in Cambarus Viridis.

W. J. Moenkhaus.

Among the crayfishes used for dissection in the laboratory we came upon a specimen that had three pairs of abdominal appendages modified for copulatory purposes. This is the first time I have ever seen such abnormality and, furthermore, have not been able to find mention in literature of a similar occurrence. I have, therefore, thought it worth while to make a note of it.

The specimen belonged to the species viridis and was about three inches in length. Unfortunately the specimen had been so much mu-

*Contributions from the Zoölogical Laboratory of Indiana University under the direction of C. H. Eigenmann. No. 53.

tilated in the dissection by the time the abnormality was noticed that it was out of the question to get a photograph of all the appendages in position. I, therefore, preserved the appendages and give herewith a drawing of the posterior view of both.

The first and second pairs of appendages were modified in the usual way and in no way differed from the corresponding appendages in the normal males of the same species. The additionally modified third pair

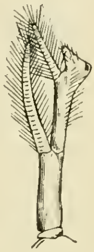


Fig. 1.

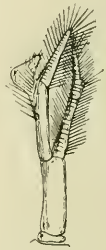


Fig. 2.

resemble in plan almost exactly the second pair. The exopod and the segmented flabellum of the endopod are much less reduced and much more extensively provided with feathered setæ than the second pair. They are of about the same size and in position converge and fit against the second pair of appendages much in the same manner that these do against the first. Whether they were in any way functional I am, of course, unable to say.

---

c. Description of a New Species of Darter from Tippecanoe Lake.

W. J. Moenkhaus.

During the summer of 1896, while collecting large quantities of Percina caprodes in Tippecanoe Lake, a single large specimen of darter was taken which could not be identified with any described species. I thought then and since, until recently, that it might be a hybrid between Percina caprodes and Hadropterus aspro because of evident intermediate characters. After holding the specimen for six years with the hope that other specimens might be taken, I last year published a note in the Proceedings of the Indiana Academy* under the title "An Aberrant Etheostoma" in

* For 1902, pp. 115-116.

which I briefly described the specimen and compared it with Percina caprodes and Hadropterus aspro. Last summer the sandbars on the south side of the east end of the lake were again extensively seined and among some 500 or 600 Percina caprodes two small specimens—probably that summer's brood—were taken which, beyond a doubt, are similar to the specimen which had been taken six years previously in a part of the lake three or four miles distant. Among a peck of darters from a part of Tippecanoe Lake that the labels do not indicate, collected in 1898 by some students of the Indiana University Biological Station, I found three similar specimens, making in all six specimens of this type from different parts of the lake. There can no longer be any doubt that we have to do with a distinct species and, so far as I can determine, the species is undescribed. This new species is among the most beautiful and largest of the darters. It gives me the greatest pleasure to name the species for Dr. Barton Warren Evermann, icthyologist, of the U. S. Fish Commission.

HADROPTERUS EVERMANNI Moenkhaus.

(New Species.)

Head 4; depth 6.16; D. XVI, 14; A. II, 11; scales 8—79—9.

The form of the body is much like that of *H. aspro*, rather elongate, fusiform, somewhat compressed posteriorly, but less pointed anteriorly. Mouth moderately large, maxillary reaching to the pupil; the cleft of mouth almost horizontal, lower jaw included; eye large, about equaling snout; interorbital rather broad, flat; gill membranes free from isthmus and separate; opercular spine and flap well developed; preopercle entire.

All scales ctenoid; nape with fewer, smaller, embedded scales; median ventral line in one specimen provided with a row of closely set, slightly enlarged scales, a second specimen has three or four such scales, the remaining specimens are without scales; the breast naked; opercle with closely set ctenoid scales slightly smaller than those on the body; cheeks with fewer still smaller, embedded ctenoid scales; lateral line complete, slightly arched over pectorals.

Pectoral and ventral fins about equal in length, measuring one and one-third in head; origin of spinous dorsal one-third the distance between the snout and base of caudal; origin of the soft dorsal and the anal equidistant from the snout, one and one-half in body length; the spinous dorsal somewhat longer than the soft dorsal and the latter than the anal; these three fins are about the same height, the order of their height in an ascending series being spinous dorsal, soft dorsal, anal; their height equals two in head.

The color patterns suggest an intermediate type between *Percina caprodes* and *Hadropterus aspro.* Sides with about nineteen large, distinct black blotches which, especially along the middle region, alternate with smaller ones, these often being the ventral ends of more or less well developed transverse bars. The dorsal side with a series of large quadrate blotches alternating and anastomosing with variously developed transverse bars. The color pattern is of the transverse type rather than the longitudinal characteristics of *H. aspro* and *macrocephalum.* In the older specimen this dorsal pattern becomes more diffuse and less regular. Dorsal two-thirds of opercle and the upper part of cheek, black. A distinct black band extends downward and another, more diffuse, forward from the eye. Both dorsals and the caudal fin, barred, pectorals indistinctly so; ventrals and anal, plain. A black spot at the base of the caudal.

TABLE OF MEASUREMENTS AND COUNTS OF ALL THE SPECIMENS.

Number of specimen—	1	2	3	4	5	6	Av.
Length of body	77.00	49.00	50.00	55.00	49.00	51.00	....
Head in length	4.05	3.82	3.84	3.93	3.92	3.92	3.91
Depth in length	6.16	7.00	6.25	6.11	6.30	....	6.36
Eye in head	3.80	3.65	3.42	3.79	3.90	4.30	3.81
Snout in head	3.95	4.00	3.82	4.66	4.17	4.33	4.14
Maxillary in head	3.58	3.65	3.71	4.66	4.17	4.23	4.00
Interorbital in head	4.63	5.13	5.20	4.66	4.17	5.20	4.83
Pectorals in head	1.36	1.28	1.30	1.21	1.56	1.30	1.33
Ventrals in head	1.31	1.42	1.32	1.40	1.39	1.44	1.38
Spinous D. from snout	3.20	2.88	2.92	3.23	3.06	3.18	3.08
Soft dorsal from snout	1.60	1.58	1.66	1.57	1.58	1.59	1.59
Anal from snout	1.64	1.58	1.61	1.62	1.58	1.59	1.60
Dorsal fin—	XVI,14	XIV,14	XV,14	XIV,13	XIV,15	XIV,13	
Anal fin—	II,11	II,10	II,10	II,11	II,11	II,11	
Scales—	7-79-9	9-84-12	9-84-11	8-82-11	9-82-12	8-84-11	82

The species is most closely related to *Hadropterus aspro* and *Hadropterus macrocephalum.* From the former it differs most strikingly in the color pattern, especially that of the dorsal side, which is transverse in type rather than longitudinal, and in the greater number of scales, which in this species are ctenoid instead of cycloid, on the cheeks and opercles.

Type No. 9785. Museum Indiana University.

Cotype No. 9786. Museum Indiana University.

Cotypes have also been deposited in the U. S. National Museum, U. S. Fish Commission, Museum of Stanford University and British Museum of Natural History.

---

d. Myxomycetes of Lake Winona.

Fred Mutchler.

With the advice and consent of Dr. C. A. King, I decided to take the time not required in teaching during the Station Session of 1902 in making a systematic study of the Myxomycetes of the lake neighborhood and this report shows the result of the work.

The season was one especially favorable for such a study, inasmuch as the frequent warm rains were very conducive to a luxuriant growth of all kinds of fungi.

This list is by no means complete, though I feel sure that it contains the majority of the forms indigenous to the region. Had it been possible to continue the study for another month I feel sure that the list would have been very materially increased, for myxomycetes were as plentiful at the close as they were at the opening of the station work.

Quite a number of specimens were collected on special excursions to Turkey Lake, Tippecanoe River, and North Manchester. I have included in this list species found on those trips that I did not find at Winona. The locality of such species is indicated in every case. All others were collected in the immediate neighborhood of the lake.

Didymium nigripes I found growing October 20, on Sphagnum that I brought to Clark University from the lake. On November 21 I noticed the same species growing on rabbits' dung that I had also brought from there.

My first attempt was to follow the classification and nomenclature as given in Lister's Mycetozoa. I soon found, however, that there are species here not given in that work, and I therefore used McBride's Myxomycetes of North America in connection with it.

The list including eighty-six species belonging to twenty-one genera is as follows:

1. Ceratomyxa porioides (Alb. and Schw.) Schroeter. Very common on decayed wood from July 1 to August 10. Frequently found covering almost the entire surface of decaying trunks.

2. Physarum viride Pers. Collected at least on three different trips, June 27, July 13, and July 20. On bark of fallen trees.

3. P. pulchripes Peck. Found in one collection, July 3. On bark of an old oak stump.

4. P. nutans Pers. Collected in considerable quantities from bark of fallen elm, July 9.

5. P. polymorphum. Found spreading in large patches over bark of a beech stump and on blades of grass and leaves of briars nearby, July 14. Turkey Lake.

6. P. nefroideum Rost. Brought into the laboratory several times. Collected from bark of fallen cottonwood, July 17.

7. P. galbeum Wingate. On oak bark, July 18.

8. P. auriscalpium Cooke. On decaying leaves. Turkey Lake, July 14.

9. P. nucleatum Rex. Not common. Bark of fallen ash, July 20.

10. P. maculatum McBr. On decaying wood in considerable quantity, July 24.

11. P. didermoides Rost. A single specimen collected on a decaying sycamore stump, July 21.

12. P. nodulosum Cooke and Balfour. On fallen trunks, July 15.

13. P. globuliferum Pers. July 31. Decayed wood.

14. P. obrusseum Berk and Curtis. Collected from a fallen poplar trunk near North Manchester, August 3.

15. P. melleum Mass. Found in small quantity on decaying leaves in woods near North Manchester, August 3.

16. P. citrinum Schumacher. Collected along with *P. melleum*, North Manchester, August 3.

17. P. cinereum Pers. Found on a growing fern frond in woods near Tippecanoe River, August 5.

18. Physarella mirabilis Peck. Found literally covering the inside of a hollow sycamore stump near the biological laboratory, July 7.

19. Tilmadoche compacta Wingate. One specimen collected on oak bark, July 30. Does not seem to be plentiful.

20. *Spumaria alba* D. C. Very common on stems and leaves of herbaceous plants throughout the month of July.

21. *Fuligo septica* Gmelin. Most common of any species collected. Could be found any day throughout the season.

22. *F. violacea* Pers. Rare, collected from decayed oak stump, July 19.

23. *Leocarpus vernicosus* Link. Only a small quantity collected from the bark of an oak log, July 29.

24. *Tubulina fragiformis* Pers. Quite common on decaying wood during the month of July.

25. *T. stipitata* Rost. Only a single specimen. Collected from decayed oak stump, July 18.

26. *Craterium leucocephalum* Ditmar. Found frequently on bark of twigs, July 20 and 29.

27. *C. minimum* Berk. and Curt. Found only once. Blades of grass, July 31.

28. *Didymium crustaceum* Fries. On green blades of grass and leaves. Turkey Lake, July 14.

29. *D. nigripis* Fries. Found growing on Sphagnum and rabbit dung collected at Winona Lake.

30. *Stemonitis fusca variety genuina* Roth. Collected in abundance from decaying wood, July 4.

31. *S. fusca variety rufescens* Roth. A single specimen from decayed oak stump, June 25.

32. *S. splendens* Rost. Quite common on all kinds of decaying wood, June, July and August.

33. *S. Smithii* McBr. Found in great tufts at base of decaying oak stump, June 26.

34. *S. maxima* Schweinitz. Quite common. July.

35. *S. pallida* Wingate. Collected in small quantity on bark of fallen oak, July 10.

36. *S. Morgani* Peck. Collected in plentiful quantities on decayed oak trunk, July 16.

37. *S. Carolinensis* McBr. Found growing, July 17, on the stump where *S. Smithii* had been collected June 26. *S. Smithii* was not found at this time.

38. *S. herbatica* Peck. Single specimen. Blades of grass. July 17.

39. *S. Virginiensis* Rex. Collected from oak bark along with *S. nigrescens*, July 14. Turkey Lake.

40. *S. nigrescens* Rex. Turkey Lake, July 14.

41. *S. Webberi* Rex. On fallen elm. July 14. Turkey Lake.

42. *S. confluens* Cooke and Ellis. Collected in considerable quantities from bark of fallen oak trunk, July 20. Probably rare.

43. *Comatricha stemonitis* Sheldon. Quite common on decaying wood. Collected frequently during July.

44. *C. irregularis* Rex. On fallen cottonwood trunk, July 17.

45. *C. Subsdorfii* Ellis and Everhardt. Single specimen collected July 30, on an old rail fence.

46. *C. typhoides* Rost. Found quite plentiful on dead wood near North Manchester, August 3.

47. *C. equalis* Peck. Not common. Collected from a board fence July 30.

48. *Dictydium umbilicatum* Schrader. Collected in great abundance on various kinds of decaying wood during the month of July.

49. *Cribraria tenella* Schrader. Collected in large quantities on very badly decayed wood, June 25 to July 28.

50. *C. dictydioides* Cke. and Balf. Very common. Quite a large decaying oak trunk was found by the elementary students, while collecting, July 17, that was literally covered with this species.

51. *C. microcarpa* Pers. Taken in substantial quantities from decaying wood at Turkey Lake, July 14. Also near Tippecanoe River, August 5.

52. *C. macrocarpa* Schrader. On rotten wood, July 30.

53. *C. minutissima* Schweinitz. This species taken only once but in considerable quantity then. On a lichen covered oak trunk, July 20. On account of its smallness it is probably often overlooked by collectors.

54. *Arcyria incarnata* Pers. Very common. Collected many times on all kinds of decayed wood, June 26 to August 20.

55. *A. cinerea* Pers. Found abundantly during July on decayed wood.

56. *A. flava* Pers. On decaying maple, July 4.

57. *A. punicea* Pers. Perhaps the most common of the *Arcyrias*. Collected on almost every trip during the entire time the station work was going on.

58. *A. ferruginea* Sauter. Found growing on old decaying cornstalks. July 4.

59. *A. incarnata nodulosa* McBr. On decaying birch, July 10.

60. *A. digitata* Pers. Quite common on decaying maple. The sporangia are usually collected in tufts of from four to twelve. July 10.

61. *A. pomiformis* Rost. Found along with *A. digitata*, July 10.

62. *A. vitellina* Phillips. Turkey Lake, July 14.

63. *A. Œrstedtii* Rost. Growing on decayed wood—maple and cottonwood, July 23.

64. *A. magna* Rex. On decaying trunks, Tippecanoe River, August 5.

65. *A. albida* Pers. Very common on dead wood of various kinds. July, August.

66. *Hemitrichia clavata* Rost. Collected from decaying watery trunks, July 3.

67. *H. rubiformis* Lister. Very common. Usually found growing on the watery decaying wood under the bark of fallen trunks. Sporangia are often sessile.

68. *H. intorta* Lister. On decaying oak, July 17.

69. *H. stipitata* Mass. Only a small specimen collected from water soaked wood, July 21.

70. *H. serpula* Rost. Found in abundance in the inner bark of water soaked wood. Tippecanoe River, August 5.

71. *Ophiotheca chrysosperma* Currey. Collected July 20 and 28, on inner bark of fallen willow trunks.

72. *O. Wrightii* Berk. and Curt. Collected in considerable quantity on inner bark of fallen elm trunks July 23.

73. *Oligonema nitens* Rost. Collected in small quantity in decaying wood near North Manchester, August 3.

74. *O. flavidum* Mass. Found along with *O. nitens*, North Manchester, August 3.

75. *Perichaena corticalis* Rost. Collected in small quantity on fallen elm trunk under outer bark, July 30.

76. *P. variabilis* Rost. On inner bark of willow trunk, July 30.

77. *Trichia contorta* Rost. Collected only in small quantity, July 8, in decayed wood of oak stump.

78. *T. affinis* DeBary. Found in considerable quantity in decaying maple, July 8.

79. *T. fallax* Pers. Quite common on various decaying woods, July 10.

80. *T. favoginea* Pers. Collected quite frequently on various woods during the month of August. More abundant than any other member of the genus.

81. T. scabra Rost. Collected from decayed wood near Tippecanoe River, August 5.

82. T. persimilis Karst. Single specimen collected July 26. Decayed elm.

83. T. Iowensis McBr. Found growing in rotten wood near Tippecanoe River, August 5.

84. Lycogala exiguum Morg. Not common. Collected only once. June 26.

85. L. flavo fuscum Rost. Several specimens collected from water soaked decaying wood. Turkey Lake, July 14.

86. L. miniatum Pers. Very common on all kinds of decaying trunks. This species was found on almost every collecting trip.

---

c. The Plankton of Winona Lake.

Chancey Juday.

Winona Lake is one of the numerous lakelets found in northern Indiana. It is located in Kosciusko County about one mile (1.6 kilometers) southeast of the city of Warsaw. Concerning the physical features of the lake but little need be said as two hydrographic maps showing many of these points, have been published; one by Large in 1896 (Proc. Ind. Acad. Sci., 1896) and another by Norris in 1901 (Proc. Ind. Acad. Sci., 1901). The lake is irregular in outline and has an average length north and south of about one and an eighth miles (1.8 kilometers) and an average width east and west of about seven-tenths of a mile (1.1 kilometers) with a large bay extending westward from the north end. It has an area of about 0.9 of a square mile (2.3 square kilometers) and a maximum depth of eighty-one feet (twenty-five meters). Two small creeks flow into the southeastern portion of the lake and there are several large springs along the east side.

The data for this paper were collected at the Indiana University Biological Station during the summer of 1901. I wish to acknowledge my indebtedness to Dr. C. H. Eigenmann, Director of the Station, for many courtesies shown me. I am also much indebted to Mr. Clarence Kennedy and Mr. Heilman C. Wadsworth for their valuable assistance both in making the observations and in the tedious work of counting the material.

TRANSPARENCY.

The transparency of the water was determined by means of a Seechi's disk, about fifteen centimeters in diameter. The depth at which this disk just disappeared from view varied from 2.1 meters as a minimum to 2.5 meters as a maximum.

TEMPERATURES.

The thermophone and deep sea thermometer were not in working order so that the temperatures had to be taken by means of a pump and hose. This method, of course, is subject to considerable error and the results were found to be of comparatively little value except to determine the location and extent of the thermocline, so that the distribution of the plankton with regard to this region, might be studied.

The temperature observations were made in the deepest part of the lake, and they consisted of eight sets in July and ten sets in August. During July there was very little wind so that the upper stratum of water was not disturbed to any great extent. As a result this stratum accumulated considerable heat during this period. The surface temperature, taken at a depth of eight or ten centimeters, averaged 28.0° C. for the eight sets of observations, with 31.2° C. as a maximum.

During August, however, the wind was much stronger and the upper stratum of water was much more thoroughly stirred up. As a result, the average surface temperature for the ten sets of observations was 25.0° with a maximum of 26.0.°

The thermocline consisted of a stratum of water three meters in thickness. The difference in temperature between the top of this stratum and the bottom of it varied between 9.0° and 12.0°. In July it extended from four meters to seven meters, and in August from five meters to eight meters. The downward movement was doubtless due to the stronger winds prevailing in August.

The change in bottom temperature during the two months was very slight, 7.5° being the minimum and 8.0° the maximum.

METHODS.

The plankton observations as well as the temperature observations were made in the deepest part of the lake and by the pump method. An ordinary pitcher pump, 1-inch garden hose, and a plankton net whose straining part was made of Dufour's No. 20 bolting cloth, were used. The quantity of water strained for a catch was the amount produced by forty strokes of the pump, which averaged 22.5 liters.

The counting method was used to determine the relative abundance of the various plankton forms. In most cases 20 per cent. of the material obtained in a catch was counted, and the results thus obtained for the various forms were multiplied by five in order to determine the number of individuals in a whole catch. Whenever a catch contained a comparatively small number of individuals, for example, the catches near the surface in day time, the whole catch was counted. Also, all the individuals of the larger forms, such as Epischura and Leptodora, which are readily recognizable with the naked eye, were counted.

The sets of observations may be divided into five groups:

1. Twenty sets of day catches which were made not earlier than 9 a. m., nor later than 4 p. m.

2. Six sets of night catches which, with one exception, were made between 9 p. m. and midnight. On September 2, a series was made as early as 8 p. m., but this, however, was an hour and a half after sunset.

3. Four sets of evening catches were made. These were begun shortly before sunset and continued at half hour intervals an hour or more after sunset.

4. The morning observations were begun one and a half to two hours before sunrise and were continued at thirty minute intervals until after sunrise. Six sets of these were made.

5. In August there were two sets of observations in which catches were made at the surface at regular intervals during the entire night. Both series were begun before sunset and continued until after sunrise. Catches were made at half hour intervals until 8 and 9 p. m., respectively, then every hour until 3 and 4 a. m., respectively, and again at half hour intervals until after sunrise. The results of these observations are shown in Figs. 1 to 4.

The first and second groups covered the entire depth of the lake (twenty-five meters), while the catches of the third and fourth groups were confined to the upper four meters. The fifth group consisted of surface catches.

THE PLANKTON FORMS.

PHYTOPLANKTON.

The phytoplankton was made up of three forms, Clathrocystis, Coelosphaerium and Oscillaria. Clathrocystis was much more abundant than the other two forms as it made up about 75 per cent. of the total quantity of phytoplankton.

CRUSTACEA.

Copepoda.—My thanks are due Prof. C. Dwight Marsh for his determination of the following copepods:

Epischura lacustris Forbes.
Diaptomus oregonensis Lillj.
Diaptomus birgei Marsh.
Cyclops pulchellus Koch.
Cyclops brevispinosus Herrick.
Cyclops leuckarti Sars.
Cyclops albidus Jurine.
Cyclops prasinus Fischer.
Cyclops serrulatus Fischer.
Ergasilus.

The following concerning Diaptomus birgei is quoted from Professor Marsh's letter: "The finding of D. birgei is of great interest to me. I described the species some years ago from a few specimens from New Lisbon, Wisconsin, and have never seen a specimen since. I had begun to fear that I had described a freak form and that the species would not stand; but here comes the creature in the proper proportions. It is a little queer that I should have found it only in two such widely separated localities, but doubtless it lives at some intermediate locations."

Cladocera.—The following limnetic forms were found:

Daphnia hyalina Leyd.
Daphnia pulex De G. var. *pulicaria* Forbes.
Daphnia retrocurva Forbes.
Diaphanosoma brachyurum Sars.
Ceriodaphnia lacustris Birge.
Leptodora hyalina Lillj.
Chydorus.
Bosmina,

Littoral forms:

Pleuroxus procurvatus Birge.

Pleuroxus denticulatus Birge.

Eurycercus lamellatus O. F. M.

Acroperus harpae Baird.

The following genera were represented by at least one species each. *Alona*, *Graptoleberis*, and *Simocephalus*.

Cypris and *Corethra* larvæ were found in some of the catches.

ROTIFERA.

Four members of this group were specifically identified, *Triarthra longiseta*, *Anurea cochlearis*, *Anurea aculeata*, and *Notholca longispina*. The other members of the group belonged to the genera *Asplanchna*, *Polyarthra*, and *Mastigocerca*.

CHANGE IN QUANTITY OF PLANKTON.

These observations covered too brief a period, July 10 to September 3, to show much concerning the increase or decrease of the various plankton constitutents. In general, it may be said that there was comparatively little change. There was apparently a slight increase of the phytoplankton, due mainly to an increase of Clathrocystis. Only two forms of the crustacea showed any change. During August, there was a perceptible increase of Diaptomus and Cyclops. They were found to be twice as numerous the first of September as the last of July and first of August.

DIURNAL MOVEMENT.

Epischura lacustris.—This form was not found regularly in the day catches as it was present in only six of the twenty day series. On these six occasions it was confined to the thermocline, that is, between five and seven meters. It was taken, however, in the surface catches of the six night series. The time of its appearance at the surface varied from half an hour to an hour and a half after sunset and it disappeared from the surface about an hour before sunrise. In the all-night series of August 5-6, it was found in only one catch. This was at 9 p. m., five individuals per 100 liters of surface water. In the all-night series of August 27-28, it reached a maximum of 140 per 100 liters at 8 p. m.

Diaptomus.—As noted above, two species were present, but they were not counted separately. For the most part, Diaptomus remained in the upper ten meters of the lake as those found below this depth constituted less than 5 per cent. of the total number of individuals taken in either a day or a night series. They were found at the surface in sixteen of the twenty day series, but, with two exceptions, there was a marked increase in the number of individuals at the surface at night. This increase varied from five to twenty-five fold. The two exceptions were surface catches made on cloudy days. These differed but little from the night surface catches. The increase at the surface usually began about sunset and the greatest decrease occurred half an hour to an hour before sunrise.

Fig. 1 shows the surface conditions for Diaptomus in the two all-night series. The vertical spaces represent the number of individuals per hundred liters of surface water and the horizontal spaces represent the time between 6 p. m. and 6 a. m. The curves show a striking similarity of conditions although the observations were separated by a time interval of three weeks. They show that the maximum number was found at the surface at 7:30 p. m. on both occasions. Both also show a decided decrease during the next half hour, a second but smaller rise at midnight, a third near morning, and a fourth is indicated for the period immediately following sunrise. Diaptomus was not found in the surface catch on August 5 at 11 a. m. and there were 160 per 100 liters on August 27 at 9 a. m.

Cyclops.—Several species were present but no attempt was made to count them separately. They were distributed through the entire depth of the lake. They were found at the surface in all the day catches. In general, the night increase was comparatively small as it did not exceed five fold. There was little or no difference between the surface catches made on cloudy days and those made at night.

The curves of Fig. 2 represent the status of Cyclops in the two all-night series. The early evening conditions differ a great deal as there is no maximum in the curve for August 27-28 corresponding to the 7:30 p. m. maximum of August 5-6. Beyond this, however, the curves are very similar. The surface catch on August 5 at 11 a. m. showed a total of 160 Cyclops per 100 liters and there were 200 on August 27, at 9 a. m.

Nauplii.—They were found throughout the entire depth of the lake and showed no evidence of a movement.

Ergasilus.—This form was irregularly distributed in the upper six meters and showed no movement.

Daphnia hyalina. — In this species, the young and the adults were counted separately. The ratio between them was very variable. The young constituted from 10 per cent. to 78 per cent. of the entire number of individuals of a series. The young predominated near the surface on bright sunny days and the adults predominated in the deeper strata. In all but one set of observations, 70 per cent. to 95 per cent. of the total number of *D. hyalina*, were found in the upper seven meters and in this one instance 60 per cent. were in this region.

Usually a few young were found at the surface in the daytime. Likewise adults were found at the surface on two cloudy days but, on clear days, they were at a depth of one to two meters. In three sets of observations, adults appeared at the surface about half an hour after sunset, and on a fourth occasion about sunset. In five sets of morning observations, the time of their disappearance from the surface varied from nearly two hours before sunrise as a maximum to thirty minutes before sunrise as a minimum.

Figs. 3 and 4 represent both young and adult in the all-night series. It will be noted that the curves for young and adult in each series cross and recross each other, showing that the ratio between them was very variable. The two curves for adults do not show the similarity that the curves for Diaptomus and Cyclops do. In fact, if plotted together, they cross each other several times, one curve showing an increase of individuals at the same hour that the other shows a decrease. In the first series, August 5-6, the adults reached a pronounced maximum at 8 p. m., while in the series of August 27-28, two equal maxima were observed, one at 7:30 p. m. and the other at 10 p. m.

There is the same lack of similarity between the curves representing the young. The first series showed a maximum of young at 8 p. m. and the second at 4:30 a. m.

Daphnia pulicaria.—It occupied the region between the middle of the thermocline and the bottom. It was usually most numerous within one to three meters of the bottom. There was practically no diurnal movement. Adults were found at the surface in one evening catch and at a depth of only one meter in a night catch. These were the only indications of a movement, *Daphnia retrocurva.*—It was rarely found at a greater depth than seven meters. Both young and adult were one to three meters below the surface on clear days. Both appeared at the surface in the evening about half an hour after sunset. In the morning, however, the adults left the surface before the young. The young usually disappeared about sunrise while the adults moved down from the surface an hour or more before sunrise. The surface maximum of young and adults combined, was found three-quarters of an hour after sunset in the first all-night series and half an hour later in the second, about 8 p. m. in each case.

Diaphanosoma brachyurum.—A comparatively small number of this species was found. It was rather irregular in its movements but, in general, it appeared at the surface thirty to forty-five minutes after sunset and left the surface an hour or more before sunrise. It was found at a depth of one meter, usually, in the daytime, and rarely occurred in catches below a depth of seven meters.

Ceriodaphnia lacustris.—This form was confined to the upper four meters and was present in very small numbers. There was no diurnal movement shown by it.

Leptodora hyalina.—Only a small number were found. It occurred in only five of the twenty day series. In these five instances, it was confined to the region of the thermocline, that is, between four and eight meters. Both young and adult appeared at the surface in the evening from thirty to forty-five minutes after sunset. The young left the surface about an hour before sunrise and the adults half an hour or more earlier.

Chydorus and *Bosmina* were found in very small numbers. No diurnal movement was noted.

Cypris.—There was, apparently, an extended horizontal migration of Cypris as it was found in a third of the morning and evening series, and these observations were made in the deepest part of the lake. In the daytime, however, Cypris was never found in the limnetic region of the lake but in the littoral region.

A few *Corethra* larvæ were found in and below the thermocline in the daytime. In a few instances they came to the surface at night.

Rotifera.—The rotifers showed no diurnal movement. With respect to their vertical distribution, they form three groups:

1. *Mastigocerca*, *Polyarthra*, and *Aspianchna* were confined to the upper five, six and seven meters respectively, or the region in and above the thermocline.

2. *Anurea aculeata* and *Triorthra* occupied the region below a deph of ten meters. They were usually most abundant within two or three meters of the bottom.

3. *Anurea cochlearis* and *Notholca longispina* were found through the entire depth of the lake.

MAXIMUM NUMBER AT SURFACE.

This diurnal migration must not be taken to mean that the individuals of the various species concerned, congregate at the surface at night in such numbers as to form what might be called a "swarm," for no such aggregation was noted. This is shown by the fact that *Diaptomus*, *Cyclops* and *Daphnia hyalina*, in a majority of the night observations, were more numerous at a depth of one or two meters or even deeper, than at the surface. It simply means that the upper stratum, one or two meters in thickness, is sparsely populated on bright, sunny days, but that this region is more or less densely populated at night.

Blanc (1898) and Fordyce (1900) found the greatest number of crustacea at the surface at 4 a. m. My observations do not agree with their results. Figs. 1 to 4 do not show a morning maximum with the exception of young *Daphnia hyalina* in the second series. On the other hand, *Diaptomus* reached a maximum at 7:30 p. m., adult *D. hyalina* at 7:30 and 8 p. m., and *Cyclops* at 7:30 p. m. and midnight. Also, each of the other forms showing a diurnal movement, reached its maximum about 8 p. m.

CAUSES OF DIURNAL MOVEMENT.

Various theories have been advanced to account for this phenomenon. It has been ascribed to various factors such as food, temperature, light, gravity, and in some cases chemical stimuli. Experiments on several of the crustacea which show diurnal movement, seem to show that light is the primary factor. But generally, there are other factors involved which may modify the effect of light to a very considerable degree, thus making the phenomenon complex instead of apparently very simple.

The migrating forms of Winona Lake may be separated into two groups. The first group includes those whose day position bears a more or less direct relation to the intensity of the sunlight. *Daphnia hyalina* and *retrocurva*, *Diaptomus*, and *Cyclops* belong to this group. The Daphnias desert the upper meter or two on bright, sunny days and the other two members occupy this region in rather limited numbers. But, on cloudy days, all are found in this region in nearly as large numbers as at night. This seems to show that light is the primary factor controlling their movements. They move down to avoid intense light and then move up into this region again as soon as the intensity of the light is sufficiently decreased.

Epischura, *Leptodora*, and *Corethra* larvæ belong to the second group. The depth to which these descend in the daytime did not depend, apparently, upon the intensity of the sunlight as they were found at the same depth on cloudy as on clear days. Besides, it does not seem probable that sunlight alone would cause them to descend to so great a depth, that is, five to seven meters or more, especially since the transparency of the water was so low, 2.1 to 2.5 meters. Therefore, it seems reasonable to suppose that some other factors are very largely responsible for their movements.

Daphnia pulicaria might also be added to this group. While it showed only a very slight tendency toward diurnal movement in Winona Lake, it did show distinct and regular migrations in one of the Wisconsin lakes upon which the writer made observations. In the latter lake the same as in Winona Lake, it remained in and below the thermocline in the daytime and in neither case was its day position affected by the intensity of the sunlight. In general, the diurnal migration of all the members of this group, seems to be much more akin to the "nocturnal habits" of many other animals, than are the movements exhibited by the members of the first group.

Some crustacea upon which experiments have been performed, have shown that they are attracted by diffuse light. If this were true of all crustacea, and if it were to hold true for them in their natural haunts as well as in the laboratory, then one might suppose that there would be morning and evening surface increases of about equal proportions. Furthermore, it would not be unreasonable, perhaps, to expect moonlight to produce an appreciable effect, if the crustacea were attracted by diffuse light. For the most part, however, the truth of this supposition is not confirmed by the crustacea of Winona Lake. With the exception of the young *Daphnia hyalina* in the second all-night series, there was no morning surface increase comparable in every way to that of the evening.

Diaptomus was the only other form that showed any tendency toward a considerable surface increase after midnight, but its morning increases were much smaller than those of the evening. Then, too, moonlight had no appreciable effect upon the diurnal movement of any of the crustacea.

SUMMARY.

1. There was comparatively little change in the quantity of plankton.

2. Diurnal movement was shown by *Epischura*, *Diaptomus*, *Cyclops*, *Daphnia hyalina* and *retrocurva* *Diaphanosoma*, *Leptodora*, and *Corethra* larvæ.

3. These various forms reached a maximum at the surface about 8 p. m.

4. Light is a very important factor in the movement of *Diaptomus*, *Cyclops*, and *Daphnia hyalina* and *retrocurva*. It is, apparently, not so important a factor in the movement of *Epischura*, *Daphnia pulicaria*, *Leptodora*, and *Corethra* larvæ.

5. Diurnal movement was not affected by moonlight.

LITERATURE CITED.

Blanc, 1898. Le Plankton nocturne du Leman. H. Blanc. Arch. des sci. physiq. et nat., T. 6, 1898.

Fordyce, 1900. The Cladocera of Nebraska. Charles Fordyce. Trans. Amer. Micro. Soc., Vol. XXII, pp. 119-174, 1900.

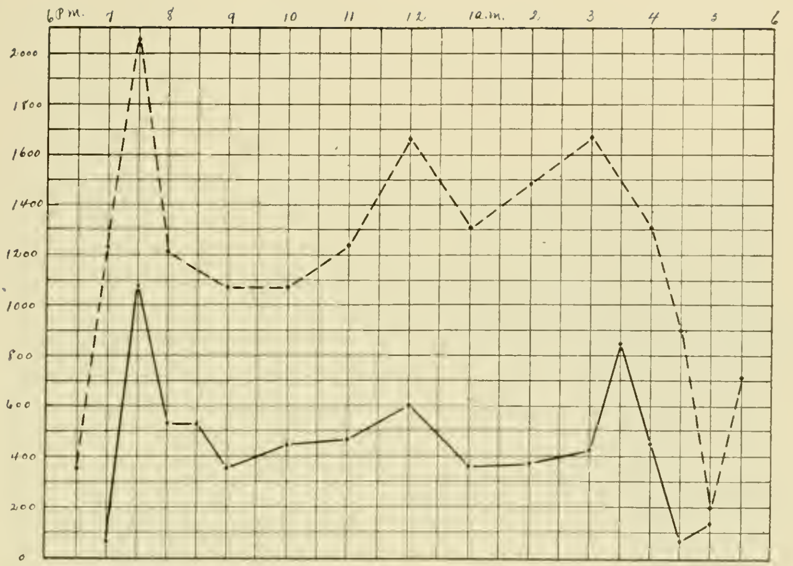

6 P.M.
7
8
9
10
11
12
1 a.m.
2
3
4
5
6
2000
1800
1600
1400
1200
1000
800
600
400
200
0

Fig. 1.

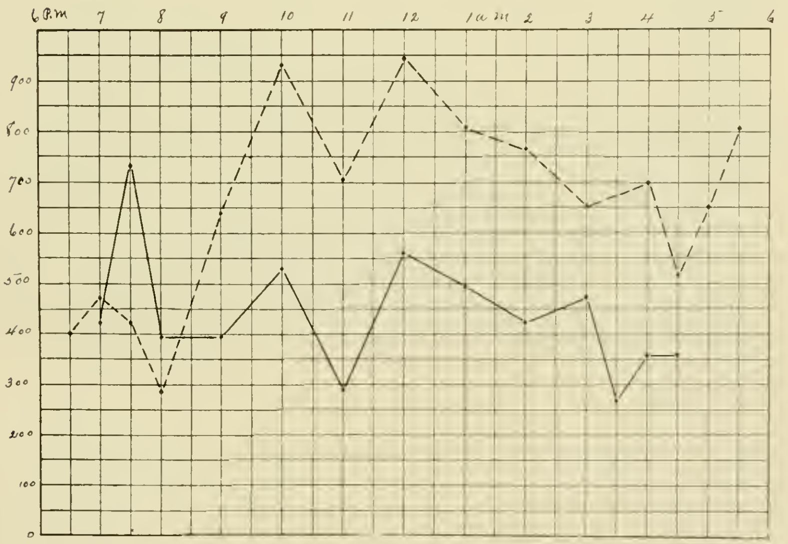

6 P.M
7
8
9
10
11
12
1 a m
2
3
4
5
6
900
800
700
600
500
400
300
200
100
0

Fig. 2.

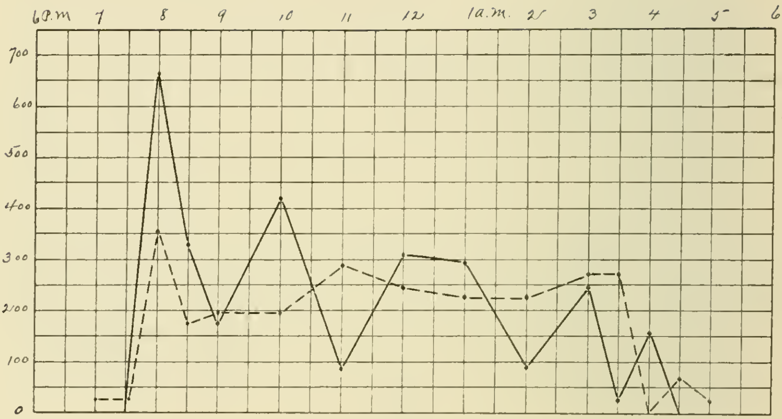

6 P.M 7 8 9 10 11 12 1 a.m. 2 3 4 5 6
700
600
500
400
300
200
100
0

Fig. 3.

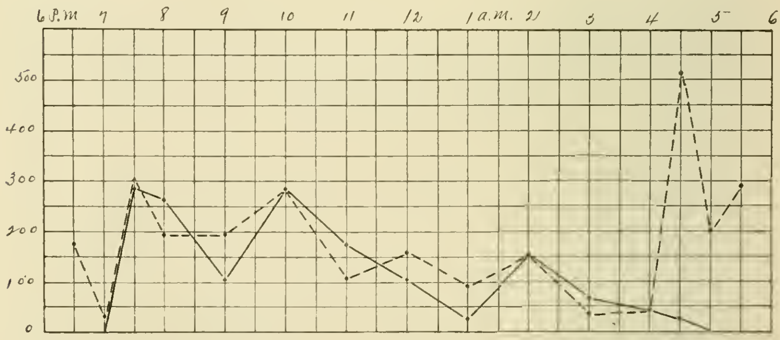

6 P.M 7 8 9 10 11 12 1 a.m. 2 3 4 5 6
500
400
300
200
100
0

Fig. 4.

EXPLANATION OF FIGURES.

Fig. 1. *Diaptomus.* Scale, one vertical space equals 100 individuals per hundred liters of surface water.

——————— August 5–6.

·················· August 27–28.

Fig. 2. *Cyclops.* Scale, one vertical space equals 50 individuals per hundred liters of surface water.

——————— August 5–6.

------------------ August 27–28.

Fig. 3. *Daphnia hyalina.* Scale, one vertical space equals 50 individuals per hundred liters of surface water.

——————— Adult. } August 5–6.
·················· Young. }

Fig. 4. *Daphnia hyalina.* Scale, one vertical space equals 50 individuals per hundred liters of surface water.

——————— Adult. } August 27–28.
·················· Young. }

f. The Birds of Winona Lake.

Clarence Guy Littell.

During the summer of 1902, from June 21 to August 28, while a student at the Indiana University Biological Station I devoted all of my time to a field study of the birds about Winona Lake. I present here my notes on the occurrence and habits of the birds observed.

The region about Winona Lake was fully described in the Proceedings Indiana Academy of Science for 1901 and a detailed description is not necessary. Suffice it to say that the lake is surrounded by swamps, flooded in times of extreme high water, and by hills reaching a height of forty feet. The vegetation varies from the aquatics in the margin of the lake to swamp-grasses and bushes in the marshes, and to oak forests on the hills.

Observations on birds were all made within a radius of one mile from the lake shore. In the following list the numbers in brackets refer to the A. O. U. Code and Check-list.

[6] *Podilymbus podiceps* (Linn.). Pied-billed Grebe.

This Grebe is not common around Winona Lake. I have only seen it twice, both times near the reedy shores of the western side.

[190] *Botaurus lentiginosus* (Montag.). American Bittern.

I have flushed this bird several times in a small swamp at the southeastern corner of the lake, but have been unable to find a nest.

[191] *Ardetta exilis* (Gmel.). Least Bittern. Fig. 3.

This bird is rather common in the small swamps bordering on the lake, but owing to the lateness of the season when I arrived, I was able to find but one nest which contained at the time three pure white eggs. I found this nest on July 23, in the middle of a swamp. It was a platform of grasses set in the swamp grass.

[194] *Ardea herodias* Linn. Great Blue Heron.

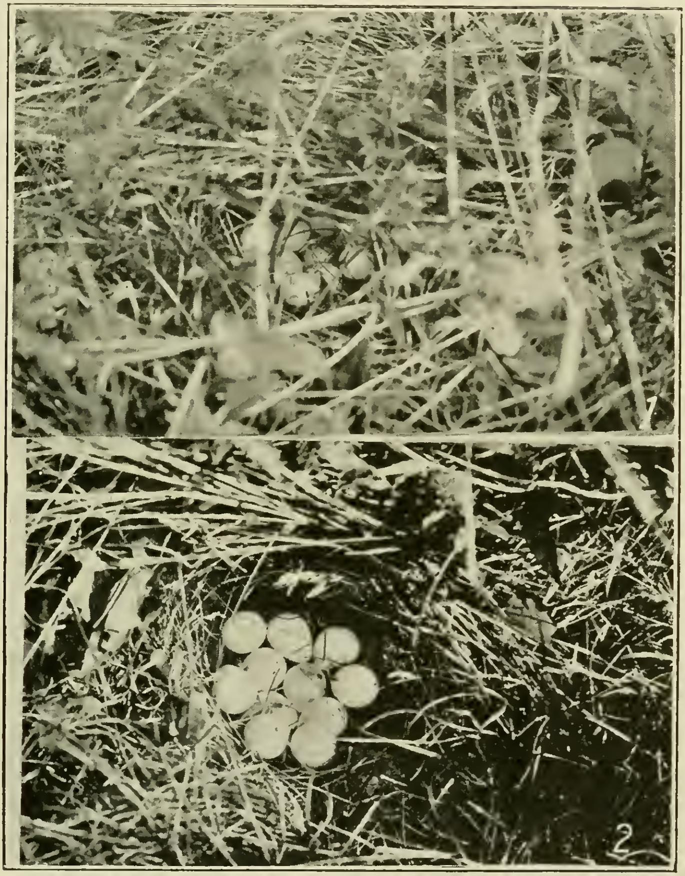
This bird has been identified flying over the lake several times. I have never flushed it.

[201] *Ardea virescens* Linn. Green Heron.

This species is common around the lake and undoubtedly nested in the vicinity in numbers in the spring. I found several old nests that I believe were built by this bird.

[214] *Porzana carolina* (Linn.). Sora.

I flushed three of these rails in a cornfield near a swamp, in the latter part of July. After a short flight they dropped into a marsh, and I failed to find them again.



[256] *Totanus solitarius* (Wils.). Solitary Sandpiper.

This bird is probably not rare around the lake although I flushed it but three times. It stays in rather removed places. Twice I saw it on a sandbar on the western side of the lake.

[263] *Actitis macularia* (Linn.). Spotted Sandpiper.

The most common wader around the lake.

[273] *Ægialitis vocifera* (Linn.). Killdeer.

Common. Often seen along railroad and on golf links.

[289] *Colinus virginianus* (Linn.). Bobwhite. Figs. 1 and 2.

Very common.

[316] *Zenaidura macroura* (Linn.). Mourning Dove. Fig. 4.

Very common around the lake, nesting all through the summer in all sorts of places. It seems to prefer places near lake shore. I found one nest on a brush pile, about twenty feet from the lake in a very exposed position; another in a tree overhanging the lake, in a small hollow, where the limb joined the trunk. The nest in the latter case consisted of two or three dead leaves.

[325] *Cathartes aura* (Linn.). Turkey Buzzard.

Common.

[331] *Circus hudsonius* (Linn.). Marsh Hawk.

Common around the lake. Nests in marshy places near small inlets.

[333] *Accipiter cooperi* (Bonap.). Cooper's Hawk.

Not common. I have identified one specimen while flying.

[337] *Buteo borealis* (Gmel.). Red-tailed Hawk.

Not rare. I have identified it several times. It is, however, much more common farther south.

[360] *Falco sparverius* Linn. Sparrow Hawk.

Not rare. I have identified it several times, but it is not common.

[368] *Syrnium nebulosum* (Forst.). Barred Owl.

Rare. One specimen was shot here in the summer of 1901. Personally, I have never seen it here.

[373] *Megascops asio* (Linn.). Screech Owl.

Common. Breeds in numbers although all young were out when I arrived.

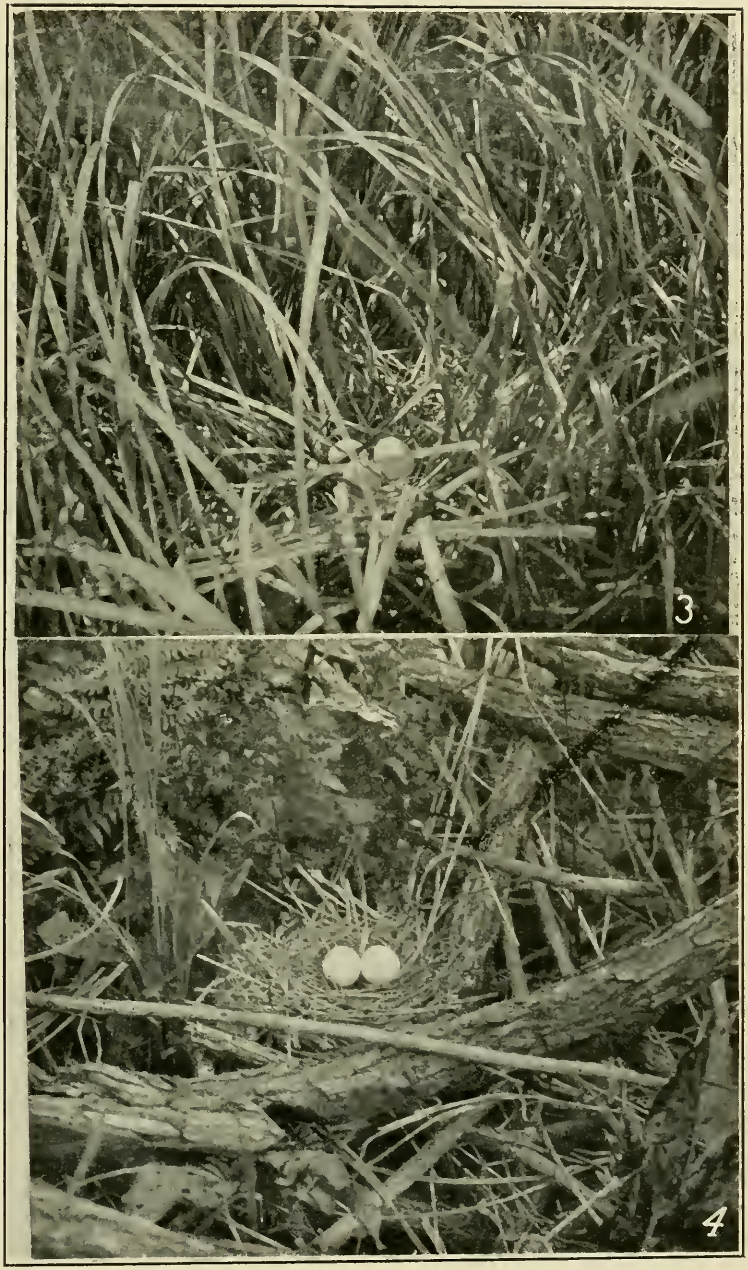
[375] *Bubo virginianus* (Gmel.). Great Horned Owl.

I have heard this owl twice during the summer. Probably not very common.

[387] *Coccyzus americanus* (Linn.). Yellow-billed Cuckoo.

Very common. Breeds commonly all during summer.

[388] *Coccyzus erythrophthalmus* (Wils.). Black-billed Cuckoo. Figs. 5, 6, 7 and 8.


3
4

Common, but not easily seen. I found one nest on the side of a rather steep hill, the female was sitting on the nest. I took a negative of her just as she was. I then scared her off the nest and found that she only had one egg. This was on the morning of July 13. I came back every morning and made negatives of her on the nest in different positions, afterwards scaring her off, but I found only one egg until July 17. At three o'clock in the afternoon of the 17th I found two eggs. The eggs were smaller than those of the Yellow-billed Cuckoo and did not have the bluish cast. The nest is a much better affair than the Yellow-billed Cuckoo builds. By the 18th I could approach my hand within eighteen inches of the cuckoo before she left the nest. Whenever she left her nest she generally flew about thirty feet and then sat perfectly motionless until I left. She hardly ever uttered a sound. Her positions on the nest were at times rather acrobatic. This is illustrated to some extent by the photographs. On July 24 the first egg was hatched into one of the ugliest young birds I have ever seen. On July 26 egg number two had disappeared but the young cuckoo was thriving. On July 27 feathers were pretty well started. On July 28 everything was as usual, on the afternoon of the 30th the bird had disappeared. It did not seem ready to leave the nest but probably the mother coaxed it off early on account of my visits.

[390] *Ceryle alcyon* (Linn.). Belted Kingfisher.

Very common. I found one nest in a railroad bank. Another in a steep bank along a creek.

[393] *Dryobates villosus* (Linn.). Hairy Woodpecker.

Four individuals of this species were seen this summer.

[394] *Dryobates pubescens* (Linn.). Downy Woodpecker.

Very common.

[402] *Sphyrapicus varius* (Linn.). Yellow-bellied Sapsucker.

Common.

[406] *Melanerpes erythrocephalus* (Linn.). Red-headed Woodpecker.

Very common. These Woodpeckers have become very tame, especially on the Winona Assembly ground. They frequently hop around in the road like English Sparrows.

[412] *Colaptes auratus* (Linn.). Flicker.

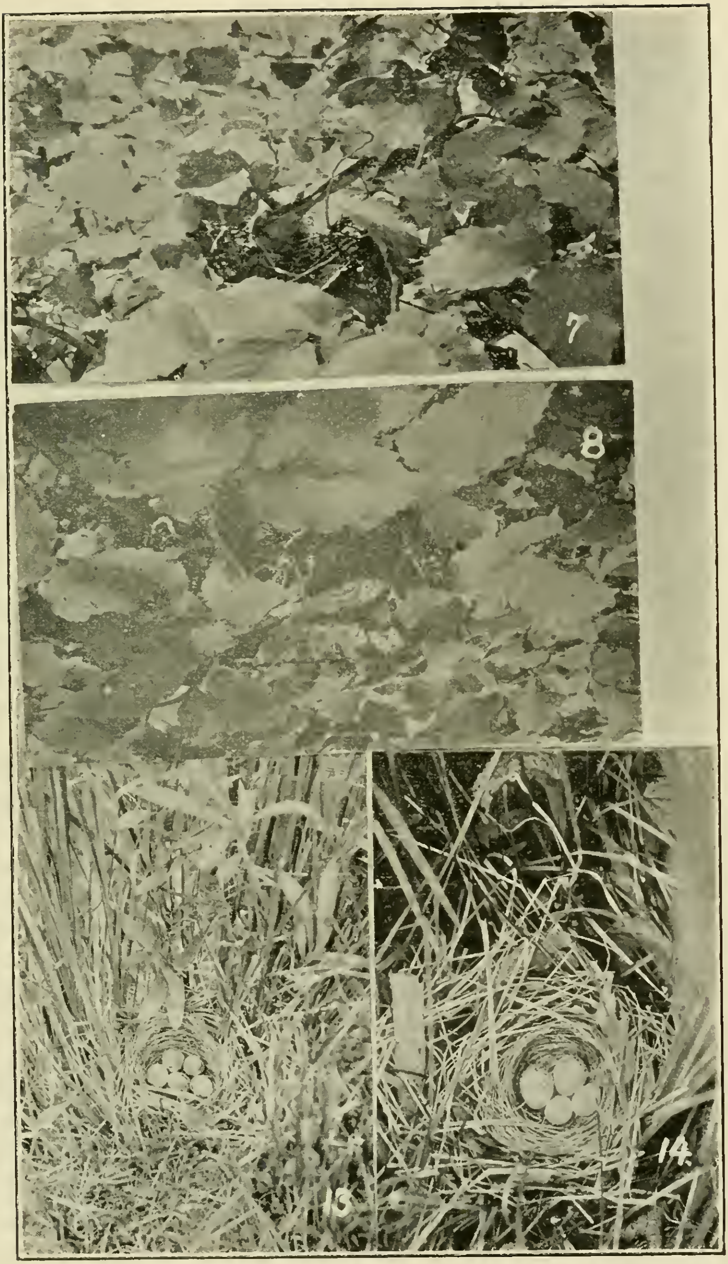
Very common.

[417] *Antrostomus vociferus* (Wils.). Whip-poor-will. Figs. 9, 10, 11, 12, 16.

Common. Often heard, but rarely seen. I found one nest on June 27. I was crossing an old and rotten rail fence at the top of a woody embank-


5
6

ment which sloped off sharply to Cherry Creek. The hill was covered with young willows, weeds and old dry leaves. Large red oaks were scattered plentifully here and there. The top rail on the fence broke with my weight and I dropped with a crash on the other side. It seemed that at almost the same time, I heard a loud chuck. About five feet in front of me a female Whip-poor-will was lying; she looked as if I had fallen upon her. She lay with outspread wings, with head and tail up, the middle part of her body sagging down as if her back were broken. Somewhat deceived, I started toward her but she edged away, still going through various contortive tricks. I looked around and stepped cautiously in the direction from which I thought she came, the frightened bird, all the while, giving a series of angry chucks. Finally in a bunch of poison ivy, I found an elliptical brown and lilac spotted egg in the least indentation in the dry leaves. About six inches away was the shell of another egg. But where was the young bird? At last I saw it; not only saw it but comprehended that it was a young Whip-poor-will. It lay close to the egg, and looked something like a piece of mouldy earth. A few feet away it seemed to fade right into the ground. It was perfectly helpless and was apparently not more than an hour old. I took a negative of it and left immediately so as to allow the mother to go back on the nest. When I stole back softly, in five minutes, she was brooding. She resembled perfectly the dead leaves around her. If she had not been frightened by the breaking rail, I would never have discovered her. I left at eleven o'clock (June 21) and returned at four o'clock that afternoon and the unhatched egg was chipped in one place. I reached the nest next morning at eight o'clock and young Whip-poor-will No. 2 was just out of the shell. There was still a piece of shell sticking to the down on its back. I judged that No. 2 was about twenty-one hours younger than No. 1. I took a negative of the two young ones and left. I had read that a mother Whip-poor-will carried her young away a distance if they are handled. I resolved, therefore, although I did not put much faith in the statement, to build a pen around the nest. This I did on the afternoon of June 28. When I went up softly I could now put my hand within two feet of the old female before she would move. When she did go she jumped up in a hurry, kicking the young several inches apart, where they lay very still. She would fall within three or four feet of me and go through the broken back performance, giving at the same time hoarse but vigorous chucks. After


7
8
13
14

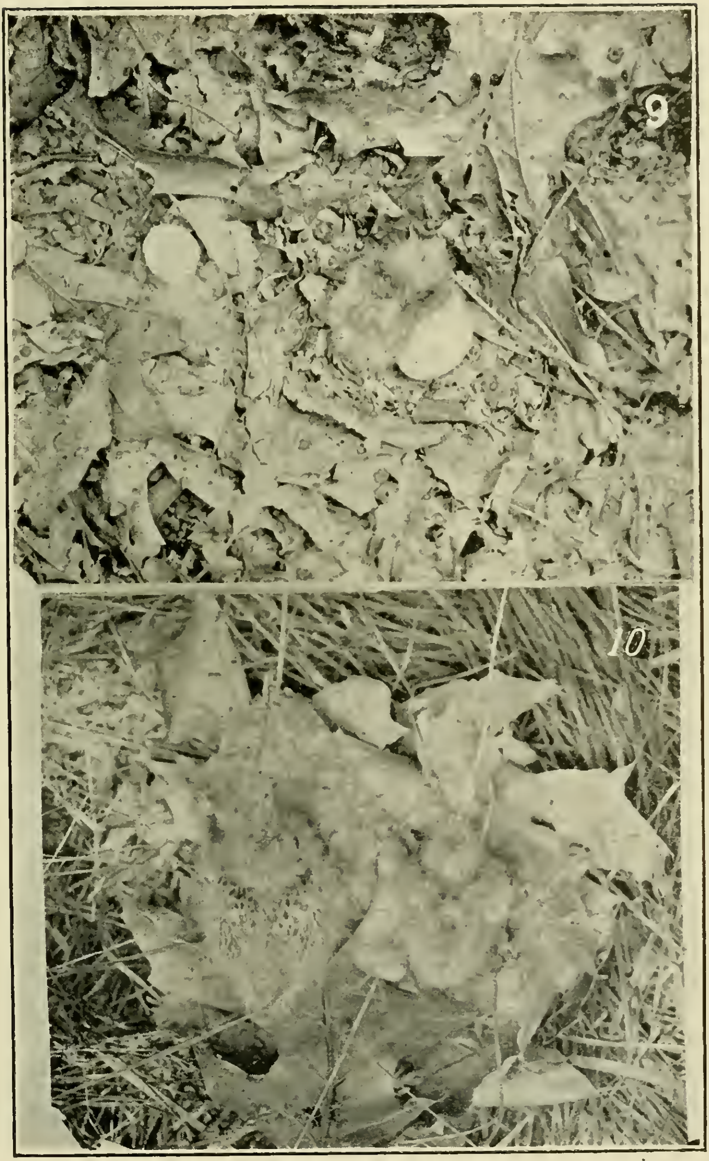
a time she would fly off twenty or thirty feet and sit either on a stump or lengthwise on a limb or log. She always sat lengthwise with her head toward me and apparently did not move an eyelid while I was there. I would scarcely leave the nest until she would be back brooding. Her flight was always perfectly noiseless. In leaving the nest the bird never emitted a sound, but as soon as she fell to the ground she always gave the same rapid series of hoarse chucks.

Her large full eye was always very noticeable at such times. I returned at 9 a. m. June 29. The young one No. 2 was just about two-thirds the size of the older one. The day was cold and raw and the older bird commenced to utter a shrill peet. This sound was perfectly indistinguishable to me at a distance of ten feet. However, it reached the ears of the mother who sat thirty feet away. She immediately became restless and commenced to fly from one object to another until I took the hint and left. I was scarcely forty feet away when I saw the mother fly to the nest.

I returned at 4 o'clock in the afternoon of the same day (July 29). The older of the young ones could now toddle around some and was not quite as helpless. The mother bird in rising kicked the two little birds about two feet apart. The younger lay perfectly still where she kicked it, but the older one toddled on about one foot farther and hid under a leaf where it was perfectly indistinguishable.

On the next day, June 30, the older bird could run quite lively for a short distance. It ran with extended wings, as a quail does. The younger was still helpless. On this day I searched the entire neighborhood to see if I could scare up the male bird. I had never seen him yet. I hunted in vain. I returned to the nest and while gazing at the mother bird brooding I saw to my astonishment a large mosquito light on her head near the base of her bill. The mosquito probed around awhile and then crawled out to the very tip of her bill, stayed there meditating for a minute and then flew away. All the while the mother bird never moved a muscle.

I returned to the pen on the morning of July 1 and found the birds where I had left them. The younger bird could now move around pretty lively, but was much smaller than the other. The old bird was getting accustomed to my presence now, so that I could photograph her with the lens of the camera not more than three feet from her, without scaring her from the nest. After taking the negative I approached my hand within six inches of her before she quietly but quickly flew away. She still per-


9
10

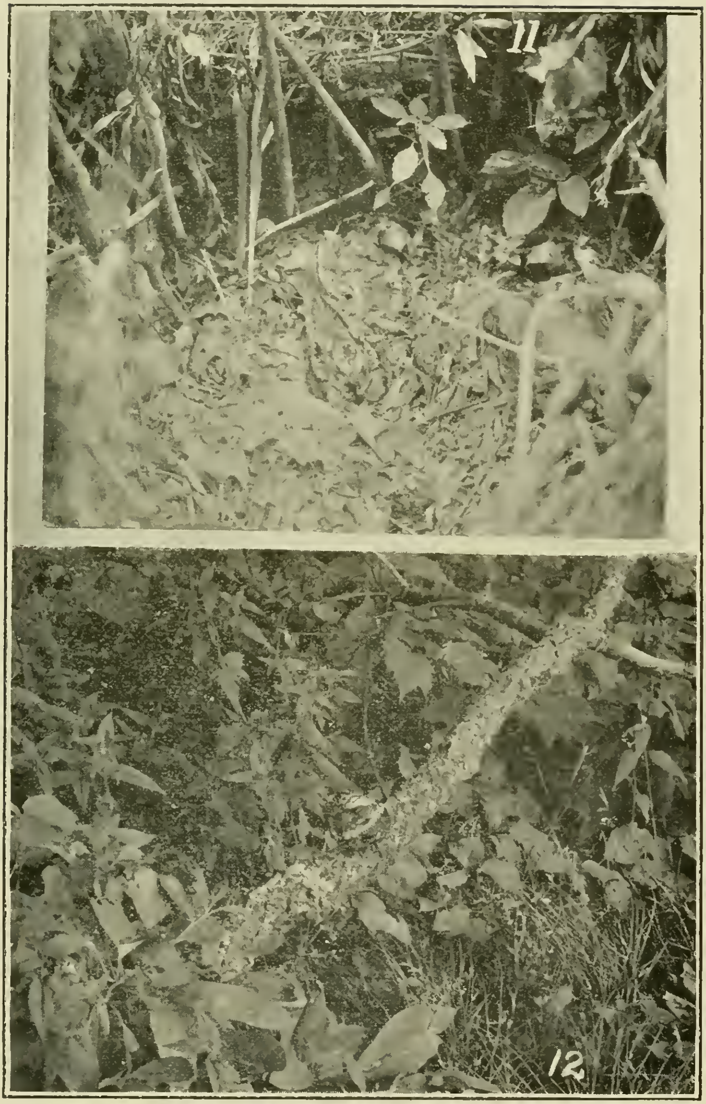
sisted in her acrobatic tricks to try to draw me away from the nest and she did in fact go through this same performance every time I visited her.

On the next day, July 2, I scared the mother from the nest by touching her on the head and the two little Whip-poor-wills both ran and hid under a leaf. It took some little time for me to find them again. The older now had promise of future feathers. Nothing was visible on the younger but down.

July 3, when I attempted to scare the mother bird from the nest she flew around my head quite fiercely, touching my ear once with her wing and then fell to the ground in her usual attitude of broken-back misery. The older of the two young ones now had the beginning of some mottled feathers.

At 9 o'clock on the following morning, July 4, I arrived at the pen. Imagine my surprise and chagrin to find the enclosure empty. Apparently I was wrong and Whip-poor-wills did carry their young away. I decided she could not carry them very far away so I commenced to beat the bushes around the pen. About ten feet north of the pen I flushed the mother bird. I looked down just in time to see young Whip-poor-will No. 1 run under a leaf but did not see No. 2 at all. I looked around under the leaves for a few minutes and finally discovered No. 2 sitting calmly on an old leaf right before my eyes. I brought them together and photographed them. It was a warm day and they were directly in the sun's rays. In a short time I noticed that their throats began to vibrate rapidly and each uttered a few shrill peets. Both, then, almost simultaneously toddled off and stopped in the shelter of a little weed. I left them and examined the pen. I found several places where even the old Whip-poor-will could get through. I therefore decided that she had coaxed them to follow her instead of carrying them. So, to prove it, I brought a box with the bottom knocked out and about one and one-half feet high, and placed this over the nest. I reasoned that if she carried them she could carry them out of that box without any trouble; if she coaxed them they could not get out as one and one-half feet was too much for the young ones.

I returned three days later, July 7. The family were still there just as I had left them. Whip-poor-will No. 1 now had a much better coat of feathers, and quills were beginning to appear on No. 2. I made a visit to the nest once every day now for four days and after scaring the Whip-poor-will off would retire to a distance and then slip back softly. I found that the mother bird invariably lit on the edge of the box before going to


11
12

the nest. She always lit on the north side of the box. No new developments appeared until four days later, on July 11. When I arrived at fifteen minutes of nine on the following morning, I set my camera down and walked boldly up to the nest to inspect. A little noise never scared the old bird. When I got about five feet from the box a bird sprang out, but not the homely little female. This was a Whip-poor-will undoubtedly, but it had a white ring around its neck and also displayed two dazzling white tail feathers. At last I had found the male brooding. He did not fall at my feet as did the female but flew to a log about thirty feet away, eyed me with evident disapproval, uttered a few protesting chucks and then with a flirt of his white tail feathers vanished among the bushes. I now turned to the nest and to my surprise found only one bird there and that was Whip-poor-will No. 2. It was all made plain now. The mother had succeeded in getting the older one to fly over but the younger was not able to do so. Therefore, she had spirited the older away, leaving her mate to brood the younger. I retreated about thirty feet and sat down to watch developments. In about ten minutes the male Whip-poor-will appeared, lit on the edge of the box opposite to the side that the female always lit on, sat there two or three minutes and then dropped in. I approached and tried to get a photograph of him but he absolutely refused to sit for me and so I left. I returned twice the next day, July 12, to get a negative, but he was just as wild as ever. When I arrived at the box at 8:30 the following morning, July 13, the box was empty; the last bird had flown. Thus is the history of the family for sixteen days, that being the time required for them both to fly. They would have probably remained near the old nest several days longer if they had been undisturbed.

[420] *Chordeiles virginianus* (Gmel.). Night Hawk.

Not rare. I saw it three times during the summer.

[423] *Chætura pelagica* (Linn.). Chimney Swift.

[428] *Trochilus colubris* Linn. Ruby-throated Humming bird.

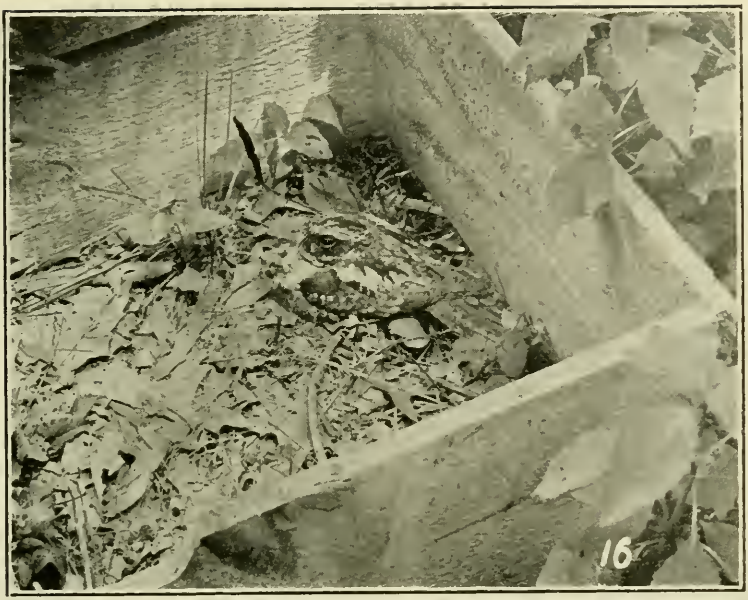
Rather common. I have been unable to find a nest but have seen this bird very often.

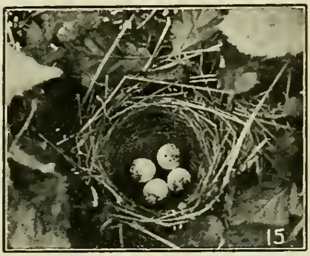
[444] *Tyrannus tyrannus* (Linn.). King Bird.

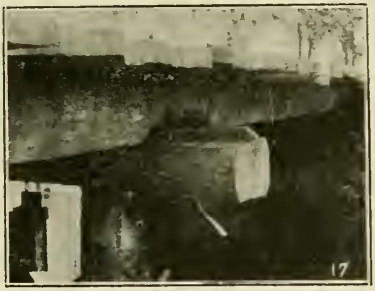
Very common. One of the liveliest and commonest birds around the lake.

[452] *Myiarchus crinitus* (Linn.). Great Crested Flycatcher.

Common.





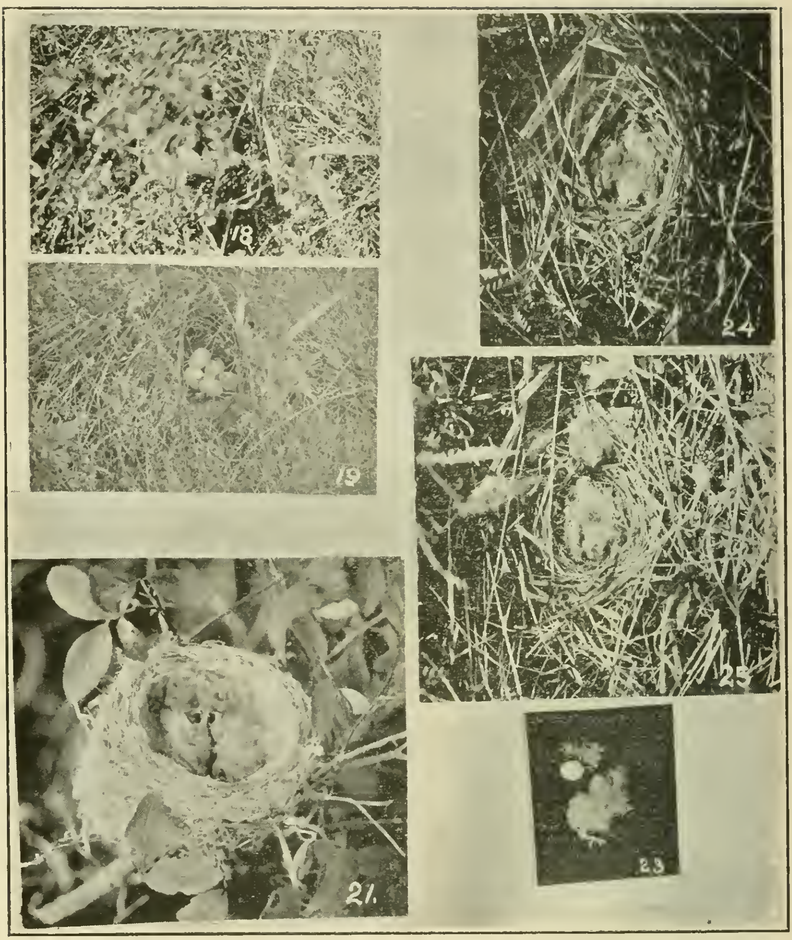


[456] *Sayornis phœbe* (Lath.). Phœbe. Fig. 17.

Common. Breeding all through the summer. I found one nest under the veranda roof of one of the hotels. I took the negative shown in Fig. 17 on July 7. The nest was under a small bridge near the station. It contained four young almost ready to fly.

[461] *Contopus virens* (Linn.). Wood Pewee.

Very common. These birds are very common in the Assembly grounds and have become tame. I found several nests; one with fresh eggs on July 21.



[465] *Empidonax virescens* (Vieill.). Acadian Flycatcher.

I shot one of these July 7, the only one I have identified during the summer.

[477] *Cyanocitta cristata* (Linn.). Blue Jay.

Very common. These birds have become very tame in the park, eating remains of lunches, etc. I have often seen one take a bath in a certain little trough of running water; crowds of people passing within eight or ten feet. I found one nest under the porch roof of one of the cottages.

[488] *Corvus americanus* Aud. Crow.

Common. These birds' lives seem to be a burden to them around the lake on account of the numerous Kingbirds who attack them at every opportunity.

[494] *Dolichonyx orizivorus* (Linn). Bobolink. Fig. 13.

Common. These birds are to be found in large flocks around the lake in boggy meadows. I have found several nests. Fig. 13 represents a nest in a clump of swamp grass on the edge of a small swamp.

[495] *Molothrus ater* (Bodd.). Cowbird. Fig. 14.

Common. These birds seem to have a preference for the nest of the Maryland Yellow-throat. It is an exceptional thing to find a nest of this little warbler without its young Cowbird or Cowbird eggs. The negative of the two cowbird's eggs in the nest of a Maryland Yellow-throat was taken July 1.

[497] *Xanthocephalus xanthocephalus* (Bonap.). Yellow-headed Blackbird.

Rare. I have seen only one of these birds this summer. It was sitting on an old fence post in a dense swamp.

[498] *Agelaius phœniceus* (Linn.). Red-winged Blackbird.

Very common. These birds nest in large numbers around Winona Lake.

[501] *Sturnella magna* (Linn.). Meadow Lark. Figs. 18 and 19.

Very common. Numerous nests were found on the golf links near the lake until the middle of August. The photographs of the Meadow Lark's nest were taken July 17. On July 25 the young had left the nest.

[506] *Icterus spurius* (Linn.). Orchard Oriole.

Not common. I have only seen three pairs this summer.

[507] *Icterus galbula* (Linn.). Baltimore Oriole.

Common.

[511b] *Quiscalus quiscula æneus* (Ridgw.). Purple Grackle.

Very common. This bird is quite common in the park. It is found extensively also in meadows a mile or so back from the lake.

[529] *Spinus tristis* (Linn.). American Gold Finch.

Common. These beautiful birds are quite common around the lake. I have often seen them taking a bath at a certain sandy beach on the southeast shore of the lake.

[540] *Poocætes gramineus* (Gmel.). Vesper Sparrow.

Not rare. This sparrow is fairly common in the higher meadows back of the lake.

[——] *Passer domesticus* (Linn.). English Sparrow.

Very common.

[542a] *Ammodramus sandwichensis savanna* (Wils.). Savanna Sparrow.

Not common. I shot two of these sparrows in a bushy pasture, rather higher than surrounding fields. They are very difficult to see as they run through the grass and will rise only as a last resort.

[546] *Ammodramus savannarum passerinus* (Wils.). Grasshopper Sparrow.

Rare. I shot one of these sparrows in a clover field. It is the only one I have identified here this summer.

[547] *Ammodramus henslowii* (Aud.). Henslow's Sparrow.

Rare. I have succeeded in taking one of these sparrows in a wet meadow. It arose from a tuft of grass and dived into a willow bush.

[560] *Spizella socialis* (Wils.). Chipping Sparrow.

Common. This sparrow does not seem to breed here as commonly as in most places in this State.

[563] *Spizella pusilla* (Wils.). Field Sparrow. Fig. 15.

Very common. The photograph was taken July 11. The nest was situated about six inches above the ground in a clump of grass.

[581] *Melospiza fasciata* (Gmel.). Song Sparrow.

Very common. Always to be seen, rain or shine, sitting on the top of small willow trees near the lake on the eastern side. The photograph of its nest was taken July 8.

[584] *Melospiza georgiana* (Lath.). Swamp Sparrow.

Not rare. I have seen only five or six of these dark colored sparrows this summer.

[587] *Pipilo erythrophthalmus* (Linn.). Towhee.

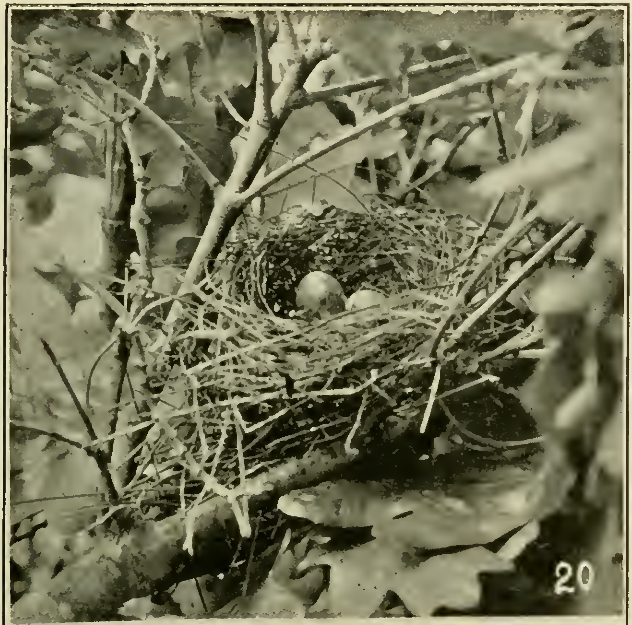
Very common. A bird whose power of song is of no mean order. Always to be found among the hazel bushes around the lake scratching among the dead leaves. I found a nest with eggs as late as August 20. They keep singing throughout August. With the exception of the Wood Pewee this is the most abundant species seen about the lake in August.

[593] *Cardinalis cardinalis* (Linn.). Cardinal Grosbeak.

Common. To be heard at all times of day from some lofty perch.

[595] *Habia ludoviciana* (Linn.). Rose-breasted Grosbeak.

Not rare. I have seen this beautiful bird several times and heard it much oftener. It is generally flitting around in a double row of old willows in the park.


20


22

[598] *Passerina cyanea* (Linn.). Indigo Bunting.

Very common. Its song is one of the most persistent all through the summer.

[604] *Spiza americana* (Gmel.). Dickcissel.

Not common. This bird is not as common as in southern and central Indiana. I have only seen ten or twelve individuals this summer.

[608] *Piranga erythromelas* Vieill. Scarlet Tanager. Fig. 20.

Common. I have succeeded in finding but one nest of this bird this summer but they are doubtless fairly common. I photographed the nest on August 2. It then contained three eggs. The nest was on the horizontal limb of a red oak, about six feet from the trunk and twelve feet from the ground.

[610] *Piranga rubra* (Linn.). Summer Redbird.

Rare. I have seen but one individual of this species.

[611] *Progne subis* (Linn.). Purple Martin.

Common.

[612] *Petrochelidon lunifrons* (Say). Cliff Swallow.

Not rare. This bird is not often seen. It is more common inland than near the lake.

[613] *Chelidon erythrogaster* (Bodd.). Barn Swallow.

Common. Often seen skimming the air near and over the lake.

[614] *Tachycineta bicolor* (Vieill.). Tree Swallow.

Common. Living in dead trees close to the lake. Often seen skimming over the surface of the lake seemingly within three or four inches of the water.

[616] *Clivicola riparia* (Linn.). Bank Swallow.

Common. Found nesting in the bank of the railroad and various places.

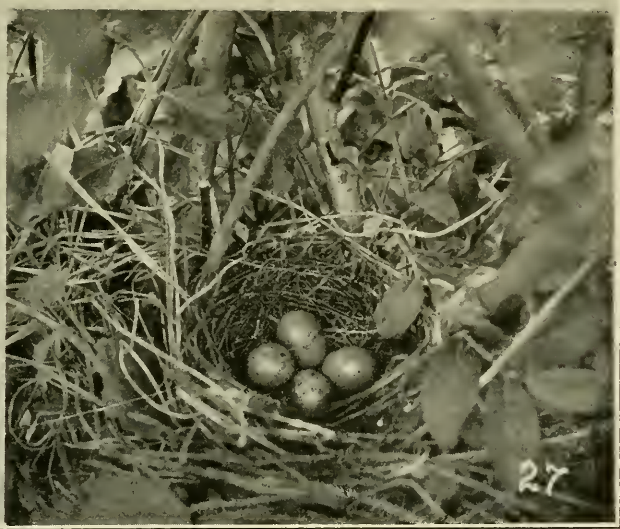
[619] *Ampelis cedrorum* (Vieill.). Cedar Bird.

Not common. I have seen three pairs this summer. On August 19 I found a pair of these birds in a swamp with two young. They had left the nest.

[622] *Lanius ludovicianus* Linn. Loggerhead Shrike.

This bird is not very common around the lake. I have seen two individuals. Their nesting time is so much earlier than when I arrived that all that did nest here had left to wander over the country.


26


27

[624] *Vireo olivaceus* (Linn.). Red-eyed Vireo.

Common. Probably much more common than they seem, as they are rather hard to identify if they do not sing. A most curious bird. I have seen one of these little birds follow me over one hundred yards from pure curosity apparently.

[627] *Vireo gilvus* (Vieill.). Warbling Vireo.

Fairly common. This little bird is much oftener heard than seen. It prefers lofty perches, generally around damp places. I have in mind a very large willow near the lake shore, in swampy ground, that often offers a perch for one of these songsters.

[628] *Vireo flavifrons* Vieill. Yellow-throated Vireo.

Not common. At least I have not often recognized it.

[636] *Mniotilta varia* (Linn.). Black and White Warbler.

Rare. I have seen but one specimen of this warbler. It was picking industriously at an old gnarled root of a white oak. The tree was on the bank of Cherry Creek, about one half a mile up from the mouth. I searched all around the tree but could find no signs of a nest.

[652] *Dendroica æstiva* (Gmel.). Yellow Warbler. Fig. 21.

Very common. This bird's nest is very often found in young willows and in rose bushes around the lake. In this region they seem to prefer swampy places for nesting. I have frequently seen males of this species with the chestnut stripes few or wanting entirely. The nest in the photograph was taken on July 1. It was situated in a wild rose bush on the edge of a swamp.

[658] *Dendroica rara* (Wils.). Cerulean Warbler.

Rare. I have noted two of this species. I shot one of them. It was hunting over the bark of an old oak, up in the topmost branches. The other one was in the top of a large sycamore.

[674] *Seiurus aurocapillus* (Linn.). Oven Bird.

Rare. The rather damp forests do not seem to be adapted to this bird. I secured one specimen and recognized it at another time.

[675] *Seiurus noveboracensis* (Gmel.). Water Thrush.

Not rare. This is a hard bird to identify and is perhaps more common than it seems. I have found one nest on the bank of Cherry Creek.

[676] *Seiurus motacilla* (Vieill.). Louisiana Water Thrush.

Not rare. To be seen at times along Cherry Creek and the lake shore. They are very quick in their movements and hard to see.

[677] *Geothlypis formosa* (Wils.). Kentucky Warbler.

Not rare. These birds inhabit the low wet woods so abundant in this region. I have found one nest here.

[681] *Geothlypis trichas* (Linn.). Maryland Yellow-throat. Figs. 22, 23, 24, 25.

This is the most common warbler around Lake Winona. In fact it is, probably, excepting the song-sparrow, the most common songster here. I have found numerous nests; generally in rather damp ground at the bottom of a clump of weeds, about four or five inches up. When you approach the nest of eggs the female will noisily drop over the side and run away through the weeds, from which it is almost impossible to flush her. When their young are hatched they resent intrusion, often flying by you within three or four feet.

On the morning of July 23, I found a nest containing three eggs of the Maryland Yellow-throat and one of the Cowbird. It was in a bunch of weeds within six inches of the ground. The place was rather damp and about twenty yards from the lake shore. It was so cleverly concealed I would never have found it had not the female jumped up. I took a negative and left, coming back twice a day till July 26. On my first trip in the morning the eggs were still unhatched but at 3 o'clock in the afternoon I found the Cowbird and one Maryland Yellow-throat hatched and another almost out as the shell was chipped considerably. I came back at 5 o'clock and the second Maryland Yellow-throat was out.

On coming back next morning things were the same; two birds and one egg. The young Maryland Yellow-throats kept their mouths open all the time while the Cowbird never opened its mouth. The young Maryland Yellow-throats were continuously struggling to maintain their place and keep the Cowbird from smothering them.

On the 28th the extra egg had disappeared and was not to be seen around the nest.

On the 29th things were as usual and on the 30th they were also the same. On the 31st the last born Maryland Yellow-throat had disappeared and was not to be seen around the nest. The Cowbird and the remaining Maryland Yellow-throat had feathered out pretty well by this time. On August 4 the Cowbird was occupying the entire nest and the Maryland Yellow-throat was sitting on the edge. They were both ready to leave. In the afternoon at 4 o'clock the nest was empty. The vociferous cries of the old birds assured me that they were in the weeds thereabouts, and so I left them.

[683] *Icteria virens* (Linn.). Yellow-breasted Chat. Fig. 26.

Not common. I found only one nest of this bird. It was in a bush three feet up on a steep bank sloping down Cherry Creek from Chicago Hill. I photographed it on July 13. It then contained three eggs.

[687] *Setophaga ruticilla* (Linn.). American Redstart.

Common. This little bird is often seen flashing from some perch after an insect and then returning to its lookout again. I found one nest in the fork of a sapling about eight feet up.

[704] *Galeoscoptes carolinensis* (Linn.). Catbird. Fig. 27.

Very common. Nesting in damp thickets largely. The nest in the photograph was discovered July 2. It was situated in a bush in swampy ground near the lake shore.

[705] *Harporhynchus rufus* (Linn.). Brown Thrasher.

Very common. A bird having, as a rule, extreme devotion to nest and seemingly without fear when disturbed.

[718] *Thryothorus ludovicianus* (Lath.). Carolina Wren.

Rare. I have seen but one specimen of this wren and that was about four miles away from the lake, near an old abandoned log hut. I hunted diligently for a nest but failed to find one or to see the mate.

[721] *Troglodytes aëdon* Vieill. House Wren.

Not common. I have seen but nine specimens of this wren during two months of summer. I can not account for it as twenty or thirty miles from here they are common. The large number of Jays in the park and around the lake may have something to do with it.

[724] *Cistothorus stellaris* (Licht.). Short-billed Marsh Wren.

Rare. I noticed one of these birds sitting on a reed in a marsh, singing. The marsh was full of the long-billed wren, but I have only seen the short-billed wren once in this locality.

[725] *Cistothorus palustris* (Wils.). Long-billed Marsh Wren.

Common. They are confined to the little swamps around the lake. I found twenty-six nests within twelve square feet in one swamp. The nests are globular with a very small entrance in one side which often takes quite a search to find. They are generally lined with vegetable down or moss.

[727] *Sitta carolinensis* Lath. White-breasted Nuthatch.

Common. These birds are often seen around the lake. I have watched a pair hunt over a willow within four feet of my window.

[728] *Sitta canadensis* Linn. Red-breasted Nuthatch.

Rare. I have seen one specimen in company with a pair of White-breasted Nuthatches. These were hunting on some large oaks near Tippecanoe River, a few miles away from the lake. They worked within twenty feet of me at one time.

[731] *Parus bicolor* Linn. Tufted Titmouse.

Common. Generally to be heard and then seen.

[735] *Parus atricapillus* Linn. Chickadee.

Very common. To be seen about the first of August in large flocks among the trees. Noted by their wheezy note and industrious tapping.

[751] *Polioptila cærulea* (Linn.). Blue-gray Gnatcatcher.

Not common. I have seen only four individuals.

[755] *Turdus mustelinus* Gmel. Wood Thrush.

Common. Their music is often heard around the lake.

[761] *Merula migratoria* (Linn.). Robin.

Very common.

[766] *Sialia sialis* (Linn.). Bluebird.

Not common. Bluebirds seem to avoid this locality for some reason. I have not seen over thirteen or fourteen specimens this summer.

DESCRIPTION OF FIGURES.

Figure 1. Nest of a Bob White just as found.

Figure 2. The same nest with the grass which concealed it pushed aside. The eggs themselves were not touched.

Figure 3. The nest and eggs of a Least Bittern. It is a mere platform of swamp grass about two feet above the water. The water was about three feet deep.

Figure 4. The nest of a Mourning Dove. The nest was in a very exposed position on a brush pile. It was about twenty feet from the lake shore.

Figure 5. The nest and eggs of a Black-billed Cuckoo. It was on the hanging limb of an oak about five feet from the ground.

Figure 6. The same nest with one young bird.

Figure 7. A back view of the Black-billed Cuckoo sitting on her nest.

Figure 8. A side view of the Black-billed Cuckoo on her nest.

Figure 9. Nest of Whip-poor-will with a young Whip-poor-will, of part of the shell it came from and of an unhatched egg.

Figure 10. A view of the two young Whip-poor-wills, showing difference in size, caused by about twenty-one hours difference in age.

Figure 11. Female Whip-poor-will brooding in a pen place around the nest.

Figure 12. Whip-poor-will lengthwise on a log, resembling a knot.

Figure 13. Bobolink's nest in a clump of swamp grass. One side of the clump of grass is cut away to expose the nest.

Figure 14. Nest of a Maryland Yellow-throat with two Cowbird eggs.

Figure 15. Field Sparrow's nest and eggs.

Figure 16. Female Whip-poor-will brooding. The two young have their heads out in front. They are in a box placed around them after she had coaxed the young away from the first pen.

Figure 17. Phoebe's nest with young.

Figure 18. Nest of a Meadowlark.

Figure 19. The same nest with the grass pushed aside so as to expose the eggs.

Figure 20. The nest of a Scarlet Tanager. It was on a horizontal limb of a red oak, placed about six feet from the trunk of the tree and about twelve feet from the ground.

Figure 21. The nest and young of a Summer Warbler. The nest was in a wild rose bush.

Figure 22. The nest and three eggs of a Maryland Yellow-throat and one of a Cowbird.

Figure 23. One young Cowbird, two young Maryland Yellow-throats and one egg of the Maryland Yellow-throat.

Figure 24. One surviving young Maryland Yellow-throat and the young Cowbird. Same nest as in Fig. 22.

Figure 25. The young Maryland Yellow-throat pushed upon the edge of the nest by the Cowbird, while the Cowbird comfortably fills the nest. Same nest as in Figs. 22 and 24.

Figure 26. The nest and eggs of a Yellow-breasted Chat. The nest is situated in the fork of a bush about two and one-half feet from the ground.

Figure 27. The nest and eggs of a Catbird. The nest was in a bush at the edge of a swamp.

g. A List of the Dragonflies of Winona Lake.

Clarence Hamilton Kennedy.

The dragonflies in the list below were collected by the writer during the summer of 1900 and by Mr. E. B. Williamson and the writer during the summer of 1901. The writer is especially indebted to Mr. E. B. Williamson for assistance and encouragement in the work.

The region indicated in this paper by the term "Winona Lake" includes not only the present body of water of that name but also the lowlands surrounding it, which, together with the present lake-bed once formed the bed of a much more extensive body of water. There are thus included the two short tributaries of the present lake, Cherry Creek and Clear Creek, and also about a quarter of a mile of the present outlet down as far as the old glacial dam. This gives a small, well-defined region in which, with the exception of the surroundings afforded by larger streams, are included nearly all types of dragonfly environment, swamp, meadow, woodland, lake and stream.

Consequently the number of species found is relatively large. The list, if we count *Sympetrum assimilatum* as a distinct form, now numbers forty-five species. It is fairly complete for the smaller kinds but will probably have several additions yet from among the larger, swift-flying, rarer species.

The outlet as far as the old glacial dam should be well worked. Here will probably be found several stream inhabiting species not at present included in the list. Thorough collecting during May and June might add a species or two not found later in the season. Practically no collecting has been done previous to June 25.

1. *Calopteryx maculata* (Beauvois).

This species is extremely abundant in the heavy shade along the banks of Cherry Creek during the early and middle summer. In 1900, after a few heavy rains about the 1st of August their numbers were greatly diminished.

2. *Hetærina americana* (Fabricius).

Common in the old outlet below the first wagon bridge. A male was taken at the mouth of Cherry Creek about the first of August, 1900.

3. *Lestes disjunctus* Selys.

A male and female taken by Mr. E. B. Williamson in the swamp south of the lake on July 13, 1900. One female taken by the writer south of the lake July 23, 1900.

4. *Lestes rectangularis* Say.

Four males taken by Mr. E. B. Williamson in the swamp south of the lake, July 13, 1900. One male taken by the writer at the same place, July 6, 1901.

5. *Lestes vigilax* Hagen.

One female was taken August 15, 1900, south of the lake.

6. *Lestes inequalis* Walsh.

One female was taken in the spatterdock beds on the south shore of the lake, July 8, 1901.

7. *Argia putrida* (Hagen).

Occasional on the sand bank and pier at the mouth of Cherry Creek.

8. *Argia violacea* (Hagen).

Fairly common about the water. This species is especially abundant along the banks of Cherry Creek during August.

9. *Argia sedula* (Hagen).

One specimen, a male, was taken July 8, 1901, along the south shore of the lake.

10. *Argia tibialis* (Rambur).

Three males of this species were taken south of the lake, July 13, 1900, E. B. Williamson.

11. *Argia apicalis* (Say).

Two males were taken by Mr. E. B. Williamson, south of the lake, July 13, 1900. One female was taken by the writer July 26, 1901, in the same swamp.

12. *Nehalennia posita* (Hagen).

Common in the grass about the laboratory.

13. *Nehalennia irene* (Hagen).

One specimen, a male, was taken by Mr. E. B. Williamson near the Biological Station, June 22, 1901.

14. *Enallagma hageni* (Walsh).

This species is common in the vegetation along the shores of the lake until the middle of July.

15. *Enallagma carunculatum* Morse.

Common everywhere about the lake. Next to *En. signatum* this is the most common species of *Enallagma* about the lake.

16. *Enallagma aspersum* (Hagen).

"A single female was taken June 27, 1901, in the woods on Chapman Hill, near Winona Lake. The female of this species of *Enallagma* is so distinctively colored that I do not hesitate to record the species for the State on such scanty material."*

17. *Enallagma traviatum* Selys.

This species is common on the willows and in the sedges about Winona Lake until the middle of July.

18. *Enallagma geminatum* Kellicott.

Very common on the willows near the laboratories until the middle of July. They have generally become rare by August 1.

19. *Enallagma exsulans* (Hagen).

This species occurs with *En. traviatum, En. geminatum* and *En. carunculatum*. It is common until August 1.

20. *Enallagma antennatum* (Say).

This species is common about the laboratories during June. One male was taken, July 6, 1901, along the south shore of Winona Lake.

21. *Enallagma signatum* (Hagen).

This is the most abundant form of *Enallagma*. It is especially abundant over the lily beds where it reaches its maximum abundance during the latter part of the summer after most other *Enallagmas* have disappeared.

22. *Enallagma pollutum* (Hagen).

This species is common on the lily beds along the south shore of Winona Lake during July where it appears only at dusk, probably remaining secreted in the dense vegetation of the adjoining swamp during the daytime. One specimen, a male, was taken on the lily beds at the old outlet August 17, 1900, by Dr. Howe.

23. *Ischnura verticalis* (Say).

This is common about the sedges and lily beds. The females are apparently much more abundant than the males, especially is this so among those found in the sedges and grasses.

* E. B. Williamson. Proceedings Indiana Academy of Science, 1901, p. 119.

24. *Progomphus obscurus* (Rambur).

Taken along the shore in front of the laboratories during the latter part of June, 1901. E. B. Williamson.

25. *Dromogomphus spinosus* Selys.

Taken during July several times at Winona Lake. E. B. Williamson.*

26. *Boyeria vinosa* (Say).

Occasional in the woods about the lake, where they are generally found flying slowly in and out among the bushes hunting small diptera.

27. *Basiaeschna janata* (Say).

One specimen, a female, was taken August 5, 1900, in the bacteriological tent by Mr. Showers. The specimen is not at hand. The late date makes us doubt the identification.

28. *Anax junius* (Drury).

This species is common during the early summer about the shores and over the lily beds. A few badly frayed individuals remain the entire season.

29. *Epicordulia princeps* (Hagen).

Common during the entire summer along the shores of the lake, over the lily beds, and back over the swamps and meadows. It is a very strong flier and is on the wing from dawn to dark, never being seen to alight, and seldom seen in copulation.

30. *Tramea lacerata* Hagen.

This is common about the shores and over the lily pads the entire summer. It is a high, swift flier and, though common, is seldom taken.

31. *Perithemis domitia* (Drury).

This little dragonfly is common over the lily and potamogeton beds. Of the two sexes the males are much the more abundant.

32. *Celethemis eponina* (Drury).

Very common over the lily and potamogeton beds during the middle and latter part of summer. Constantly pairing.

33. *Celethemis elisa* (Hagen).

This very pretty species is moderately common in the swamp south of Winona Lake during the middle and late summer.

34. *Sympetrum rubicundulum* (Say).

This species is very common in the meadows and fields about the lake during the latter part of summer. It is especially common south of the

* Proceedings Indiana Academy of Science, 1901, p. 121.

lake. Though a good flier it spends most of its time alighted on some weed or fence. A male of Var. *assimilatum* Uhler was taken July 30, 1900, by Mr. Cyrus Rutor.

35. *Sympetrum obtrusum* (Hagen).

One specimen, a female, taken July 13, 1900, was doubtfully referred to this species by Mr. E. B. Williamson. This species should be fairly common.

36. *Sympetrum vicinum* Hagen.

Two females were taken during the summer of 1900, one by Dr. J. R. Slonaker, and one by the writer.

37. *Sympetrum corruptum* (Hagen).

"Near Winona Lake, August 10, 1901, one male. Miss N. O. Harrah."*

38. *Mesothemis simplicicollis* (Say).

Common during the entire summer over the lily beds, along the sandy shores and over the sloughs and swamps.

39. *Pachydiplax longipennis* (Burmeister).

Generally associated with *Mesothemis simplicicollis*, but very much less abundant.

40. *Libellula basalis* Say.

This is the most conspicuous species of dragonfly about the lake, and of the larger forms the most abundant. It is found everywhere over the meadows and swamps, along the shores and over the lily beds.

41. *Libellula incesta* Hagen.

Seldom. One male was taken on the lily bed at the outlet, July 28, 1900. Another was seen earlier in the season flying slowly up and down Cherry Creek.

42. *Libellula cyanea* Fabricius.

Occasional. Associated with *Mesothemis simplicicollis* and *Pachydiplax longipennis* over the lily beds.

43. *Libellula pulchella* Drury.

Next to *Libellula basalis* this is the most abundant of the larger species. Common in nearly all situations.

44. *Plathemis lydia* (Drury).

This species is common about the drain ditches in the fields south of the lake. An occasional specimen is seen near the mouth of Cherry Creek.

A *Tramea*, either *carolina* or *onusta*, was seen in 1901 several times about the laboratories. Also in the field just back of Chapman Hill a *Pantala*,

---

* Williamson, Proceedings Indiana Academy of Science 1901, p. 120.

probably *hymenaea*, gave the collectors several wild chases. Both *Celethemis fasciata* and *Libellula semifasciata* are almost certain to be taken sooner or later.

---

h. A New Diagnostic Character for the Species of the Genus Argia.

Clarence Hamilton Kennedy.

The following paper was undertaken at the suggestion of Mr. E. B. Williamson, to whom the writer is also indebted for other suggestions and for much of the material examined.

The paper is the result of an attempt to find some character, if possible structural, by which the females of the five species of Argia found in Indiana could be separated.

The characters generally used in the classification of Odonata are the venation of the wings, the shape of the prothorax, the shape of the abdominal appendages, and the color pattern. A distinction upon the basis of venation has not been attempted. The color pattern is notoriously inadequate, and after careful comparison I find that the structure of the prothorax and abdominal appendages is equally so.

After a close study of the thorax a structure was discovered rarely, if ever, used in classification, which in the case of the five Indiana species is sufficiently different to separate the females readily. This is the peculiar shield-shaped structure on the anterior end of the mesepisternum. I can find no mention of this very peculiar structure except in Selys' "Synopsis des Agrionines." Here, just as I was finishing this paper, I found the following, in which Selys recognizes the diagnostic value of this character in the case of the females of the genus Argia: "De grandes difficultés se présentent pour donner les diagnoses des quarante-six espèces (Argia) Américaines, dont plusieurs sont trèsvoisines les unes des autres. Les appendices anals des mâles et *les lames du devant du thorax* des femelles fournissent, il est vrai, pour la plupart, des caractères positifs; mais ils eussent rendu les diagnoses très-longues, et ces organes ne pouvant etre bien vus qu' avec un certain grossissement, j'ai cherché dans les diagnoses de ce Synopsis, à me passer de ces caractères, qui seront réservés pour une monographie spéciale."*

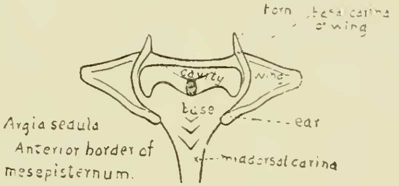
---

* De Selys-Longchamps, Synopsis des Agrionines, Bulletins de l'Academie royale de Belgique, 2me série, tome XX, No. 8, p. (9).

As far as I know the "*monographic speciole*" was never published.

Calvert, too, in a paper which has just appeared on the genus *Argia*, recognizes this structure.*

This structure occurs, as far as I have examined, in all the native genera of the Zygoptera, but it is lacking entirely in the Anisoptera or possibly is replaced there by the low transverse carina across the extreme anterior end of the mesepisternum. It is found on the same general plan in the different genera, consisting of a heart-shaped enlargement of the mid-dorsal carina, on either side of which is a triangular wing with its apex running down to the mesinfraepisternum.



In the genus Argia a more or less oblong depression (cavity—see figure above), bounded on either end by the high basal carina of either wing (see figure above) occurs in front of the heart-shaped end of the mid-dorsal carina. The basal carina of each wing ends in front in a horn, and behind, in the case of the females of four of the five species, in an ear-like lobe (the ear—see figure above). In the male no elaborate expansion into an ear occurs. The most striking differences in this structure are those of the size and shape of the ears. As these ears are absent in the males, for them the structure loses most of its diagnostic value. However, for interest in comparison, figures of this structure as it occurs in the males of the five species are shown in the plate (see Plate 11, Figs. 1, 3, 5, 7 and 9). By reference to them it will be seen at once that, in the male, this structure is of a more generalized type than in the female. The structure as found in the male is nearer the general type found in related genera.

The above would seem to indicate that this structure is a sexual organ functioning in the female and merely passively present in the male. One would at once jump at the conclusion that it is the organ by which the male holds the female during the act of copulation. The cavity would

* Calvert, Bull. Mus. Comp. Zool. Nov. 1902.

seem especially fitted for the insertion of the abdominal appendages of the male. But from direct observation it is known that the male holds the female by the prothorax, probably by the encircling groove at its anterior end. Moreover, because this structure is covered by the posterior lobe of the prothorax, it would be impossible for the male to reach it. See Plate 11, Fig. 2.

Nevertheless this structure must in some way be involved in the act of copulation. It is interesting to note that in the Anisoptera where the male holds the female by the head instead of by the thorax this peculiar structure is not developed at all.

But whatever its function, or whether it has a function or not, its form is sufficiently different in the females of the different species of Argia, and sufficiently constant among those of any given species to warrant its use in classification. How far this structure is good in showing relationships, it is difficult to say. According to it *putrida* would fall in a very distinct group by itself. *Aipcalis* would fall by itself. *Violacea*, *sedula*, and *tibialis* would fall in a group by themselves, in which *violacea* and *sedula* would be much more closely related than either to *tibialis*.

A key to females may be constructed as follows:

A. The ears entirely absent. The whole structure wide laterally and narrow from front to back. . . . . *apicalis*.

AA. The *posterior edge* of each wing produced into a broad rectangular lobe. The median longitudinal fossa of the base broad and shallow . . . . *putrida*.

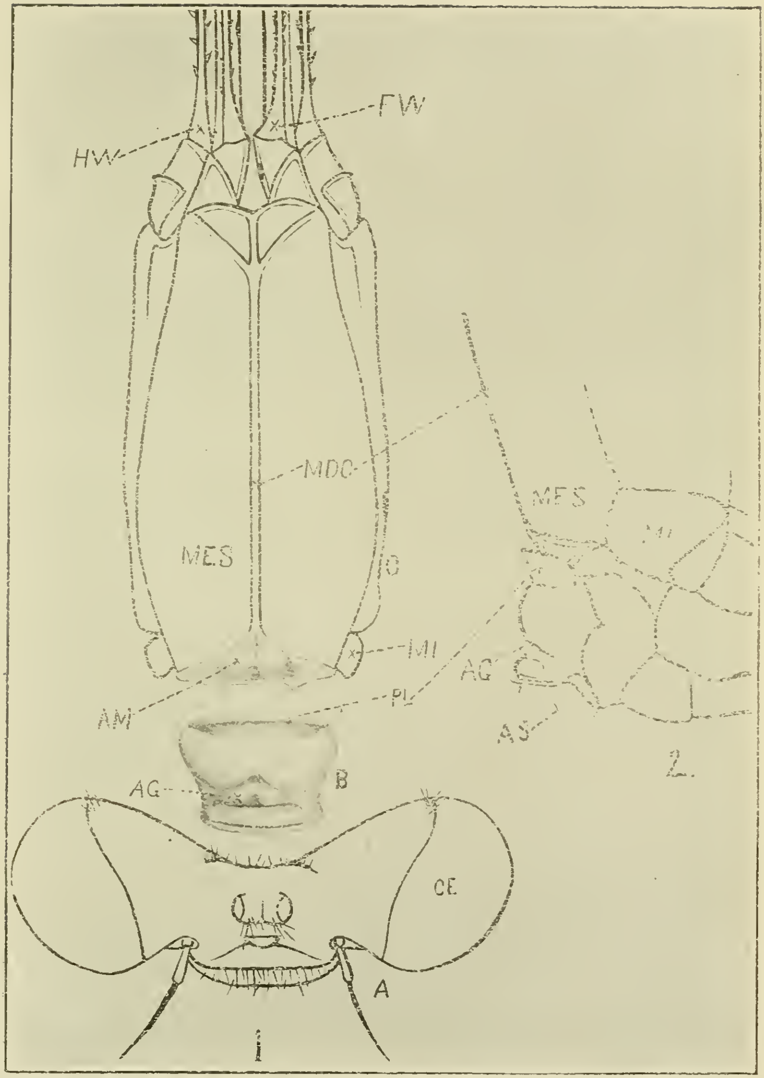
AAA. The *posterior angle* of each wing produced into an ear. The median fossa relatively deep.

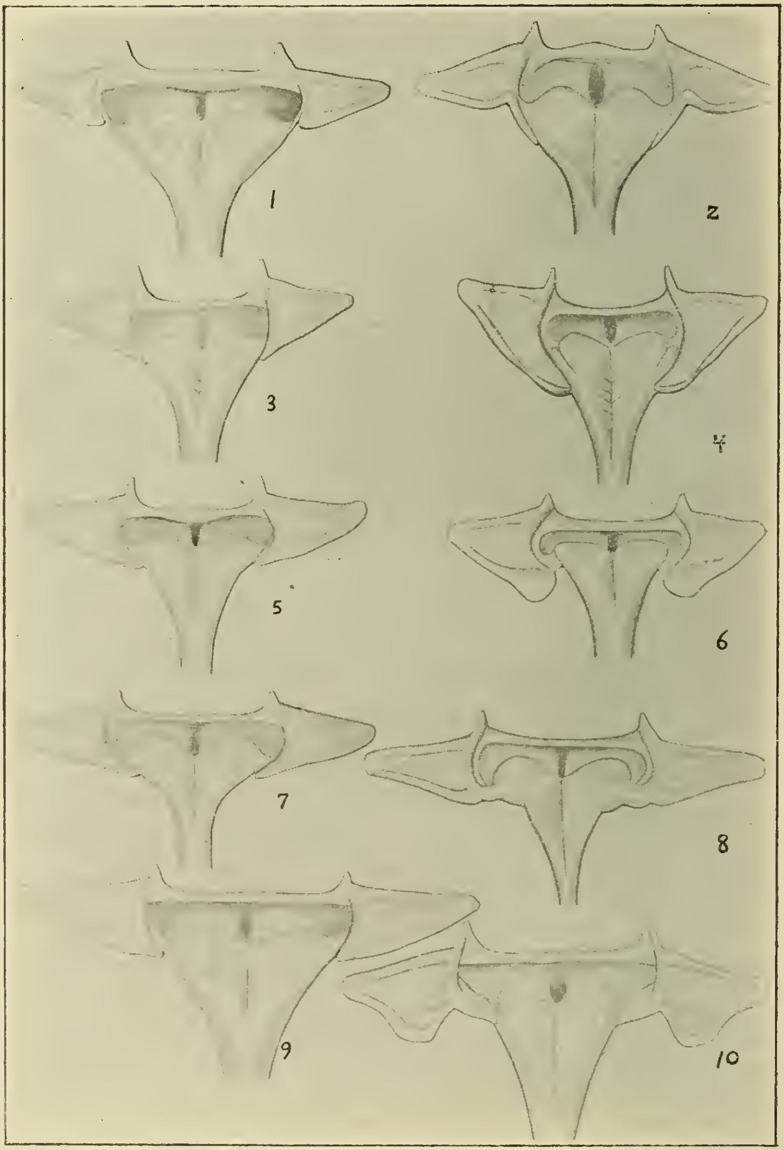
B. The apex of each ear pointing forwards and upwards. The entire structure relatively deep from front to back. *tibialis*.

BB. The apex of each ear pointing upwards and backwards.

C. The cavity very narrow. The ears broad and flat. *violacea*.

CC. The cavity of usual width. The posterior edge of each ear turned up. . . . . *sedula*.


FW
HW
MDC
MES
MES
MI
AM
PL
AG
AS
AG
B
CE
A
1
2.


1
2
3
4
5
6
7
8
9
10

EXPLANATION OF THE PLATES.

Plate I.

The drawings were made with a camera lucida, using a Bausch and Lomb 1/6 objective with the lower lens removed and a 2-inch eyepiece.

Fig. 1. *Argia apicalis* (Say). Bluffton, Ind., August 18, 1900, E. B. Williamson. Dorsal view of head, prothorax, and mesothorax of ♂, disjointed.

A—Head. *CE*, compound eye.

B—Prothorax. *PL*, posterior lobe. *AG*, anterior groove.

C—Mesothorax, the metathorax showing underneath. *AM*, anterior end of mesepisternum. *MDC*, middorsal carina. *MES*, mesepisternum. *MI*, mesinfraepisternum. *HW*, hindwing. *FW*, forewing.

Fig. 2. *Argia apicalis* (Say). Bluffton, Ind., August 18, 1900, E. B. Williamson. Lateral view of prothorax, and mesothorax.

AS—Articulating surface for head. Other lettering as for Fig. 1.

Plate II.

The drawings were made with a camera lucida, using a Bausch and Lomb 1/6 objective and 2-inch eyepiece.

1. *Argia tibialis* (Rambur). Bluffton, Ind., June 17, 1901, E B. Williamson. Anterior end of mesepisternum of ♂.

2. *Argia tibialis* (Rambur). Bluffton, Ind., June 17, 1901, E. B. Williamson. Anterior end of mesepisternum of ♀.

3. *Argia sedula* (Hagen). Fort Wayne, Ind., July 18, 1901, E. B. Williamson. Anterior end of mesepisternum of ♂.

4. *Argia sedula* (Hagen). Fort Wayne, Ind., July 18, 1901, E. B. Williamson. Anterior end of mesepisternum of ♀.

5. *Argia violacea* (Hagen). Tippecanoe River, Ind., July 2, 1901, E. B. Williamson. Anterior end of mesepisternum of ♂.

6. *Argia violacea* (Hagen). Pittsburg, Pa., June 15, 1899, E. B. Williamson. Anterior end of mesepisternum of ♀.

7. *Argia apicalis* (Say). Bluffton, Ind., June 2, 1901, E. B. Williamson. Anterior end of mesepisternum of ♂.

8. *Argia apicalis* (Say). Bluffton, Ind., June 2, 1901, E. B. Williamson. Anterior end of mesepisternum of ♀.

9. *Argia putrida* (Hagen). Bluffton, Ind., June 17, 1901, E. B. Williamson. Anterior end of mesepisternum of ♂.

10. *Argia putrida* (Hagen). Fort Wayne, Ind., July 18, 1901, E. B. Williamson. Anterior end of mesepisternum of ♀.

Investigation of the Action Between Manganese Dioxide and Potassium Chlorate in the Production of Oxygen.

Edward G. Mahin.

The method for preparing oxygen by heating mixtures of potassium chlorate and manganese dioxide has been used by chemists for some time. Since, however, the manganese dioxide comes out unchanged at the end of the process, yet considerably lowers the temperature necessary for decomposition of potassium chlorate, its exact function has been and is yet imperfectly understood.

There is not only a practical, but also a very interesting theoretical question involved in the explanation of the reaction taking place in this process, and it was the desire for obtaining further light on certain points that led Professor Ransom and the writer, at the suggestion of the former, to jointly undertake a study of the facts. Some questions, the settlement of which was to be attempted, were: 1. Does variation in proportion of potassium chlorate and manganese dioxide affect the temperature at which oxygen is evolved, and, if so, what mixture yields it at the lowest temperature? 2. Is the action continuous when the mixture is heated for a long period at or just above the decomposition temperature, and what are the products? 3. Heating for a period just below this temperature, are any intermediate products formed and what are they? 4. To notice any new facts brought out by the experimental work.

Search of the literature shows that the men who have performed the most important work upon this particular phase of the subject are McLeod, Brunck and Sodeau. McLeod had noticed the well-known fact that a gas resembling chlorine was evolved with oxygen, and in 1889, published a statement of experimental work, deducing the following reactions:

$$2\,MnO_2 + 2\,KClO_3 = K_2Mn_2O_8 + Cl_2 + O_2.$$

$$K_2Mn_2O_8 = K_2MnO_4 + MnO_2 + O_2.$$

$$K_2MnO_4 + Cl_2 = 2\,KCl + MnO_2 + O_2.$$

Upon this basis he explained the supposed fact that free chlorine is evolved only at the beginning of the process, since chlorine is liberated by the first reaction and at the lowest temperature, and that corresponding to this free chlorine, there was a certain amount of undecomposed potassium manganate at the end. In 1893 Brunck argued that if these reactions took place, the residue should either be alkaline or contain potassium manganate, or permanganate, and that he could obtain no evidence that either was the case. He brought forward experimental evidence to prove that the evolved gases did not contain more than a mere trace of chlorine and affirmed his belief that the odor and the property of bluing starch and potassium iodide paper was due to ozone. In 1894 McLeod stated that when the gases were led through alkaline silver nitrate solution, and this later acidified, a precipitate was obtained which corresponded in quantity with the alkalinity of the residue in the generator. He could obtain no evidence of ozone. Some further work was done by these men but they did not apparently succeed in settling the point at issue.

Sodeau, in 1901, proved that the action of manganese dioxide, barium sulphate, sand, and other supposedly inert bodies increased the evolution of oxygen not mechanically, but chemically.

EXPERIMENTAL.

The apparatus used in the experimental part of the present investigation was very simple. Hard glass test-tubes five inches in length, with side necks, were used for heating the mixtures, these being placed in a bath of Wood's fusible metal, heated in a thick cast-iron cup large enough to accommodate five tubes. A thermometer was also placed in the metal. Short delivery tubes, with ends drawn to a narrow aperture, led to a vessel for collecting the evolved gases in test-tubes over water.

The manganese dioxide used was Merck's "Artificial Pure," and previous to using was heated for several hours in an open dish over a free flame, in order to remove moisture; it was then placed in a glass stoppered bottle for keeping. Eimer and Amend's potassium chlorate was dried for six hours at 105°-110° for this purpose. It was not labeled "C. P." but tested free from chlorides both before and after drying.

The first mixtures were made in the following molecular ratios of manganese dioxide to potassium chlorate: 10:1, 2:1, 1:1, 1:2, 1:10. These were ground together, placed in the tubes, and slowly heated. At 150°-165° a gas was evolved from all, showing the presence of oxygen by means of a glowing spark, and giving a strong odor of chlorine or chlorine oxide. This odor is certainly not that of ozone and may be either chlorine or chlorine oxide, or both. In this paper it will be provisionally called chlorine. It was noticed that considerable moisture collected upon the upper parts of the generator tubes, indicating that at least one of the substances still contained moisture.

Other portions of the same mixtures as above were dried in their tubes for several hours at 100°-105°. Chlorine was evolved upon heating to 122° but no oxygen was evidenced by a spark. At 135° the rate of evolution of oxygen was approximately in direct proportion to the amount of manganese dioxide used, this being the reverse of the case when the materials were not dried. This, however, is not stated as a definite law.

Four other mixtures were more carefully dried, then heated in the bath. Chlorine was evolved at 140°, oxygen at 168°.

It was early seen that no reliable results could be obtained so long as the manganese dioxide held moisture. To determine whether this substance was hygroscopic, and if so, roughly the amount of water taken up, some freshly dried material was weighed in a closed bottle, then allowed to stand open for definite periods, weighing after each period. In twenty minutes its weight increased approximately 1 per cent.; after one and a half hours, 3 per cent.; after forty-five hours, 6 per cent.

To determine the difference in behavior due to this moisture, two mixtures were prepared: In (X) the manganese dioxide was dried over a free flame, weighed in a glass-stoppered bottle and the weighed potassium chlorate added. The other mixture (Y) was of potassium chlorate and ordinary undried manganese dioxide; both were molecular mixtures. In this and future experiments chlorine was tested for by starch and potassium iodide paper. At 125° (X) gave no chlorine or oxygen. (Y) gave large quantities of chlorine but no oxygen. Much moisture collected in (Y). At 148° a steady stream of oxygen came from (Y), continuing as long as heated. No trace of chlorine or oxygen came from (X).

More manganese dioxide was purified by digesting in cold distilled water, then washing until free from chlorides. The wash water contained small amounts of manganese and calcium. The washed mass was dried for two and a half hours at 200°-210°.

Four tubes were now filled with mixtures in molecular proportions, transferring the manganese dioxide quickly at 200° to the hot weighing bottle, cooling, weighing, adding the ground and weighed potassium chlorate, and mixing. The mixtures were quickly transferred to the tubes, the delivery tubes of which were in this case guarded with granular calcium chloride. A tube of dry potassium chlorate was heated with the others, in order to judge the amount of expanding air forced over.

The tubes were kept at 135°-140° for four and a half hours; no gas was over beyond that due to simple expansion, and not the slightest trace of either chlorine or ozone was found in any generator tube. No oxygen could be discovered. The mixtures upon testing were found to contain a considerable amount of chlorides. The temperature was raised to and kept at 150° for three hours and no chlorine or oxygen was produced. The quantity of chlorides seemed to be increased. At 173° all of the tubes began to evolve oxygen and so long as this temperature was maintained a steady but slow stream of oxygen was produced. No trace of chlorine, chlorine oxide or ozone was produced as high as 180°.

At this point the work was stopped for lack of time. Thus far a few conclusions may be provisionally advanced:

The conditions under which oxygen is ordinarily produced are not ideal, and the moisture always present materially influences the reactions. This moisture makes possible the production of oxygen at a lower temperature than in the case of dry materials, also the formation of chlorine or chlorine oxide, or both, as low as 125° and before oxygen is evolved. This may be due to hydrolysis of the potassium chlorate or chloride, thus allowing oxidation by the manganese dioxide. It is possible and even probable that no chlorine would be evolved at any temperature within the ordinary range of heating, if the materials were entirely free from moisture. In such a case, McLeod's explanation must fail, since if it be true, the formation of free chlorine is a necessary step in the evolution of oxygen.

This point, with others mentioned, will be more fully investigated by future work, and it is hoped that some facts of interest may be brought out during the investigation.

Action of Heat on Mixtures of Manganese Dioxide With Potassium Nitrate and With Potassium Bichromate.

J. H. Ransom.

The fact that different metallic oxides mixed with potassium chlorate cause the latter to evolve oxygen at considerably lower temperatures than when heated alone has long been known, though the nature of the chemical action involved is not with certainty established. No work has been done, so far as I am aware, to see what the effect of these oxides might be on other substances decomposable by heat.

It seemed, therefore, of interest to investigate the subject, and especially the action of manganese dioxide on various substances, as the results might throw some light on the action between it and the chlorate.

The substances chosen for the preliminary work were potassium nitrate and potassium bichromate. When potassium nitrate is heated to a high temperature it loses one-third its oxygen and forms the nitrite. If molecular proportions of the nitrate and manganese dioxide are mixed and heated in a metal bath, little if any evolution of oxygen occurs below 285° C. Between that temperature and 350° C. there is a constant, though not rapid, evolution of a gas which gives the usual test for oxygen. The amount, however, is not large, and during the heating there are formed brown oxides of nitrogen. In the same bath was a tube containing the same weight of pure dried potassium nitrate but there was no evidence of any decomposition. During the heating some moisture collected in the colder part of the tube, but whether this had any effect in causing the decomposition of the mixture, as is found in the case of the chlorate, has not yet been determined.

When potassium bichromate is heated alone in a free bunsen flame little or no oxygen is evolved even at the highest temperature obtainable. When mixed with manganese dioxide, however, a steady stream of gas is evolved at a comparatively low temperature. The decomposition begins at 285° but does not increase greatly in rapidity up to 350°. The temperatures at which the nitrate and the bichromate decompose are so nearly the same that a similarity of action is suggested. Whether the oxygen comes from the oxide, the other substance or from both has not yet been determined. That the oxide has some effect in producing the evolution of oxygen is certain. The investigation will be continued along this and related lines and the nature of the actions will be thoroughly studied as soon as time permits. It will also be of interest to know whether such oxides as the one used will lower the temperature at which substances ordinarily decompose, but without the evolution of oxygen. Such a substance would be ammonium nitrate. This subject will also be inquired into. In the meantime I wish to reserve this field of investigation.

Criticism of an Experiment Used to Determine the Combining Ratio of Magnesium and Oxygen.

James H. Ransom.

In some of the modern laboratory manuals for use in general chemistry work an experiment is described whereby a weighed amount of magnesium powder is oxidized in a covered crucible until a constant weight is obtained. The increase in weight has been assumed to be due to oxygen, and thus the ratio of the two elements in the oxide easily calculated.

My students have performed this experiment during the last two years but have not been able to secure sufficiently concordant results to make it appear to them as illustrating the law of constant composition.

Some observations are readily made in performing the experiment. The product, except perhaps at the surface, is not white, as is magnesium oxide, but of a gray color, due evidently to a mixture of substances of different colors. Also the crucibles at the end of the experiment are coated within with a black substance which can not be removed even on scouring with sand; and the crucibles lose in weight.

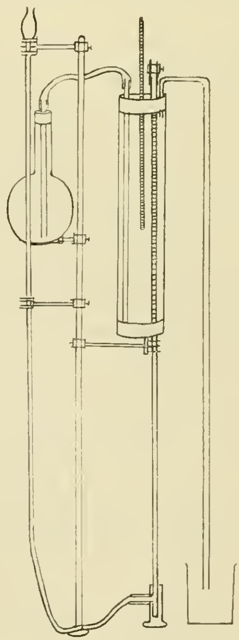
Examination of the product of burning shows that on treatment with small amounts of water ammonia is evolved, thus indicating that magnesium nitride is one of the substances present. As in this compound the ratio of the elements is 1:388 while in the oxide it is 1:667 it follows that from this standpoint the increase in weight must be less than the theory. Again, on treating the product with fairly concentrated hydrochloric acid a disagreeably odorous gas is evolved which at times is spontaneously combustible. It is, without doubt, hydrogen silicide from magnesium silicide formed by the action of magnesium on the crucible material. On treating with acid as above described there always remains a black insoluble amorphous residue mixed with white particles which under a hand-lens look like silica. The black mass when heated on platinum foil changes to a white powder which resembles silica. Apparently the black portion is silicon. It is conceivable that a part of the silicon after being formed, and during the heating, is oxidized by the air; and as it unites with nearly twice as much oxygen as does the same weight of magnesium, it might equalize the loss of the oxygen content due to the causes already indicated. Thus can be explained the nearly theoretical results so often obtained. But at best these results must remain a matter of chance and the experiment, seemingly so simple, but in reality so complicated, can not well be put into the hands of students doing their first work in chemistry.

Modifications of the experiment which will avoid these sources of error are in the mind of the writer, but have not been subjected to test for lack of time. Should they prove successful I shall be pleased at some future time to communicate them to the Academy.

An Apparatus for Illustrating Charles's and Boyle's Laws.

James H. Ransom.

Some difficulty having been experienced in making clear to students the changes in the volumes of gases due to the simultaneous changes in



temperature and pressure, it seemed that a clearer notion could be given by having a single piece of apparatus to illustrate their laws. Such an apparatus, a cut of which is presented, was devised to overcome the difficulty. It consists of an ordinary graduated gas burette connected with a reservoir for mercury and surrounded by a water jacket which in turn is connected with a flask containing water. The flask and jacket are so arranged that water of any desired temperature can be siphoned from the former through the latter, thus heating the gas in the burette to any temperature between 0° and 100° C. A thermometer inserted in the jacket indicates the temperature of the water. At the beginning of the experiment the water in the jacket should be at the room temperature, and the flask should hold several times the volume of the jacket. By the method of siphoning the change in tempeature is so gradual that the gas is heated to the water temperature almost as rapidly as the latter passes through, and there is no danger of breaking the burette. With the apparatus each law may be deduced separately with a fair degree of accuracy. Then the two laws united and the results compared with those found mathematically from a combination of the two. The idea of absolute zero is illustrated in a very clear and convincing way. If desirable the burette may be filled with different gases, and thus it may be shown that all obey (practically) the same laws.

Some $\triangle_2$-Keto-R-Hexene Derivatives.

James B. Garner.

A study of the reactions which might be brought about between benzöin and unsaturated aldehydes, ketones, and esters through the agency of cold (15° C.) alcoholic sodium ethylate, was begun several years ago[1]. At that time it was found that benzöin is added to benzalacetone giving rise to a 1.5 diketone which by loss of water and ring formation, is converted into 3-4-5-triphenyl-4-oxy-$\triangle_2$-keto-R-hexene. This substance had previously been prepared by Professor Alexander Smith[2], using potassium cyanide as condensing agent[3]. When sodium ethylate is used as condensing agent, the yield is much greater, the reaction takes place more smoothly and the product formed is purer than when potassium cyanide is used. Knoevenagel has made an exhaustive study of the $\triangle_2$-keto-R-hexene de-

[1] Dissertation, Chicago, 1897, p. 17.

[2] Berichte, *26*, 65.

[3] Amer. Chem. Jour. XXII, 250.

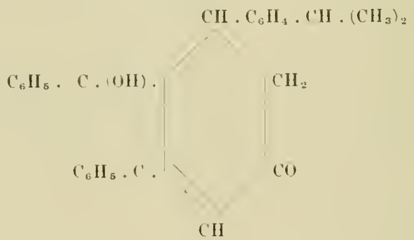
rivatives. He has found, (1) that substances of the type of acetoaceticether and aliphatic aldehydes[1], and aromatic aldehydes[2], condense in the presence of diethylamine or piperidine to form 1.5 diketones, and that these diketones, with loss of water and ring formation, are converted into $_2$-keto-R-hexene derivatives; (2) that desoxybenzöin adds itself to substances of the type benzalacetylacetone forming 1.5 diketones, which, by loss of water and ring formation, yield $_2$-keto-R-hexene derivatives.

Recently the study has been extended to include the reactions which might take place between the ketols—benzöin, cuminoin, furoin, anisoin and piperonoin—and the unsaturated ketones-benzalacetone, cuminalacetone, p-methoxy-benzalacetone, and piperonylenacetone. In all the reactions, $_2$-keto-R-hexene derivatives are formed, except in those in which furoin is used. Under no conditions has it been possible to bring about any interaction in any of the experiments in which furoin is used. All of the other reactions progress smoothly and excellent yields are obtained in each case. It has been ascertained also, that in place of the unsatured ketone, a mixture of the corresponding aldehyde and acetone may be used and the course of the reaction is in no way changed, but the yield is materially increased. To insure the completion of the reactions, however, it is necessary to boil the mixtures for fifteen minutes on the water-bath. Equal volumes of a ten per cent. solution of sodium hydroxide may be used instead of the alcoholic sodium ethylate and the same reactions will take place but the yields are very much poorer.

In the present paper the study is limited to the consideration of only those cases, which will in a general way, indicate, (1) the nature of the products formed and, (2) the extent to which the reaction is applicable.

I. ADDITION OF BENZÖIN TO CUMINALACETONE.

3-4-diphenyl-5-cumyl-4-oxy-$_2$-keto-R-hexene.



[1] Ann. *281*, 25. Ann. *288*, 321.
[2] Ann. *303*, 223.

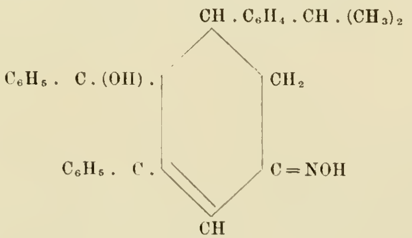
For the preparation of this $_2$-keto-R-hexene derivative, one molecule (6 gr.) of benzöin is dissolved in boiling absolute ethyl alcohol (100cc.), and to this solution is added one molecule (5.32 gr.) of cuminalacetone. This mixture is treated with an alcoholic solution (4cc.) of sodium-ethylate (.5 gr. sodium in 30cc. absolute ethyl alcohol). The mixture becomes deep red in color and upon standing in a cool place for two hours deposits clusters of needle-like crystals. The crystalline mass is filtered off and after washing with absolute ethyl alcohol is recrystallized twice from glacial acetic acid. Clusters of long, fine, white needles result which melt at 231°. It is insoluble in ligroin (40-60), ether, and cold alcohol, but dissolves readily in hot benzene, glacial acetic acid and chloroform.

Calculated as $C_{27}H_{26}O_2$.	Found.
C 84.80	84.67
H 6.81	6.92

If a mixture of one molecule each of cuminol (4.2 gr.) and pure acetone (1.7 gr.) is used instead of the cuminalacetone, it has been established by several comparable experiments that it is necessary that the reaction shall be carried on at the temperature of the water bath for fifteen minutes. Upon the cooling of the mixture, the $\triangle_2$-keto-R-hexene derivative separates in a relatively pure condition. By repeated additions of 4cc. of sodium ethylate at a time, additional quantities of the substance are obtained which make the yield almost quantitative. Experiments were made using the total quantity of sodium ethylate solution (12cc.) required for the quantitative completion of the reaction, and it was found that the reaction took an entirely different course, resulting in the formation of the sodium ethylate addition product of benzöin[6].

The condensation takes place readily when 15 grs. of a 10% solution of sodium hydroxide are used in place of the 4cc. of sodium ethylate solution.

Oxim of 3-4-diphenyl-5-cumyl-4-oxy-$\triangle_2$-keto-R-hexene.

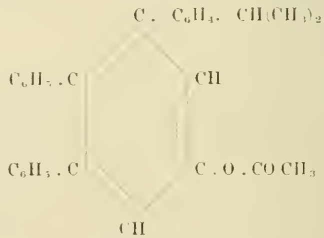


[6] Dissertation, Chicago, 1897, p. 4.

This oxim is obtained by boiling a mixture of one molecule (1 gr.) of the Δ$_2$-keto-R-hexene derivative with three molecules (.56 gr.) of hydroxylamine hydrochloride and one and one-half molecules (.56 gr.) of sodium carbonate dissolved in ethyl alcohol (140cc.) for forty-five minutes, using a return condenser. One-half of the alcohol is distilled off and the residue on cooling deposits white crystals, which, when they have been recrystallized from a mixture of benzene and ligroin, melt at 221–3°. The substance is easily soluble in hot alcohol, cold ether, acetic acid, and hot benzene, but very sparingly soluble in hot ligroin (40–60°).

Calculated as $C_{27}H_{27}O_2N$.	Found.
N. 3.53	3.72

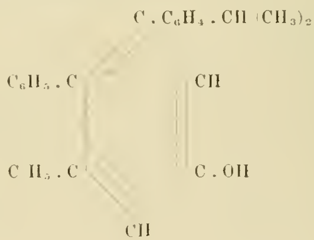
3–4–diphenyl–5–cumyl–phenol–acetate.



This body is prepared by boiling the Δ$_2$-keto-R-hexene derivative with excess of either acetic anhydride or acetyl chloride for thirty minutes. The mixture assumes a yellowish-red tint, and yields a solid substance only when it is poured into a large excess of water. The white amorphous mass recrystallizes from hot ligroin (40–60°) in bunches of long needles, melting at 98°. It is soluble in cold glacial acetic acid, benzene, ether and alcohol, but is sparingly soluble in ligroin.

Calculated as $C_{29}H_{26}O_2$.	Found.
C 85.72	85.50
H 6.40	6.62

3–4–diphenyl–5–cumyl–phenol.

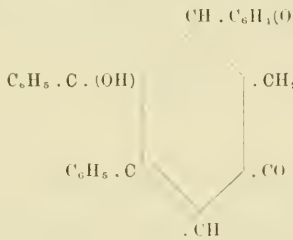


The acetate is boiled upon a water-bath with alcoholic potassium hydroxide for fifteen minutes. The mixture resulting is poured into excess of dilute hydrochloric acid, and a white mass is obtained. The amorphous phenol is recrystallized from hot alcohol. It forms white needles, which melt at 155°. It is readily soluble in cold chloroform, benzene and ether, but sparingly soluble in hot ligroin (40–60°).

Calculated as $C_{27}H_{24}O$.	Found.
C 89.00	88.96
H 6.60	6.87

II. ADDITION OF BENZOIN TO ANISYLIDEN ACETONE.

3–4–diphenyl–5–anisyl–4–oxy–Δ_2 keto–R–hexene.



The 3–4–diphenyl–5–anisyl–4–oxy–Δ_2–keto–R–hexene is prepared by the condensation of one molecule (6 gr.) of benzöin, either with one molecule (5 gr.) anisylidenacetone, or with one molecule each of anisaldehyde (3.9 gr.) and of pure acetone (1.7 gr.) under exactly the same conditions which were used in the preparation of 3–4–diphenyl–5–cumyl–4–oxy–Δ_2–keto–R–hexene. The substance crystallizes in bunches of needles, either from hot glacial acetic acid, or absolute alcohol, and melts at 233.5°. However the amount of alcohol required is large—for each gram, 70cc. of hot absolute alcohol are required. It is soluble in hot benzene and chloroform, but insoluble in ether and ligroin (40-60°). With cold concentrated sulphuric acid, a deep red coloration is produced.

Calculated as $C_{25}H_{22}O_3$.	Found.
C 81.08	80.91
H 5.95	6.03

Oxim of the 3–4–diphenyl–5–anisyl–4–oxy–Δ_2–keto–R–hexene.

For the preparation of the oxim, a method, analogous to that described in the preparation of the oxim of 3–4–diphenyl–5–cumyl–4–oxy–Δ_2–keto–R–hexene, is used. After recrystallization from hot alcohol, it melts at 196°.

It is soluble in hot glacial acetic acid, chloroform, and benzene, but insoluble in ether and ligroin (40-60°).

Calculated as $C_{25}H_{23}O_3N$.	Found.
N. 3.63	3.85

Acetate of 3–4–diphenyl–5–anisyl–phenol.

This product is obtained by boiling the Δ_2-keto–R–hexene derivative with acetyl chloride on the water-bath for ten minutes. The mixture assumes a deep red coloration. Nothing separates on cooling. When excess of water is added, however, an amorphous mass separates which, upon crystallization from hot ligroin (40-60°) or from aqueous alcohol, melts at 141^{5}–2°. It is soluble readily in cold benzene, ether, glacial acetic acid and chloroform; sparingly soluble in hot benzene and aqueous alcohol.

Calculated as $C_{27}H_{22}O_3$.	Found.
C 82.22	82.10
H 5.59	5.84

3–4-diphenyl-5–anisyl–phenol.

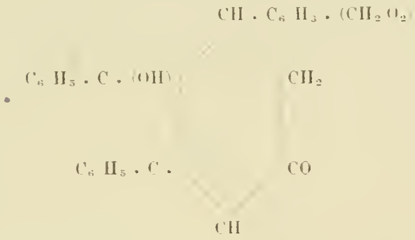
The acetate upon saponification with alcoholic potassium hydroxide yields the phenol. The reaction requires only fifteen minutes heating upon the water-bath to complete it. The product, which is obtained when the resulting solution is poured into dilute hydrochloric acid, is recrystallized from a mixture of alcohol and ligroin (40-60°) and melts at 159–60°. It is readily soluble in cold ether, benzene, chloroform and acetic acid, and almost insoluble in hot ligroin.

Calculated as $C_{25}H_{20}O_2$.	Found.
C 85.24	85.17
H 5.68	5.93

This phenol reacts vigorously at the ordinary temperature with cold concentrated nitric acid and yields nitro derivatives. These nitro bodies will be investigated later.

III. ADDITION OF BENZOIN TO PIPERONYLENACETONE.

3–4–diphenyl–5–piperyl–4–oxy– $_2$–keto–R–hexene.



One molecule (6 gr.) of benzoin and one molecule (5.9 gr.) of piperonylenacetone are dissolved in hot absolute ethyl alcohol (100cc.) and a solution (4cc) of sodium ethylate (.5 gr. sodium in 30cc. absolute alcohol) is added. As in all these condensation reactions with sodium ethylate, this mixture assumes a deep red coloration. Upon standing for two hours rosettes of yellow needle-like crystals separate. These crystals, upon recrystallization from glacial acetic acid, are obtained in fine white glittering needles, melting at 240°. The substance is soluble in hot chloroform; sparingly soluble in hot benzene and alcohol; and insoluble in ether and ligroin (40-60°).

Calculated as $C_{25}H_{20}O_4$.	Found.
C 78.12	78.00
H 5.21	5.38

The method above described for the preparation of 3–4–diphenyl–5–piperyl–4–oxy– $_2$–keto–R–hexene does not progress as smoothly and as completely as when one molecule each of piperonal (4.25 gr.) and of pure acetone (1.7 gr.) is used in place of the piperonylenacetone, and the reaction is carried out at the temperature of the water-bath. The crystals obtained by this method are very pure and clean, and the yield is almost quantitative, especially if the mother liquor is treated again with more sodium ethylate and the mixture again boiled.

Ten per cent. sodium hydroxide solution also effects the condensation. However the yield is poor.

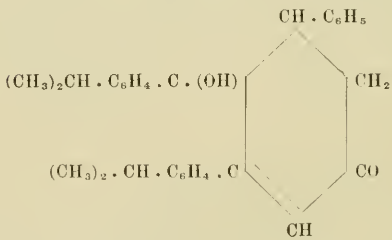
Oxim of 3–4–diphenyl–5–piperyl—4 oxy–$\triangle_2$–keto–R–hexene.

This oxim is prepared in an analogous method to that described previously for the preparation of oxims. When recrystallized from a mixture of alcohol and ligroin, crystals are formed melting at 190–1°. It is soluble in hot alcohol, cold ether, chloroform, and hot benzene, and is insoluble in ligroin (40–60°.)

Calculated as $C_{25}H_{21}O_4N$.	Found.
N 3.51	3.78

IV. ADDITION OF CUMINOIN TO BENZALACETONE[7].

3–4–dicumyl–5–phenyl–4–oxy–$\triangle_2$–keto–R–hexene.



Cuminoin, in general, reacts less rapidly than benzoin and the yields of $\triangle_2$-keto–R–hexene derivatives are poorer.

One molecule (6 gr.) of pure cuminoin[8] and one molecule (3 gr.) of pure benzalacetone dissolved in hot absolute ethyl alcohol (60cc.) are treated with a solution (6cc.) of sodium ethylate (.5 gr. sodium in 30cc. absolute alcohol). Upon the addition of the sodium ethylate, the mixture turns deep red, and after standing for six hours clusters of needles separate. By recrystallizing twice from glacial acetic acid, pure 3–4–dicumyl–5–phenyl–4–oxy–$\triangle_2$–keto–R–hexene is obtained. It melts at 214°. It is soluble in cold acetic ether, chloroform, hot benzene and ligroin (110–120°); insoluble in cold alcohol, ligroin (40–60°), and ether. The yield is about 27% of the theoretical.

Calculated as $C_{30}H_{32}O$.	Found.
C 84.90	84.77
H 7.54	7.83

[7] Dissertation, Chicago, 1897, p. 19.
[8] Berichte, XXVI, 64.

Oxim of the 3–4–dicumyl–5–phenyl–4–oxy–Δ_2–keto–R–hexene.

A molecule of the substance dissolved in alcohol was boiled with three molecules of hydroxylamine hydrochloride for an hour. On cooling, nothing appeared, but after the larger portion of the alcohol had been distilled off in the water-bath a solid separated, which on being well washed with water and recrystallized from a mixture of benzene and ligroin (40–60°) gave fine white needles melting at 208°. It may be recrystallized also from aqueous alcohol. The analysis shows it to be the monoxim.

Calculated as $C_{30}H_{33}O_2N$.	Found.
3.11	N 3.30

The substance is easily soluble in cold acetic acid, benzene, and acetic ether; insoluble in ligroin (40–60°).

3–4–dicumyl–5–phenyl–phenol acetate.

This body can easily be prepared by boiling the Δ_2–keto–R–hexene derivative with a mixture of acetic anhydride and anhydrous sodium acetate for forty-five minutes, or until the mixture becomes decidedly pink in color. The solution is then poured into a large amount of cold water and allowed to settle. After recrystallization from glacial acetic acid, it is obtained in large bunches of long radiating fibers, and melts, when pure, at 122°. It is soluble in cold benzene, chloroform, ether, and ligroin (40–60°), in hot alcohol and acetic acid.

Calculated for $C_{32}H_{32}O_2$.	Found.
85.71	C 85 60
7.14	H 7.55

The acetyl derivative, when hydrolyzed by means of alcoholic potash yields 3–4–dicumyl–5–phenylphenol.

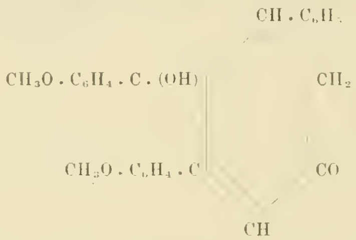
By warming the acetate in a water-bath for ten minutes with four molecules of alcoholic potash and pouring into dilute hydrochloric acid, an amorphous mass is obtained which crystallizes from warm alcohol in large thin plates, melting at 137°. This substance is soluble in cold acetic ether, benzene, chloroform, ether and hot ligroin (40–60°); insoluble in caustic soda.

Calculated as $C_{30}H_{30}O$.	Found.
C 88.66	88.26
H 7.39	7.99

The addition reactions of cuminoin with cuminalacetone, piperonylenacetone and anisylidenacetone are being studied at present, and I hope to be able soon to publish the results obtained.

V. ADDITION OF ANISOIN TO BENZALACETONE.

3–4–dianisyl–5–phenyl–4–oxy–Δ_2–keto–R–hexene.



Anisoin adds itself to the ethylene grouping much more readily than either cuminoin or benzoin to yield the expected 1.5 diketone, but the readiness with which this 1.5 diketone loses water to form the corresponding Δ_2-keto-R-hexene derivative is markedly less. In fact the 1.5 diketone constitutes the major portion of the reaction product. Attempts to prepare the 1.5 diketone pure, *i. e.*, free from the Δ_2-keto-R-hexene derivatives, have failed partially. However, its approximate melting point has been obtained, namely, 168-174°. When boiled with the ordinary solvents in which it is soluble, the 1.5 diketone loses water and forms the Δ_2-keto-R-hexene derivative, which melts at 207°.

The mixture of the 1.5 diketone and the Δ_2-keto-R-hexene derivative is prepared as follows:

One molecule (4.4 gr.) of anisoin and one molecule (2 38 gr.) of benzalacetone are dissolved in absolute ethyl alcohol (62cc.) and to the mixture sodium ethylate solution (4cc.) is added. The solution becomes deep red and upon standing for two hours deposits a large mass of crystals (2.4 gr.). The solid is filtered off and washed well with absolute alcohol. A trial determination of the melting point shows that the product is a mixture. It melts at 168–74° and 204°. The mother liquor from the crystals upon treatment with more sodium ethylate solution yields more of the same products (.4 gr.) Upon recrystallization from either of three solvents—benzene, alcohol or acetic acid—fine white needle-like crystals are obtained, having a constant melting point of 207°. It is soluble in chloroform, slightly soluble in ligroin, and insoluble in ether.

Calculated as $C_{26}H_{24}O_4$.	Found.
C 78.00	77.62
H 6.00	6.13

The acetate and oxim have been prepared, but as yet no analyses have been made, but the physical properties determined correspond very closely with those of the other Δ_2–keto–R–hexene derivatives which I have prepared.

An investigation of the reaction of anisoin with cuminalacetone, piperonylenacetone and anisylidenacetone is being carried on.

Geology of the Jemez-Albuquerque Region, N. M.

Albert B. Reagan.

(Abstract.)

(Original published by the American Geologist. Illustrations used by permission of that Publishing Company.)

GENERAL DESCRIPTION.

The Jemez-Albuquerque Region described in this paper, is in northwestern New Mexico between longitude 106.° 20′ and 107° W. and latitude 35° and 36° N. Roughly speaking, it is a triangle with its apex toward the south. It is bounded on the southeast by the San Dia Mountains, on the southwest by the Rio Puerco, and on the north by the upper plateau of the Jemez Mountains. Its principal river is the Rio Grande, and its commercial center is Albuquerque. The Santa Fe Railroad enters the region at the northeast, near Thornton, and passes through it, just to the east of the Rio Grande to Albuquerque. At this point the road branches, one branch of the system going to El Paso, Texas, the other, the Atlantic and Pacific, to California and the Pacific coast.

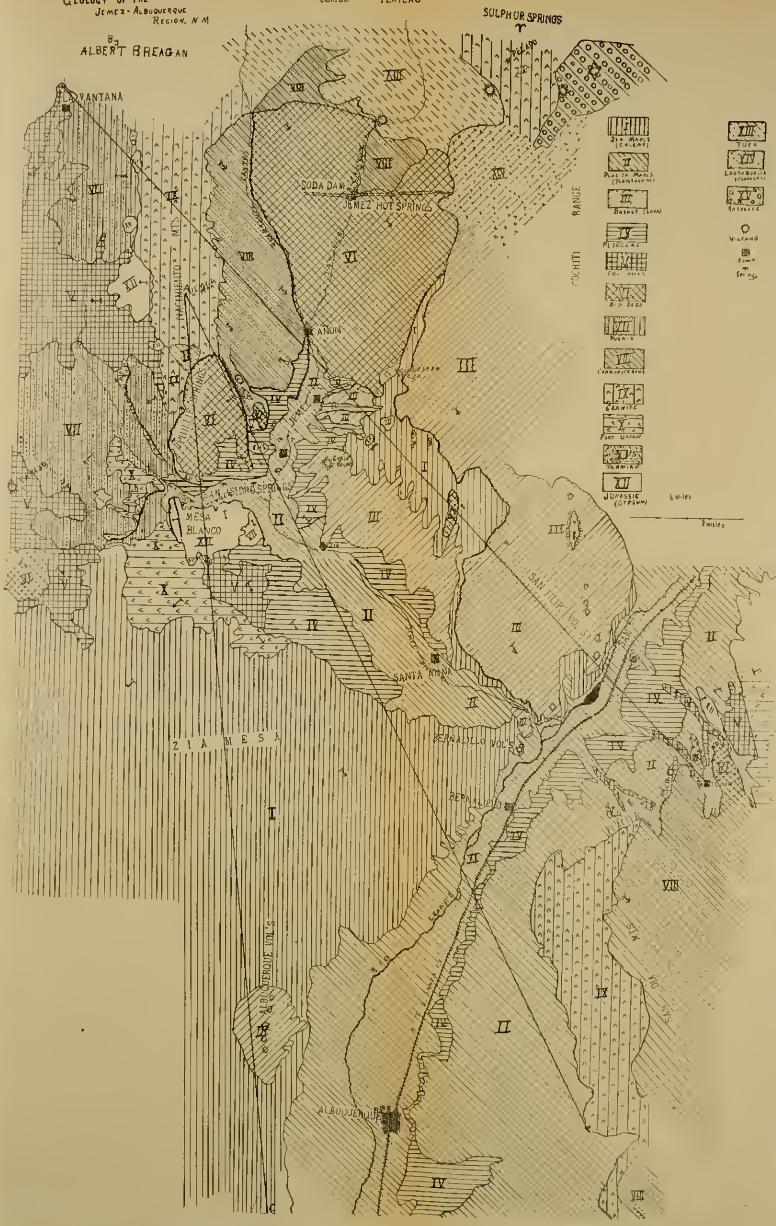
GENERAL SURVEY.

This section, as a whole, is one vast desert area, sparsely covered with grass, piñones, red cedar, sage brush and cactus, except in the valleys where there is sufficient water for irrigation. In these valleys corn, wheat, fruit and beans are raised by the natives and Mexicans. To consider the entire area again, it presents two basin-shaped districts, the Rio Puerco and the Rio Grande, with the strata in each respective basin dipping in general toward its center. The separating line at the north between these basins is the Nacimiento Mountains, the west wing of the Jemez uplift. It is continued at the south in a line of hills which decrease in altitude as they recede from the main range. The two basins merge into one below Albuquerque. The whole area is faulted and much broken and high escarpments often still mark the fault lines. Examples of such escarpments are the San Dia Mountains, Mesa Blanco, and one on each side of the Red Beds just south of the Jemez range. There is also evidence that the Nacimiento Mountains were, originally, the result of a drop on their western side. The resulting escarpment has been worn down and subsequently covered in part by sedimentations that it is not so strong in relief as the San Dia escarpment; the Carboniferous strata which flank this range on the east are entirely wanting to the west of these mountains. Mesa Blanco was left an escarpment by a drop on its northern side of more than 1,600 feet, 1,000 feet of which still remain. The escarpment to the east of the Red Bed mesa is now 900 feet in height and the escarpment to the west of the same mesa is 1,200 feet. On its western margin the strata of this mesa dip toward the east at a great angle, and at a greater angle toward the west on its eastern side. The whole country, as is indicated above, is extremely broken up; the rivers in their process of base-leveling have chiseled their channels deep into the rock. Great dikes and numerous volcanoes puncture the strata; and lava-flows cover hundreds of square miles of its surface. The dip of the whole region, when a dip is noticeable, is usually away from the mountains at an angle ranging from 15° to 90.° In many places the region is a bad land country. Where the lava is superimposed on it, it is of the "mal pais" type; and where the lava is wanting, especially along the break-lines, "mauvaises terres." The culminating points of the area under consideration are, the crest of the San Dia Mountains, the monolith Mt. Cabizon on the Rio Puerco and Mt. Pelado, the culminating point of the Jemez Mountains.

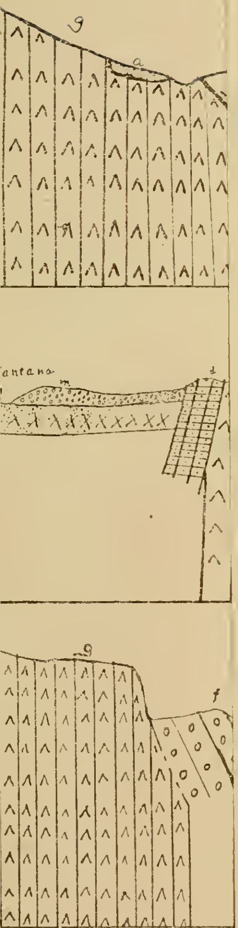
NATURE OF ROCKS.

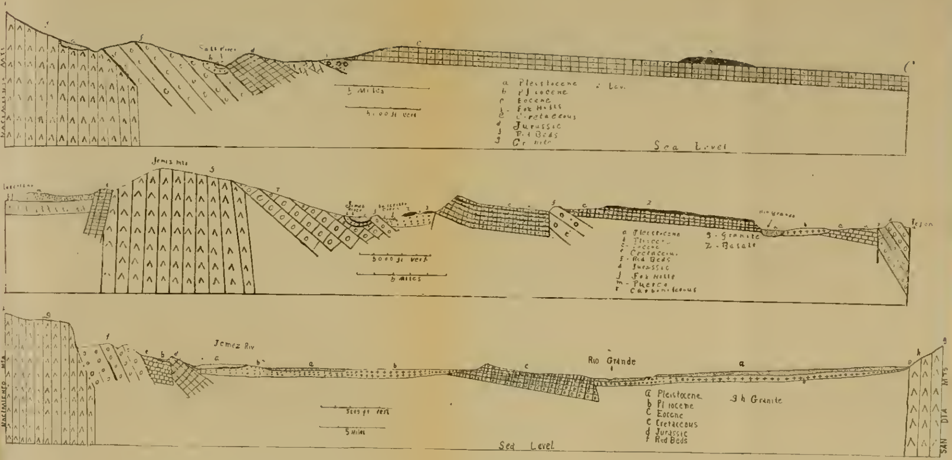
The rocks of this region are intrusive, eruptive and sedimentary.

The intrusive rocks are the cores of the respective mountain districts of Jemez and San Dia, and the dikes throughout the entire area. They are granites, porphyries, gneisses, etc. The eruptive rocks are volcanic



GEOLOGY OF THE JEMEZ-ALBUQUERQUE REGION, N.M.
By ALBERT B. REAGAN
JEMEZ PLATEAU
SULPHUR SPRINGS
VENTANA
SODA DAM
JEMEZ HOT SPRINGS
NACIMIENTO MTS
CAÑON
COCHITI RANGE
SAN ISIDRO SPRINGS
MESA BLANCO
SANTA ANNA
ZIA MESA
BERNALILLO VOL'S
BERNALILLO
SAN FILIPE VOL'S
ALBUQUERQUE VOL'S
ALBUQUERQUE
RIO GRANDE
SANDIA MTS
Zia Marls (Eocene)
Placio Marls (Pleistocene)
Basalt flows
Pliocene
Red Beds
Pueblo
Carboniferous
Granite
Fort Union
Jurassic (Gypsum)
Tufa
Labradorite
Volcano
Pueblo
Springs
3 miles


g
a
antana
m
g
f



a Pleistocene
b Pliocene
c Eocene
Fox Hills
Cretaceous
Jurassic
Sea Level
Jemez Mts
Red Beds
Jurassic
Fox Hills
Puerco
Carboniferous
9 - Granite
Z - Basalt
Jemez Riv
Rio Grande
a Pleistocene
b Pliocene
C Eocene
C Cretaceous
d Jurassic
f Red Beds
9 h Granite
5 Miles
Sea Level
SAN DIA MTS

plugs, lavas and tuffs. The lavas are basalt, trachyte and rhyolite. Obsidian also occurs in large quantities on the Jemez Plateau. The sedimentary deposits are the country rocks of nearly the entire region where not covered with lava. They were laid down in the seas and lakes that surrounded the islands which now form the high mountains of San Dia and Jemez. These deposits date back well into the Carboniferous, and continue almost without break to the recent times.

RIVERS.

The rivers of the region are the Rio Puerco, the Jemez and the Rio Grande. The Rio Puerco, as we have seen, closes in on the west the region discussed in this paper; the Jemez River and its tributaries drain the south and also the southwest slopes of the Jemez Mountains; and the Rio Grande passes south through the section east of the Jemez Mountains, and west of the San Dias. The Rio Puerco and the Jemez rivers are tributaries of the Rio Grande.

MOUNTAINS.

The mountains, as has been stated, are the San Dia and Jemez. The former was caused by a fault of 11,000 feet along their western side, 7,000

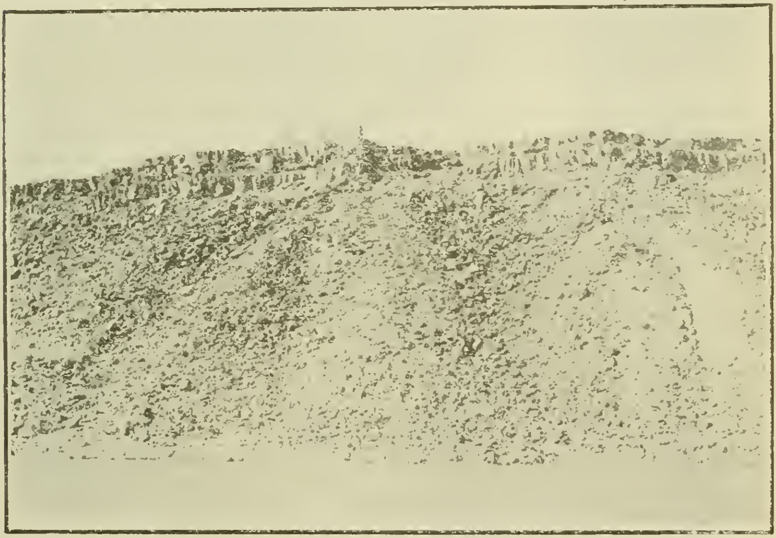
Little Pigmy Volcano.

feet of which still remain, as an escarpment. Their core is granite, their cap Carboniferous. The latter (the Jemez Mountains) have a core of red granite, overlaid in most cases, with hundreds of feet of volcanic debris, except along the west wing of the group where the crest is granite.

STRATIGRAPHY.

At the close of Carboniferous times or earlier, the Jemez Mountains were uplifted, and associated with their development are to be found large intrusions of granites and porphyries occupying an axial position. During the period of mountain building the western flank of the Jemez was faulted off. These mountains were subsequently surrounded by a shallow Jurassic sea, in which were deposited red sandstones and shales to a thickness of 2,600 feet. Then came the Jurassic revolution. The mountains were re-elevated and the Jurassic strata to the west of the mountains were faulted and tilted to a nearly vertical position. At this time the volcanoes near Pelado became active, and poured out the great rhyolitic sheet which now on the plateau covers the granite porphyritic core of the Jemez range, over which these same volcanoes, at a later time,

hurled out 120 feet of pumiceous tuff. These mountains were still islands in Cretaceous times, but their area then was much greater than formerly. In this period the mountains seem to have been gradually rising until in the Fort Union epoch great swamps covered the entire country, the sea being obliterated for a time. In these swamps vegetation was luxuriant, and the vegetable matter laid down in them forms today the coal fields of northwestern New Mexico. At the close of the Fort Union epoch, there was a slow subsidence. The Puerco was deposited on the Fort Union, and then the Eocene on that, the whole series being conformable. Then



there came a violent change. The whole country was elevated above the sea, much faulted and broken up, and blocked basins on a grand scale resulted. These depressions were the lakes of Pliocene times. One large lake existed in the vicinity of Jemez, and another in the Rio Grand Valley. The lake at Jemez was filled up with the Jemez marls by the tributaries of the Jemez River; and the Rio Grande Lake was silted up with the Albuquerque marls, probably by the tributaries of the river which at present occupies that valley. When these lakes were almost filled, there was a further re-elevation of the country, and the rivers at once commenced to cut down their respective channels; but this deepening of their


G.B.H.

channels was suddenly arrested by the seismic disturbances and the lava flows of Post-Tertiary times. The former changed the incline of the river channels, and the latter dammed up the rivers, thus forming lakes. In these lakes were deposited the Pleistocene marls of the river valleys. At the close of the Pleistocene, these lakes in turn were obliterated and the country took on the general appearance that it has today.

ECONOMICS.

CLIMATE.

The altitude of this region, 5,000 to 9,000 feet above the sea, and the latitude thirty-five to thirty-six degrees north, combine to give it a climate which for mildness and equality has no superior in the world. Its location, near the center of the vast rainless region of the West, and its remoteness from any large body of water, give it an atmosphere almost totally devoid of moisture. At the same time, by reason of the latitude and altitude, the air is both warm and light, thus furnishing, in unlimited quantities, nature's sovereign remedy for all diseases of the lungs.

Soil.—The soil on the table lands, especially on the Tertiary formations, is poor. There is too much alkali. But if the water for irrigating purposes could be had, even the soil of these mesas, in a few years, could be made productive. It would require considerable labor and the use of fertilizers such as gypsum, burned lime, etc., but in the end it would pay.

On the mountain plateaus the soil is good, especially in the Jemez Mountains in the Valle Grande country. This great valley, to interpret the Mexican, occupies a high altitude, averaging 9,000 feet. "It embraces 100,000 acres, and forms fine prairies with abundant grasses. On it also the fir and pine are most magnificently developed."

In the valleys the soil is, without exception, the best in the world. It surpasses even the soil of the Nile Valley. In speaking of the Rio Grande mud, Dr. Loew, in the U. S. Geological Surveys of the Territories west of the 100th meridian (Vol. III., p. 578-582) says:

"Irrigation with these mud-carrying waters furnishes the lands with a layer of the best virgin soil in a finely pulverized condition, and the belief of the farmer that the Rio Grande water is an efficacious fertilizing agent is fully warranted by the facts revealed by the chemical analysis.

Indian Village of Jemetz, Jemez Valley. Tertiary Buttes. Nacimiento Mountains.

Indian Village of San Felipee. Rio Grande and San Dia Mountains.

Indeed the inhabitants of the Rio Grande will never require any other fertilizer than the waters of the Rio Grande Del Norte."

MINERAL RESOURCES.

Coal.—The Fort Union coal formation underlies most all the lands in this region, except the mountain districts. Its coal outcrops are quite a distance from the railroad and until just recently only Mexicans and Indians knew of its occurrence. The coal is a good quality and the seams are thick. It is reasonable to believe that the time is not far distant when coal will be mined there on a large scale.

Gypsum.—The Jurassic rocks, wherever found, are capped with gypsum from ten to forty feet in thickness. Owing to its thickness and its lack of

Picture showing Tufa near Jemez Hot Springs.

cover, it can be worked to a great advantage. With railroad facilities a great industry will be developed, for the raw material is of good quality.

Gold, Silver and Copper.—The mountains are crossed in all directions by mineral bearing veins; but to date the ores found are too low in grade to ship, the railroad being too far away, and they are not enough in quantity to pay to put a smelter on the ground to smelt them. Should a railroad be put up Jemez Valley, mining would at once become a paying business. Besides the ore in veins, placer gold is found in the Pleistocene deposits, but water for hydraulic mining is wanting. Could the necessary water be obtained, this region would without doubt become one of the leading placer mining districts of the west.

Medicinal Springs.—The springs of the region are numerous, most all are hot, and all possess medicinal properties. Among them are the famous Jemez Hot Springs, and the Sulphurs. These springs surpass those of Minnesota and California. They are visited by people from every part of the United States, and foreigners not infrequently visit them.

This region, with its building stone, with its gypsum, with its forests, with its medicinal springs, with its gold and silver veins and coal fields, and with its fertile soil and unequaled climate, is one of the best regions in New Mexico; and under proper handling, will become one of the wealth-producing regions of the country.

The Jemez Coal Fields.

Albert B. Reagan.

The Jemez coal fields are situated about twenty-five miles west of Bernalillo, thirty miles a little to the west of north of Albuquerque, and six miles south of the Jemez River at San Isidro in longitude 106° 50′ west, and in latitude 35° 30′ north. They cover an area of about twenty square miles.

The strata of this field show a predominance of soft yellow sandstones interbedded with clays and sandy shales. Interbedded with these are strata of brown coal which are freely exposed in the perpendicular walls of the mesas. These coal seams vary from two to twelve feet in thickness; and, along one fault in this respective coal area, seventy feet of coal are exposed at one view. In examining these coal fields, it was observed that in many instances the strata had been destroyed by fire; and the coal being burned out, the roofs had caved in by a succession of faulting, or had collapsed under the pressure. That the destroying agent was fire is attested not only by the clay accompanying the seams being turned to brick, but also by heaps of slag composed of silicates of iron and aluminum. This coal is bitumenous and Fort Union, or Laramie. It is very brittle, somewhat laminated, dull luster.

These coal fields are quite a distance from the railroad, and until just recently only Mexicans and Indians knew of the coal outcrops there. This coal is a good quality and the seams, as we have seen, are thick. The time, no doubt, is not far distant when coal will be mined there on a large scale the same as at Gallop at the western limit of the same coal horizon.

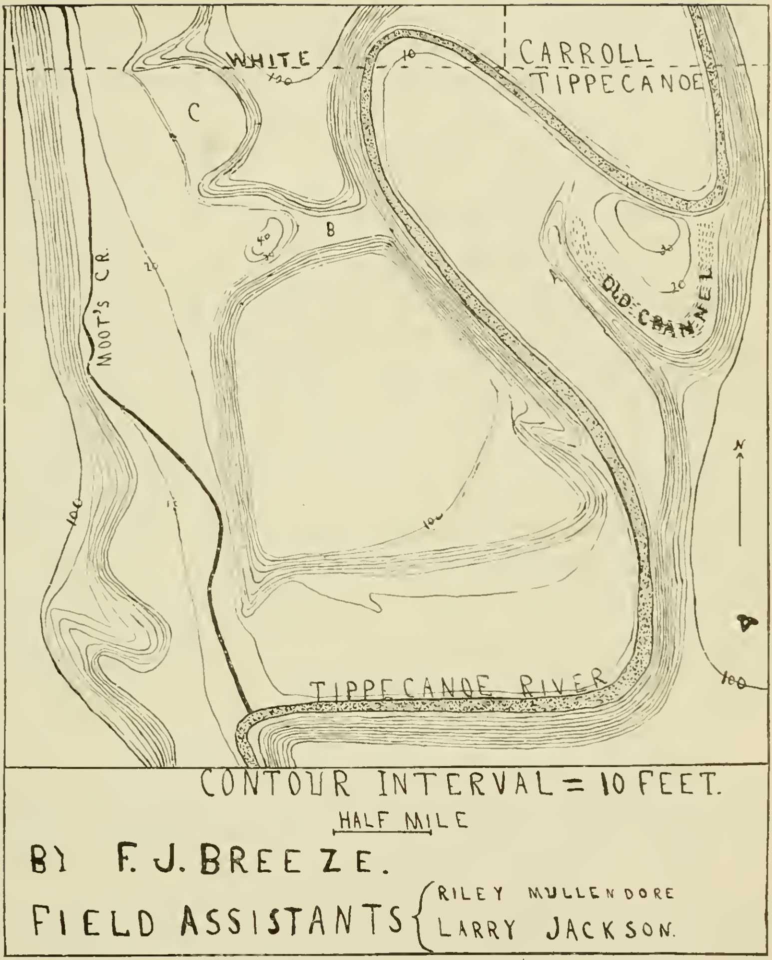
Some Topographic Features in the Lower Tippecanoe Valley.

Fred J. Breeze.

In the valley of the Tippecanoe about a mile below the Carroll--Tippecanoe line are two features of relief which perhaps deserve some attention.

On the east side of the river is a long, narrow ridge of gravelly material, about twenty-five feet high, a few yards wide, and three-fourths of a mile long. (See A on map.) It starts from a hundred foot bluff, and in a short distance slopes down to an elevation of twenty-five feet, and for the remaining distance is nearly level. On the up-river side of the ridge is an abandoned channel of comparative recency. This ridge is evidently a remnant of a large spur of upland which was gradually made narrower by the southward movement of a river bend, of which the present abandoned channel marks the southern limit. Before the spur had been entirely removed, the river straightened its course, thus forsaking the bend; and the remnant of the upland spur is this narrow ridge.

Just west of the ridge, on the other side of the river, is a gap joining the valley of the Tippecanoe with that of Moot's Creek, a tributary which empties about a mile below. (See B on map.) The floor of this gap is forty feet above the river, is nearly 200 yards wide, and is bounded on the north and south by bluffs sixty feet high. At first sight it seems that this gap was formerly the mouth of Moot's Creek; but investigation justifies



another explanation. For two or three miles above its mouth, Moot's Creek flows in a valley roughly parallel with that of the Tippecanoe. At many places the creek valley widens into crescentic hollows which are separated from each other by sharp-pointed, narrow ridges. The floors of these semi-circular areas are about twenty feet higher than the present flood-plain. One of these areas is marked C. Doubtless the gap B was one of the widened portions of the valley, and only a very narrow strip of upland separated it from the Tippecanoe Valley. Later, after Moot's Creek had swung to the west side of its valley, the Tippecanoe by its westward meander removed the dividing strip, thus forming the present gap.

The Action of Hydrogen Peroxide on Cuprous Chloride.

W. M. Blanchard.

This investigation was suggested by the results obtained in the study of the action of large volumes of water on cuprous chloride. Some time ago my attention was called to the fact that when a large volume of water is added to cuprous chloride the salt becomes orange colored. If this water is removed and a second quantity added the color of the salt deepens, and if this operation is carried on long enough, a few days being sufficient if the water is changed every few hours, the salt finally becomes a bright red and in all respects resembles cuprous oxide. Upon analysis the compound proved to be almost pure cuprous oxide.

A search through the literature at command was made but no such action as this was found recorded. A careful study of the reaction was then made. It was at first believed that the reaction took place according to this equation:

$$Cu_2Cl_2 + H_2O = Cu_2O + 2\ HCl.$$

It seemed that the first water added resulted in the conversion of a part of the cuprous chloride into cuprous oxide and hydrocloric acid and that no further change took place until this acid was removed, and more water added. But further investigation showed that this was not correct. The water removed was found to contain cupric chloride; this salt could be produced in this case only by oxidation, and the oxidation could result in all probability only from oxygen dissolved·in the water.

By properly constructed apparatus it was shown that water which had been previously boiled for an hour and cooled in a current of hydrogen produced no change on cuprous chloride.

About this time I had access to Dammer's Handbook of Inorganic Chemistry and there I found a reference to this very reaction. It was expressed by the following equation:

$$2\ Cu_2Cl_2 + O = Cu_2O + 2\,CuCl_2.$$

A further study of the reaction proved this to be correct. The reaction, however, is not complete, for only about 97 per cent. of the cuprous chloride is changed, even when the process is carried on for several months and the compound shaken repeatedly with water in a stoppered bottle.

Since these results are produced by dissolved oxygen it seemed that the reaction might be hastened by running a current of oxygen into the water containing cuprous chloride in suspension, since in this case the oxygen could be replenished as fast as used up. The experiment was carried out, but instead of getting a red product, a blue one was obtained. This is probably the basic chloride described by Mallet[1] as formed when a current of moist air is passed over hot cuprous chloride.

This unexpected result led to a study of the action of hydrogen peroxide on cuprous chloride. The investigation is not complete; the results obtained up to date are as follows:

When hydrogen peroxide is added to cuprous chloride, the color of the salt immediately becomes a dirty green, and upon the addition of more peroxide, finally becomes a delicate blue. The compound appears very flocculent. If the reaction is carried out in a bottle or flask connected with a burette, a considerable amount of oxygen can be collected. The volume of oxygen evolved does not seem to bear any direct ratio to the amount of cuprous chloride used. If the reaction is carried out at 100° instead of at ordinary temperature, the reaction seems to be the same except that the evolution of the oxygen is much more rapid. The compound is evidently a basic chloride. It is insoluble in water, does not change in boiling with water, does not materially diminish in weight or change in color until heated to 250,° and is easily soluble in dilute acids and in ammonia. There is some evidence in favor of the following reaction:

$$3\,Cu_2Cl_2 + 6\,H_2O = 2\,Cu_2ClO.OH + 2\,CuCl_2 + 5\,H_2O + 3\,O$$

The reaction probably taking place in two stages. The blue compound would seem to have the composition:

$$\begin{matrix} Cu < OH \\ \quad\; O . 3\,H_2O \\ Cu < Cl \end{matrix}$$

A curious fact was observed in connection with this study which seems to be true of other complex copper ions. If this blue compound is dissolved in ammonia and hydrogen peroxide added, a violent reaction takes

[1] Comp. rend. 62. 249.

place, accompanied by a rapid evolution of oxygen. The compound itself does not produce such a change, neither does ammonia, but only the solution of the one in the other. It was found that copper sulphate dissolved in ammonia will behave in the same manner.

Ripple Marks in Hudson Limestone of Jefferson County, Indiana.

Glenn Culbertson.

In the proceedings of the Indiana Academy of Science for 1901, and in a paper entitled: Concerning Well Defined Ripple Marks in Hudson River Limestone, Richmond, Indiana, Prof. Joseph Moore and Allen D. Hole describe Hudson limestone ripple marks near Richmond, Indiana.

In this paper I desire to give briefly the location and some points of description of similar markings in the Hudson limestone of Jefferson County, Indiana. In this county, to my knowledge, Hudson limestone ripple marks occur in five widely separated localities and at six different horizons. In all essential points the accurate and full description of the ripple marks at Richmond may be applied to those mentioned in this paper.

The geographical positions of the Jefferson County markings will be given in the order of their geological horizons, the Clinton limestone being used as a basis for measurements. Following this a few of the principal points of interest touching the ripple marks will be included.

The Wolf Run ripple marks are found at the roadside and in the creek bottom within 200 yards of the end of the Ryker's Ridge pike on Wolf Run in Madison Township. In this place there are two quite distinct series of markings. The upper is in a stratum approximately seventy feet below the Clinton outcropping on the neighboring slope. The lower is in a stratum some six or eight inches below the first. The upper series of marks are exposed over a space some 35x8 feet, while the lower is exposed over a surface of some three or four square yards. The trend of the crests of the upper marks is N. 70° E., and of the lower N. 50° E., approximately. I say approximately since there are many small irregularities in the trend of the crests. These crests are, however, essentially parallel. The stone in which all the markings spoken of in this paper occur is the blue, abundantly fossiliferous limestone, so characteristic of the lower and middle Hudson formation in the region of the Cincinnati geanticline. The fossils found in the various ripple marked limestones vary with the horizon in which they occur.

The thickness of the stratum containing the upper Wolf Run marks is from two to three inches, while that of the lower is from one and a half to two inches. The distance from crest to crest or wave length is in the upper series twenty-one inches, and in the lower eighteen inches, approximately. The depth of trough in the upper is one and a half inches, and in the lower one to one and a half inches.

The Clifty Creek series of markings occur in the bed of that stream at a point about one and one-fourth miles above the bridge on the Madison and Hanover pike. The ripple marks are exposed in this place at intervals for a distance of 200 yards. The trend of the crests here is N. 10°-15° E., quite a little irregularity being noticed. The distance from crest to crest is from thirty to thirty-six inches, and the depth of trough three inches. The thickness of stratum five to seven inches, and the approximate vertical distance below the Clinton limestone, 190 feet.

In the bed of the West Fork of Indian Kentucky Creek, one-third of a mile above Manville, a series of ripple marks are found extending some seventy-five yards where the stratum is unbroken. This series I shall call the Van Buren, since they are found but a short distance from the house of John Van Buren. The trend of crests here is N. 40° E.; wave length, thirty inches; depth of trough one and a half to two and a half inches; thickness of stratum, two to three and a half inches. The approximate vertical distance below the Clinton limestone is 342 feet.

In the creek bed, beneath the bridge across the east fork of Indian Kentucky Creek, and within 200 yards of Manville postoffice, a ripple marked layer of limestone from four to six inches thick is exposed at intervals for a distance of 130 yards. At low water the marks are here exposed over a space of 150x25 feet and as many as sixty consecutive crests may be counted. The trend here is approximately N. 10° E., the wave length thirty inches, the depth of trough two and a half inches, the vertical distance below the Clinton formation 350 feet. At this place the wide exposure, amounting at times to 300 or more square yards, affords an excellent opportunity for the study of the relations which the marks bear to each other. It is observed that, while the crests are not straight, but more or less curving in their outline, they are essentially parallel.

On Doe Run, about two miles from Brooksburg, a ripple marked limestone is exposed in the creek bed, over a space of a few square yards. The trend of crests here is approximately N. 45° E.; wave length, thirty-three to thirty-six inches; depth of trough, three inches; thickness of limestone, three to five inches. The vertical distance of this series of marks below the Clinton formation could not be determined so readily as in the other cases, since the outcropping Clinton is not found within a distance of several miles. An approximate vertical distance of 380 feet below Clinton was reckoned on the basis of an observed westerly dip of ten feet to the mile of the Clinton formation in other parts of the county.

The main facts in regard to these ripple marks are placed in tabular form below.

These Hudson limestone ripple marks are exceptional in that ripple marks are unusual in limestone, being found in sandstones and shales chiefly. They are exceptional also in the fact that they are of such large size. A few inches usually measures the distance from crest to crest of ripple marks. Since a ripple is a small wave, these limestone markings might well be called wave marks, were that term not preoccupied. These ripple marks indicate essentially seashore conditions during the period occupied in depositing some 300 feet of Hudson rocks and that the conditions finally resulting in the Cincinnati Geanticline or uplift at the close of the Ordovician, had long been present. The trend of these marks from N. 10° E. to N. 75° E., goes far towards indicating prevailing winds from the northwest or the southeast during that part of paleozoic time represented in the deposition of these rocks.

Location.	Trend.	Distance from Crest to Crest.	Depth of Trough.	Vertical Distance below Clinton Limestone.	Thickness of Limestone Stratum.
Upper Wolf Run Series	N., 75° E.	21 in.	1½ in.	70 ft.	2–3 in.
Lower Wolf Run Series	N., 50° E.	18 in.	1–1½ in.	70 ft. 8 in.	1½–2½ in.
Clifty Creek Series..............	N., 10°–15° E.	30–36 in.	2–3 in.	190 ft.	5–7 in.
Van Buren Series	N., 40° E.	30–36 in.	1½–2½ in.	340 ft.	2–3½ in.
Manville Bridge Series..........	N., 10° E.	30 in.	2½–3 in.	352 ft.	4–6 in.
Doe Run Series	N., 45° E.	33–36 in.	3 in.	375 ft.	3–5 in.

INDEX, 1902.

PROCEEDINGS OF THE

Indiana Academy of Science

1903

PROCEEDINGS

OF THE

Indiana Academy of Science

1903.

EDITOR, - - WILLIAM J. KARSLAKE.

ASSOCIATE EDITORS:

AMOS BUTLER, W. S. BLATCHLEY,
C. H. EIGENMANN, P. N. EVANS,
DONALDSON BODINE, THOMAS GRAY,
JOHN S. WRIGHT.

INDIANAPOLIS, IND.
1904.

INDIANAPOLIS:
WM. B. BURFORD, PRINTER.
1904.

TABLE OF CONTENTS.

AN ACT TO PROVIDE FOR THE PUBLICATION OF THE REPORTS AND PAPERS OF THE INDIANA ACADEMY OF SCIENCE.

[Approved March 11, 1895.]

Preamble.

WHEREAS, The Indiana Academy of Science, a chartered scientific association, has embodied in its constitution a provision that it will, upon the request of the Governor, or of the several departments of the State government, through the Governor, and through its council as an advisory body, assist in the direction and execution of any investigation within its province, without pecuniary gain to the Academy, provided only that the necessary expenses of such investigation are borne by the State; and,

WHEREAS, The reports of the meetings of said Academy, with the several papers read before it, have very great educational, industrial and economic value, and should be preserved in permanent form; and

WHEREAS, The Constitution of the State makes it the duty of the General Assembly to encourage by all suitable means intellectual, scientific and agricultural improvement; therefore,

Publication of the Reports of the Indiana Academy of Science.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That hereafter the annual reports of the meetings of the Indiana Academy of Science, beginning with the report for the year 1894, including all papers of scientific or economic value, presented at such meetings, after they shall have been edited and prepared for publication as hereinafter provided, shall be published by and under the direction of the Commissioners of Public Printing and Binding.

Editing Reports.

SEC. 2. Said reports shall be edited and prepared for publication without expense to the State, by a corps of editors to be selected and appointed by the Indiana Academy of Science, who shall not, by reason of such services, have any claim against the State for compensation. The form, style of binding, paper, typography and manner and extent of illustration of such reports, shall be determined by the editors, subject to the approval of the Commissioners of Public Printing and Stationery. Not less than 1,500 nor more than 3,000 copies of each

Number of printed Reports.

of said reports shall be published, the size of the edition within said limits to be determined by the concurrent action of the editors and the Commissioners of Public Printing and Stationery: *Provided*, That not to exceed six hundred dollars ($600) shall be expended for such publication in any one year, and not to extend beyond 1896: *Provided*, That no sums shall be deemed to be appropriated for the year 1894.

Proviso.

Disposition of Reports.

SEC. 3. All except three hundred copies of each volume of said reports shall be placed in the custody of the State Librarian, who shall furnish one copy thereof to each public library in the State, one copy to each university, college or normal school in the State, one copy to each high school in the State having a library, which shall make application therefor, and one copy to such other institutions, societies or persons as may be designated by the Academy through its editors or its council. The remaining three hundred copies shall be turned over to the Academy to be disposed of as it may determine. In order to provide for the preservation of the same it shall be the duty of the Custodian of the State House to provide and place at the disposal of the Academy one of the unoccupied rooms of the State House, to be designated as the office of the Indiana Academy of Science, wherein said copies of said reports belonging to the Academy, together with the original manuscripts, drawings, etc., thereof can be safely kept, and he shall also equip the same with the necessary shelving and furniture.

Emergency.

SEC. 4. An emergency is hereby declared to exist for the immediate taking effect of this act, and it shall therefore take effect and be in force from and after its passage.

AN ACT FOR THE PROTECTION OF BIRDS, THEIR NESTS AND EGGS.

[Approved March 5, 1891.]

Birds.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana,* That it shall be unlawful for any person to kill any wild bird other than a game bird, or purchase, offer for sale any such wild bird after it has been killed, or to destroy the nests or the eggs of any wild bird.

Game Birds.

SEC. 2. For the purpose of this act the following shall be considered game birds: the Anatidæ, commonly called swans, geese, brant, and river and sea ducks; the Rallidæ, commonly known as rails, coots, mudhens, and gallinules; the Limicolæ, commonly known as shore birds, plovers, surf birds, snipe, woodcock and sandpipers, tattlers and curlews; the Gallinæ, commonly known as wild turkeys, grouse, prairie chickens, quail, and pheasants, all of which are not intended to be affected by this act.

Penalty.

SEC. 3. Any person violating the provisions of Section 1 of this act shall, upon conviction, be fined in a sum not less than ten nor more than fifty dollars, to which may be added imprisonment for not less than five days nor more than thirty days.

Permits.

SEC. 4. Sections 1 and 2 of this act shall not apply to any person holding a permit giving the right to take birds or their nests and eggs for scientific purposes, as provided in Section 5 of this act.

Permits to Science.

SEC. 5. Permits may be granted by the Executive Board of the Indiana Academy of Science to any properly accredited person, permitting the holder thereof to collect birds, their nests or eggs for strictly scientific purposes. In order to obtain such permit the applicant for the same must present to said Board written testimonials from two well-known scientific men certifying to the good character and fitness of said applicant to be entrusted with such privilege, and pay to said Board one dollar to defray the necessary expenses attending the granting of such permit, and must file with said Board a properly executed bond in the sum of two hundred dollars, signed by at least two responsible citizens of the State as sureties. The bond shall be forfeited to the State and the permit become void upon proof that the holder of

Bond.

Bond forfeited.

such permit has killed any bird or taken the nests or eggs of any bird for any other purpose than that named in this section, and shall further be subject for each offense to the penalties provided in this act.

Two years. SEC. 6. The permits authorized by this act shall be in force for two years only from the date of their issue, and shall not be transferable.

Birds of prey. SEC. 7. The English or European House Sparrow (Passer domesticus), crows, hawks, and other birds of prey are not included among the birds protected by this act.

Acts repealed. SEC. 8. All acts or parts of acts heretofore passed in conflict with the provisions of this act are hereby repealed.

Emergency. SEC. 9. An emergency is declared to exist for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

OFFICERS—1903-1904.

PRESIDENT,
CARL L. MEES.

VICE-PRESIDENT,
GLENN CULBERTSON.

SECRETARY,
JOHN S. WRIGHT.

ASSISTANT SECRETARY,
J. H. RANSOM.

PRESS SECRETARY,
G. A. ABBOTT.

TREASURER,
WILLIAM A. McBETH.

EXECUTIVE COMMITTEE.

Carl L. Mees,
Glenn Culbertson,
John S. Wright,
J. H. Ransom,
G. A. Abbott,
William A. McBeth,
Willis S. Blatchley,
Harvey W. Wiley,
M. B. Thomas,
D. W. Dennis,
C. H. Eigenmann,
C. A. Waldo,
Thomas Gray,
Stanley Coulter,
Amos W. Butler,
W. A. Noyes,
J. C. Arthur,
J. L. Campbell,
O. P. Hay,
T. C. Mendenhall,
John C. Branner,
J. P. D. John,
John M. Coulter,
David S. Jordan.

CURATORS.

BOTANY .... J. C. Arthur.
ICHTHYOLOGY .... C. H. Eigenmann.
HERPETOLOGY, MAMMALOGY, ORNITHOLOGY .... Amos W. Butler.
ENTOMOLOGY .... W. S. Blatchley.

COMMITTEES, 1903-1904.

PROGRAM.

G. W. Benton, John S. Wright, Katherine Golden.

MEMBERSHIP.

Stanley Coulter, G. A. Abbott, A. L. Foley.

NOMINATIONS.

Donaldson Bodine, Robert Hessler, W. J. Moenkhaus.

AUDITING.

Mel. T. Cook, Wm. J. Karslake.

STATE LIBRARY.

Stanley Coulter, A. J. Bigney, O. L. Kelso.

LEGISLATION FOR THE RESTRICTION OF WEEDS.

M. B. Thomas, D. M. Mottier, C. C. Deam.

PROPAGATION AND PROTECTION OF GAME AND FISH.

C. H. Eigenmann, A. W. Butler, Glenn Culbertson.

EDITOR.

W. J. Karslake, Butler College, Indianapolis.

Address all communications to the Editor to 5780 Oak Ave., Indianapolis.

DIRECTORS OF BIOLOGICAL SURVEY.

C. H. Eigenmann, Stanley Coulter, Charles R. Dryer, M. B. Thomas, Mel. T. Cook.

RELATIONS OF THE ACADEMY TO THE STATE.

C. A. Waldo, William Watson Woollen, R. W. McBride.

GRANTING PERMITS FOR COLLECTING BIRDS AND FISHES.

A. W. Butler, D. W. Dennis, W. J. Moenkhaus.

DISTRIBUTION OF THE PROCEEDINGS.

Thomas Gray, Donaldson Bodine, L. J. Rettger, H. L. Bruner, John S. Wright, W. J. Karslake.

OFFICERS OF THE INDIANA ACADEMY OF SCIENCE.

	President.	Secretary.	Asst. Secretary.	Press Secretary.	Treasurer.
1885–6	David S. Jordan	Amos W. Butler			O. P. Jenkins.
1886–7	John M. Coulter	Amos W. Butler			O. P. Jenkins.
1887–8	J. P. D. John	Amos W. Butler			O. P. Jenkins.
1888–9	John C. Branner	Amos W. Butler			O. P. Jenkins.
1889–90	T. C. Mendenhall	Amos W. Butler			O. P. Jenkins.
1890–1	O. P. Hay	Amos W. Butler			O. P. Jenkins.
1891–2	J. L. Campbell	Amos W. Butler			C. A. Waldo.
1892–3	J. C. Arthur	Amos W. Butler	Stanley Coulter W. W. Norman		C. A. Waldo.
1893–4	W. A. Noyes	C. A. Waldo	W. W. Norman		W. P. Shannon.
1894–5	A. W. Butler	John S. Wright	A. J. Bigney		W. P. Shannon.
1895–6	Stanley Coulter	John S. Wright	A. J. Bigney		W. P. Shannon.
1896–7	Thomas Gray	John S. Wright	A. J. Bigney		W. P. Shannon.
1897–8	C. A. Waldo	John S. Wright	A. J. Bigney	Geo. W. Benton	J. T. Scovell.
1898–9	C. H. Eigenmann	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1899–1900	D. W. Dennis	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1900–1901	M. B. Thomas	John S. Wright	E. A. Schultze	Geo. W. Benton	J. T. Scovell.
1901–1902	Harvey W. Wiley	John S. Wright	Donaldson Bodine	Geo. W. Benton	J. T. Scovell.
1902–1903	W. S. Blatchley	John S. Wright	Donaldson Bodine	G. A. Abbott	W. A. McBeth.
1903–1904	C. L. Mees	John S. Wright	J. H. Ransom	G. A. Abbott	W. A. McBeth.

CONSTITUTION.

ARTICLE I.

SECTION 1. This association shall be called the Indiana Academy of Science.

SEC. 2. The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science; to promote intercourse between men engaged in scientific work, especially in Indiana; to assist by investigation and discussion in developing and making known the material, educational and other resources and riches of the State; to arrange and prepare for publication such reports of investigation and discussions as may further the aims and objects of the Academy as set forth in these articles.

Whereas, the State has undertaken the publication of such proceedings, the Academy will, upon request of the Governor, or of one of the several departments of the State, through the Governor, act through its council as an advisory body in the direction and execution of any investigation within its province as stated. The necessary expenses incurred in the prosecution of such investigation are to be borne by the State; no pecuniary gain is to come to the Academy for its advice or direction of such investigation.

The regular proceedings of the Academy as published by the State shall become a public document.

ARTICLE II.

SECTION 1. Members of this Academy shall be honorary fellows, fellows, non-resident members or active members.

SEC. 2. Any person engaged in any department of scientific work, or in original research in any department of science, shall be eligible to active membership. Active members may be annual or life members. Annual members may be elected at any meeting of the Academy; they shall sign the constitution, pay an admission fee of two dollars, and thereafter an annual fee of one dollar. Any person who shall at one time contribute fifty dollars to the funds of this Academy, may be elected a life member of the Academy, free of assessment. Non-resident members may be elected from those who have been active members but who have removed from the State. In any case, a three-fourths vote of the members present shall elect to membership. Applications for membership in any of the foregoing classes shall be referred to a committee on application for membership, who shall consider such application and report to the Academy before the election.

SEC. 3. The members who are actively engaged in scientific work, who have recognized standing as scientific men, and who have been members of the Academy at least one year, may be recommended for nomination for election as fellows by three fellows or members personally acquainted with their work and character. Of members so nominated a number not exceeding five in one year may, on recommendation of the Executive Committee, be elected as fellows. At the meeting at which this is adopted, the members of the Executive Committee for 1894 and fifteen others shall be elected fellows, and those now honorary members shall become honorary fellows. Honorary fellows may be elected on account of special prominence in science, on the written recommendation of two members of the Academy. In any case a three-fourths vote of the members present shall elect.

ARTICLE III.

SECTION 1. The officers of this Academy shall be chosen by ballot at the annual meeting, and shall hold office one year. They shall consist of a President, Vice-President, Secretary, Assistant Secretary, Press Secretary, and Treasurer, who shall perform the duties usually pertaining to their respective offices and in addition, with the ex-Presidents of the Academy, shall constitute an Executive Committee. The President shall, at each annual meeting, appoint two members to be a committee which shall prepare the programs and have charge of the arrangements for all meetings for one year.

SEC. 2. The annual meeting of this Academy shall be held in the city of Indianapolis within the week following Christmas of each year, unless otherwise ordered by the Executive Committee. There shall also be a summer meeting at such time and place as may be decided upon by the Executive Committee. Other meetings may be called at the discretion of the Executive Committee. The past Presidents, together with the officers and Executive Committee, shall constitute the Council of the Academy, and represent it in the transaction of any necessary business not specially provided for in this constitution, in the interim between general meetings.

Sec. 3. This constitution may be altered or amended at any annual meeting by a three-fourths majority of the attending members of at least one year's standing. No question of amendment shall be decided on the day of its presentation.

BY-LAWS.

1. On motion, any special department of science shall be assigned to a curator, whose duty it shall be, with the assistance of the other members interested in the same department, to endeavor to advance knowledge in that particular department. Each curator shall report at such time and place as the Academy shall direct. These reports shall include a brief summary of the progress of the department during the year preceding the presentation of the report.

2. The President shall deliver a public address on the morning of one of the days of the meeting at the expiration of his term of office.

3. The Press Secretary shall attend to the securing of proper newspaper reports of the meetings and assist the Secretary.

4. No special meeting of the Academy shall be held without a notice of the same having been sent to the address of each member at least fifteen days before such meeting.

5. No bill against the Academy shall be paid without an order signed by the President and countersigned by the Secretary.

6. Members who shall allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

7. Ten members shall constitute a quorum for the transaction of business.

MEMBERS.

FELLOWS.

R. J. Aley	*1898	Bloomington.
J. C. Arthur	1893	Lafayette.
George W. Benton	1896	Indianapolis.
A. J. Bigney	1897	Moore's Hill.
A. W. Bitting	1897	West Lafayette.
Donaldson Bodine.	1899	Crawfordsville.
W. S. Blatchley	1893	Indianapolis.
H. L. Bruner	1899	Irvington.
Severance Burrage	1898	Lafayette.
A. W. Butler	1893	Indianapolis.
J. L. Campbell	1893	Crawfordsville.
Mel. T. Cook	1902	Newcastle.
John M. Coulter	1893	Chicago, Ill.
Stanley Coulter	1893	Lafayette.
Glenn Culbertson	1899	Hanover.
D. W. Dennis	1895	Richmond.
C. R. Dryer	1897	Terre Haute.
C. H. Eigenmann	1893	Bloomington.
Percy Norton Evans	1901	West Lafayette.
A. L. Foley	1897	Bloomington.
Katherine E. Golden	1895	Lafayette.
M. J. Golden	1899	Lafayette.
W. F. M. Goss	1893	Lafayette.
Thomas Gray	1893	Terre Haute.
A. S. Hathaway	1895	Terre Haute.
W. K. Hatt	1902	Lafayette.
Robert Hessler	1899	Logansport.
H. A. Huston	1893	Lafayette.
Arthur Kendrick	1898	Terre Haute.
Robert E. Lyons	1896	Bloomington.
V. F. Marsters	1893	Bloomington.
C. L. Mees	1894	Terre Haute.
W. J. Moenkhaus	1901	Bloomington.

*Date of election.

Joseph Moore	*1896	Richmond.
D. M. Mottier	1893	Bloomington.
J. P. Naylor	1903	Greencastle.
W. A. Noyes	1893	Terre Haute.
J. H. Ransom	1902	Lafayette.
L. J. Rettger	1896	Terre Haute.
J. T. Scovell	1894	Terre Haute.
Alex Smith	1893	Chicago, Ill.
W. E. Stone	1893	Lafayette.
Joseph Swain	1898	Swarthmore, Pa.
M. B. Thomas	1893	Crawfordsville.
C. A. Waldo	1893	Lafayette.
F. M. Webster	1894	Champaign, Ill.
H. W. Wiley	1895	Washington, D. C.
John S. Wright	1894	Indianapolis.

NON-RESIDENT MEMBERS.

George H. Ashley	Charleston, S. C.
M. A Brannon	Grand Forks, N. D.
J. C. Branner	Stanford University, Cal.
D. H. Campbell	Stanford University, Cal.
A. Wilmer Duff	Worcester, Mass.
B. W. Everman	Washington, D. C.
Charles H. Gilbert	Stanford University, Cal.
C. W. Green	Stanford University, Cal.
C. W. Hargitt	Syracuse, N. Y.
O. P. Hay	New York City.
Edward Hughes	Stockton, Cal.
O. P. Jenkins	Stanford University, Cal.
D. S. Jordan	Stanford University, Cal.
J. S. Kingsley	Tufts College, Mass.
D. T. MacDougal	Bronx Park, New York City.
T. C. Mendenhall	Worcester, Mass.
Alfred Springer	Cincinnati, Ohio.
L. M. Underwood	New York City.
Robert B. Warder	Washington, D. C.
Ernest Walker	Clemson College, S. C.

*Date of election.

ACTIVE MEMBERS.

George Abbott	Indianapolis.
Frederick W. Andrews	Bloomington.
George C. Ashman	Frankfort.
Edward Ayres	Lafayette.
Edward Hugh Bangs	Indianapolis.
Walter D. Baker	Indianapolis.
Arthur M. Banta	Franklin.
J. W. Beede	Bloomington.
William N. Blanchard	Greencastle.
Edwin M. Blake	Lafayette.
Lee F. Bennett	Valparaiso.
Charles S. Bond	Richmond.
Fred. J. Breeze	Pittsburg.
E. M. Bruce	Weston, Oregon.
Herman S. Chamberlain	Indianapolis.
E. J. Chansler	Bicknell.
Otto O. Clayton	Geneva.
Howard W. Clark	Chicago, Ill.
George Clements	Springfield, Ill.
Charles Clickener	Silverwood, R. D. No. 1.
U. O. Cox	Mankato, Minn.
William Clifford Cox	Columbus.
J. A. Cragwall	Crawfordsville.
Albert B. Crow	Charleston, Ill.
M. E. Crowell	Franklin.
Edward Roscoe Cumings	Bloomington.
Alida M. Cunningham	Alexandria.
Lorenzo E. Daniels	Indianapolis.
H. J. Davidson	Baltimore, Md.
Charles C. Deam	Bluffton.
Martha Doan	Westfield.
J. P. Dolan	Syracuse.
Herman B. Dorner	Lafayette.
Hans Duden	Indianapolis.
E. G. Eberhardt	Indianapolis.
Frank R. Eldred	Indianapolis.

M. N. Elrod . . . . Columbus.
Samuel G. Evans . . . . Evansville.
Carlton G. Ferris . . . . Big Rapids, Mich.
E. M. Fisher . . . . Urmeyville.
Wilbur A. Fisk . . . . Richmond.
W. B. Fletcher . . . . Indianapolis.
Austin Funk . . . . New Albany.
John D. Gabel . . . . Montpelier.
Charles W. Garrett . . . . Logansport.
Robert G. Gillum . . . . Terre Haute.
Vernon Gould . . . . Rochester.
Walter L. Hahn . . . . Bascom.
Victor Hendricks . . . . Indianapolis.
Mary A. Hickman . . . . Greencastle.
John E. Higdon . . . . Indianapolis.
Frank R. Higgins . . . . Terre Haute.
S. Bella Hilands . . . . Madison.
John J. Hildebrandt . . . . Logansport.
J. D. Hoffman . . . . Lafayette.
Allen D. Hole . . . . Richmond.
Lucius M. Hubbard . . . . South Bend.
John N. Hurty . . . . Indianapolis.
C. F. Jackson . . . . Greencastle.
Alex. Johnson . . . . Ft. Wayne.
Edwin S. Johonnott, Jr . . . . Terre Haute.
Ernest E. Jones . . . . Kokomo.
Chancey Juday . . . . Boulder, Colo.
O. L. Kelso . . . . Terre Haute.
Norton A. Kent . . . . Crawfordsville.
Charles T. Knipp . . . . Bloomington.
Henry H. Lane . . . . Lebanon.
William E. Lawrence . . . . Richmond.
V. H. Lockwood . . . . Indianapolis.
William A. McBeth . . . . Terre Haute.
Robert Wesley McBride . . . . Indianapolis.
Rousseau McClellan . . . . Indianapolis.
Richard C. McClaskey . . . . Terre Haute.
Lynn B. McMullen . . . . Indianapolis.

Edward G. Mahin .... West Lafayette.
James E. Manchester .... Vincennes.
Clark Mick .... Indianapolis.
W. G. Middleton .... Richmond.
John A. Miller .... Bloomington.
H. T. Montgomery .... South Bend.
Walter P. Morgan .... Terre Haute.
Fred Mutchler .... Terre Haute.
Charles E. Newlin .... Irvington.
John Newlin .... West Lafayette.
John F. Newsom .... Stanford University, Cal.
R. W. Noble .... Chicago, Ill.
D. A. Owen .... Franklin.
Rollo J. Peirce .... Logansport.
Ralph B. Polk .... Greenwood.
James A. Price .... Ft. Wayne.
Frank A. Preston .... Indianapolis.
A. H. Purdue .... Fayetteville, Ark.
Ryland Ratliff .... Bloomington.
Albert B. Reagan .... Rose Bud Agency, S. D.
Allen J. Reynolds .... Peru.
Giles E. Ripley .... Decorah, Iowa.
George L. Roberts .... Greensburg.
D. A. Rothrock .... Bloomington.
John F. Schnaible .... Lafayette.
E. A. Schultze .... Ft. Wayne.
John W. Shepherd .... Terre Haute.
Claude Siebenthal .... Indianapolis.
J. R. Slonaker .... Madison, Wis.
C. Piper Smith .... Alexandria.
Retta E. Spears .... Elkhart.
J. M. Stoddard .... Indianapolis.
Charles F. Stegmaier .... Greensburg.
William Stewart .... Burlington, Vt.
William B. Streeter .... Indianapolis.
Frank B. Taylor .... Ft. Wayne.
J. F. Thompson .... Richmond.
C. H. Underwood .... Indianapolis.

A. L. Treadwell	Oxford, Ohio.
Daniel J. Troyer	Goshen.
A. B. Ulrey	North Manchester.
W. B. Van Gorder	Worthington.
Arthur C. Veatch	Rockport.
H. S. Voorhees	Ft. Wayne.
J. H. Voris	Huntington.
Frank B. Wade	Indianapolis.
Daniel T. Weir	Indianapolis.
B. C. Waldemaier	West Lafayette.
Jacob Westlund	Lafayette.
Fred C. Whitcomb	Delphi.
William M. Whitten	South Bend.
Neil H. Williams	Indianapolis.
William Watson Woollen	Indianapolis.
J. F. Woolsey	Indianapolis.
Lucy Youse	Indianapolis.

Fellows	48
Non-resident members	20
Active members	127
Total	195

LIST OF FOREIGN CORRESPONDENTS.

AFRICA.

Dr. J. Medley Wood, Natal Botanical Gardens, Berea Durban, South Africa.

South African Philosophical Society, Cape Town, South Africa.

ASIA.

China Branch Royal Asiatic Society, Shanghai, China.

Asiatic Society of Bengal, Calcutta, India.

Geological Survey of India, Calcutta, India.

Indian Museum of India, Calcutta, India.

India Survey Department of India, Calcutta, India.

Deutsche Gesellschaft, für Natur- und Völkerkunde Ostasiens, Tokio, Japan.

Imperial University, Tokio, Japan.

Koninklijke Naturkundige Vereeniging in Nederlandsch-Indie, Batavia, Java.

Hon. D. D. Baldwin, Honolulu, Hawaiian Islands.

EUROPE.

V. R. Tschusizu Schmidhoffen, Villa Tannenhof, Halle in Salzburg, Austria.

Herman von Vilas, Innsbruck, Austria.

Ethnologische Mittheilungen aus Ungarn, Budapest, Austro-Hungary.

Mathematische und Naturwissenschaftliche Berichte aus Ungarn, Budapest, Austro-Hungary.

K. K. Geologische Reichsanstalt, Vienna (Wien), Austro-Hungary.

K. U. Naturwissenschaftliche Gesellschaft, Budapest, Austro-Hungary.

Naturwissenschaftlich-Medizinischer Verein in Innsbruck (Tyrol), Austro-Hungary.

Editors "Termeszetrajzi Fuzetk," Hungarian National Museum, Budapest, Austro-Hungary.

Dr. Eugen Dadai, Adj. am. Nat. Mus., Budapest, Austro-Hungary.

Dr. Julius von Madarasz, Budapest, Austro-Hungary.

K. K. Naturhistorisches Hofmuseum, Vienna (Wien), Austro-Hungary.

Ornithological Society of Vienna (Wien), Austro-Hungary.

Zoölogische-Botanische Gesellschaft in Wien (Vienna), Austro-Hungary.

Dr. J. von Csato, Nagy Enyed, Austro-Hungary.

Botanic Garden, K. K. Universitat, Wien (Vienna), Austro-Hungary.

Malacological Society of Belgium, Brussels, Belgium.

Royal Academy of Science, Letters and Fine Arts, Brussels, Belgium.

Royal Linnean Society, Brussels, Belgium.

Societé Belge de Geologie, de Paleontologié et Hydrologie, Brussels, Belgium.

Societé Royale de Botanique, Brussels, Belgium.

Societé Geologique de Belgique, Liège, Belgium.

Royal Botanical Gardens, Brussels, Belgium.

Bristol Naturalists' Society, Bristol, England.

Geological Society of London, London, England.

Dr. E. M. Holmes, British Pharm. Soc'y, Bloomsbury Sq., London, W. C., England.

Jenner Institute of Preventive Medicine, London, England.

The Librarian, Linnean Society, Burlington House, Piccadilly, London W., England.

Liverpool Geological Society, Liverpool, England.

Manchester Literary and Philosophical Society, Manchester, England.

"Nature," London, England.

Royal Botanical Society, London, England.

Royal Kew Gardens, London, England.

Royal Geological Society of Cornwall, Penzance, England.

Royal Microscopical Society, London, England.

Zoölogical Society, London, England.

Lieut.-Col. John Biddulph, 43 Charing Cross, London, England.

Dr. G. A. Boulenger, British Mus. (Nat. Hist.), London, England.

F. DuCane Godman, 10 Chandos St., Cavendish Sq., London, England.

Mr. Howard Saunders, 7 Radnor Place, Hyde Park, London W., England.

Phillip L. Sclater, 3 Hanover Sq., London W., England.

Dr. Richard Bowlder Sharpe, British Mus. (Nat. Hist.), London, England.

Prof. Alfred Russell Wallace, Corfe View, Parkstone, Dorset, England.

Botanical Society of France, Paris, France.
Ministérie de l'Agriculture, Paris, France.
Societé Entomologique de France, Paris, France.
L'Institut Grand Ducal de Luxembourg, Luxembourg, Lux., France.
Soc. de Horticulture et de Botan. de Marseille, Marseilles, France.
La Soc. Linneenne de Normandie, Caen, France.
Societé Linneenne de Bordeaux, Bordeaux, France.
Soc. des Naturelles, etc., Nantes, France.
Zoölogical Society of France, Paris, France.
Baron Louis d'Hamonville, Meurthe et Moselle, France.
Pasteur Institute, Lille, France.
Museum d'Histoire Naturelle, Paris, France.

Bontanischer Verein der Provinz Brandenburg, Berlin, Germany.
Deutsche Geologische Gesellschaft, Berlin, Germany.
Entomologischer Verein in Berlin, Berlin, Germany.
Journal für Ornithologie, Berlin, Germany.
Prof. Dr. Jean Cabanis, Alte Jacob Strasse, 103 A., Berlin, Germany.
Augsburger Naturhistorischer Verein, Augsburg, Germany.
Count Hans von Berlspen, Münden, Germany.
Braunschweiger Verein für Naturwissenschaft, Braunschweig, Germany.
Bremer Naturwissenschaftlicher Verein, Bremen, Germany.
Ornithologischer Verein München, Thierschstrasse, 37½, München, Germany.
Royal Botanical Gardens, Berlin W., Germany.
Kaiserliche Leopoldische-Carolinische Deutsche Akademie der Naturforscher, Halle a Saale, Wilhemstrasse 37, Germany.
Königlich-Sächsische Gesellschaft der Wissenschaften, Mathematisch-Physische Classe, Leipzig, Saxony, Germany.
Naturhistorische Gesellschaft zu Hanover, Hanover, Prussia, Germany.
Naturwissenschaftlicher Verein in Hamburg, Hamburg, Germany.
Verein für Erdkunde, Leipzig, Germany.
Verein für Naturkunde, Wiesbaden, Prussia.

Belfast Natural History and Philosophical Society, Belfast, Ireland.
Royal Dublin Society, Dublin.
Royal Botanic Gardens, Glasnevin, County Dublin, Ireland.

Societa Entomologica Italiana. Florence, Italy.
Prof. H. H. Giglioli, Museum Vertebrate Zoölogy, Florence, Italy.
Dr. Alberto Perngia, Museo Civico di Storia Naturale, Genoa, Italy.
Societa Italiana de Scienze Naturali, Milan, Italy.
Societa Africana d'Italia, Naples, Italy.
Dell' Academia Pontifico de Nuovi Lincei, Rome, Italy.
Minister of Agriculture, Industry and Commerce, Rome, Italy.
Rassegna della Scienze Geologiche in Italia, Rome, Italy.
R. Comitato Geologico d'Italia, Rome, Italy.
R. Comitato Geologico d'Italia, Rome, Italy.
Prof. Count Tomasso Salvadori, Zoölog. Museum, Turin, Italy.

Royal Norwegian Society of Sciences, Throndhjem, Norway.
Dr. Robert Collett, Kongl. Frederiks Univ. Christiana, Norway.

Academia Real des Sciencias de Lisboa (Lisbon), Portugal.
Comité Geologique de Russie, St. Petersburg, Russia.
Imperial Academy of Sciences, St. Petersburg, Russia.
Imperial Society of Naturalists, Moscow, Russia.
Jardin Imperial de Botanique, St. Petersburg, Russia.
The Botanical Society of Edinburgh, Edinburgh, Scotland.
John J. Dalgleish, Brankston Grange, Bogside Sta., Sterling, Scotland.
Edinburgh Geological Society, Edinburgh, Scotland.
Geological Society of Glasgow, Scotland.
John A. Harvie-Brown, Duniplace House, Larbert, Stirlingshire, Scotland.
Natural History Society, Glasgow, Scotland.
Philosophical Society of Glasgow, Glasgow, Scotland.
Royal Society of Edinburgh, Edinburgh, Scotland.
Royal Physical Society, Edinburgh, Scotland.
Royal Botanic Garden, Edinburgh, Scotland.

Barcelona Academia de Ciencias y Artes, Barcelona, Spain.
Royal Academy of Sciences, Madrid, Spain.

Institut Royal Geologique de Suède, Stockholm, Sweden.
Societé Entomologique a Stockholm, Stockholm, Sweden.
Royal Swedish Academy of Science, Stockholm, Sweden.

Naturforschende Gesellschaft, Basel. Switzerland.

Naturforschende Gesellschaft in Berne, Berne, Switzerland.

La Societé Bontanique Suisse, Geneva, Switzerland.

Societé Helvetique de Sciences Naturelles, Geneva, Switzerland.

Societé de Physique et d'Historie Naturelle de Geneva, Geneva, Switzerland.

Concilium Bibliographicum, Zürich-Oberstrasse, Switzerland.

Naturforschende Gesellschaft, Zürich, Switzerland.

Schweizerische Botanische Gesellschaft, Zürich, Switzerland.

Prof. Herbert H. Field, Zürich, Switzerland.

AUSTRALIA.

Linnean Society of New South Wales, Sidney, New South Wales.

Royal Society of New South Wales, Sidney. New South Wales.

Prof. Liveridge, F. R. S., Sidney, New South Wales.

Hon. Minister of Mines, Sidney, New South Wales.

Mr. E. P. Ramsey, Sidney, New South Wales.

Royal Society of Queensland, Brisbane, Queensland.

Royal Society of South Australia, Adelaide, South Australia.

Victoria Pub. Library, Museum and Nat. Gallery, Melbourne, Victoria.

Prof. W. L. Buller, Wellington, New Zealand.

NORTH AMERICA.

Natural Hist. Society of British Columbia, Victoria, British Columbia.

Canadian Record of Science, Montreal, Canada.

McGill University, Montreal, Canada.

Natural Society, Montreal, Canada.

Natural History Society, St. Johns, New Brunswick.

Nova Scotia Institute of Science, Halifax, N. S.

Manitoba Historical and Scientific Society, Winnipeg, Manitoba.

Dr. T. McIlwraith, Cairnbrae, Hamilton, Ontaria.

The Royal Society of Canada, Ottawa, Ontario..

Natural History Society, Toronto, Ontario.

Hamilton Association Library. Hamilton, Ontario.

Canadian Entomologist. Ottawa, Ontario.

Department of Marine and Fisheries. Ottawa. Ontario.

Ontario Agricultural College, Guelph, Ontario.

Canadian Institute, Toronto.
Ottawa Field Naturalists' Club, Ottawa, Ontario.
University of Toronto, Toronto.
Geological Survey of Canada, Ottawa, Ontario.
La Naturaliste Canadian, Chicontini, Quebec.

La Naturale Za, City of Mexico.
Mexican Society of Natural History, City of Mexico.
Museo Nacional, City of Mexico.
Sociedad Cientifica Antonio Alzate, City of Mexico.
Sociedad Mexicana de Geographia y Estadistica de la Republica Mexicana, City of Mexico.

WEST INDIES.

Botanical Department, Port of Spain, Trinidad, British West Indies.
Victoria Institute, Trinidad, British West Indies.
Museo Nacional, San Jose, Costa Rica, Central America.
Dr. Anastasia Alfaro, Secy. National Museum, San Jose, Costa Rica.
Rafael Arango, Havana, Cuba.
Jamaica Institute, Kingston, Jamaica, West Indies.
The Hope Gardens, Kingston, Jamaica, West Indies.

SOUTH AMERICA.

Argentina Historia Natural Florentine Amegline, Buenos Ayres, Argentine Republic.
Musée de la Plata, Argentine Republic.
Nacional Academia des Ciencias, Cordoba, Argentine Republic.
Sociedad Cientifica Argentine, Buenos Ayres.
Museo Nacional, Rio de Janeiro, Brazil.
Sociedad de Geographia, Rio de Janeiro, Brazil.
Dr. Herman von Jhering, Dir. Zoöl. Sec. Con. Geog. e Geol. de Sao Paulo, Rio Grande do Sul, Brazil.

Deutscher Wissenschaftlicher Verein in Santiago, Santiago, Chili.
Societé Scientifique du Chili, Santiago, Chili.
Sociedad Guatemalteca de Ciencias, Guatemala, Guatemala.

PROGRAM

OF THE

NINETEENTH ANNUAL MEETING

OF THE

INDIANA ACADEMY OF SCIENCE,

STATE HOUSE, INDIANAPOLIS,

December 28 and 29, 1903.

OFFICERS AND EX-OFFICIO EXECUTIVE COMMITTEE.

W. S. BLATCHLEY, President. C. L. MEES, Vice-President. JOHN S. WRIGHT, Secretary.
DONALDSON BODINE, Assistant Secretary. G. A. ABBOTT, Press Secretary.
W. A. MCBETH, Treasurer.

H. W. WILEY,	STANLEY COULTER,	T. C. MENDENHALL,
M. B. THOMAS,	AMOS W. BUTLER,	JOHN C. BRANNER,
D. W. DENNIS,	W. A. NOYES,	J. P. D. JOHN,
C. H. EIGENMANN,	J. C. ARTHUR,	JOHN M. COULTER,
C. A. WALDO,	J. L. CAMPBELL,	DAVID S. JORDAN.
THOMAS GRAY,	O. P. HAY,	

With one exception, the sessions of the Academy will be held in the State House, in the rooms of the State Board of Agriculture and Horticulture; the President's address will be given in the auditorium of the Shortridge High School.

Headquarters will be at the English Hotel. A rate of $2.00 and up per day, American plan, will be made to all persons who make it known at the time of registering that they are members of the Academy.

Reduced railroad rates for the members can not be secured under the present ruling of the Traffic Association. Many of the colleges can secure special rates on the various roads. Those who can not do this, could join the State Teachers' Association, whose sessions begin on December 29, and thus secure a one-and-one-third round-trip fare.

PROGRAM COMMITTEE.

MEL. T. COOK, Greencastle, Indiana. GLENN CULBERTSON, Hanover, Indiana.

GENERAL PROGRAM.

MONDAY, DECEMBER 28.

Meeting of Executive Committee at Hotel Headquarters.................. 10:30 a. m.
General Session followed by Sectional Meetings..................... 2 p. m. to 5 p. m.
President's Address, Shortridge High School.................................... 8 p. m.
If advisable, the President's Address may be followed by a short session.

TUESDAY, DECEMBER 29.

General Session, followed by Sectional Meetings..................... 9 a. m. to 12 m.

LIST OF PAPERS TO BE READ.

ADDRESS BY THE RETIRING PRESIDENT,

WILLIS S. BLATCHLEY,

At 8 o'clock Monday evening, at Shortridge High School.

Subject: "The Indiana of Nature; Its Evolution."

The following papers will be read in the order in which they appear on the program, except that certain papers will be presented "*pari passu*" in sectional meetings. When a paper is called and the reader is not present, it will be dropped to the end of the list, unless by mutual agreement an exchange can be made with another whose time is approximately the same. Where no time was sent with the papers, they have been uniformly assigned ten minutes. Opportunity will be given after the reading of each paper for a brief discussion.

N. B.—By the order of the Academy, no paper can be read until an abstract of its contents or the written paper has been placed in the hands of the Secretary.

GENERAL.

1. "Colds" and Cold, 10m. . . . . Robert Hessler
2. A Prehistoric Fortification near Madison, Indiana, 5m. . . . . Glenn Culbertson
3. The Apache Stick Game, 10m. . . . . Albert B. Reagan
4. Some Paintings from one of the Estufas in the Indian Village of Jemez, New Mexico, 10m. . . . . Albert B. Reagan

*5. Notes on the Caves of Cuba. . . . . J. W. Beede

6. What Bacteriology has done for Sanitary Science, 10m. . . . . Severance Burrage
7. Conditions affecting the distribution of Birds in Indiana, 20m. . . . . Amos W. Butler

PHYSICS, CHEMISTRY AND GEOLOGY.

8. A new problem in Hydrodynamics with Extraneous Forces Acting, 10m. . . . . E. L. Hancock
9. On the use of Nickel in the core of the Marconi Magnet Director, 10m. . . . . Arthur L. Foley

*10. Effect of Ultraviolet Light on the action of the Coherer, 10m. . . . . Arthur L. Foley

*11. The Life of Radium, 5m. . . . . Arthur L. Foley

12. The Edison effect in a "Hylo" Lamp, 10m. . . . . . Arthur L. Foley
13. On the use of MnO_2 in the generation of O from $KClO_3$, 5m. . . . . R. R. Ramsey, Arthur L. Foley

*14. A Method of Determining the Absolute Dilation of Mercury, 5m., ... Arthur L. Foley.

---

*Paper not presented.

15. Geology of the Fort Apache Region, Arizona, (by title).......... ....Albert B. Reagan
16. Geology of Monroe County, Indiana, North of the Latitude of Bloomington ....Albert B. Reagan
17. What is the Age of the Aubery Limestone of the Rocky Mountains? ....Albert B. Reagan
*18. Some Fossils from the Lower Aubery and Upper Red Wall in the Vicinity of Fort Apache, Arizona..............Albert B. Reagan
19. The Fossils of the Red Wall Compared with Those of the Kansas Coal Measures, 10m........................Albert B. Reagan
20. Double Salts in Solution, 10m.....................P. N. Evans
21. Ionic Friction, 10m...............................P. N. Evans
22. A Topographic Result of the Alluvial Cone, 10m......A. H. Purdue
23. A Note on the Radio-Activity of Strontium-Salicylate, 10m...... ....J. F. Woolsey
24. Progress in Locomotive Testing, 10m...............W. F. M. Goss

BOTANY AND ZOOLOGY.

25. A Note on the Breeding Habits of the Common or White Sucker, 3m.......................................Glenn Culbertson
26. Additions to the Flora of Indiana, 8m................H. B. Dorner
27. Additions to the List of Gall-Producing Insects Common to Indiana, 5m......................................Mel. T. Cook
28. Botanical Notes, 10m ....M. N. Elrod
29. Bird Notes from the Indiana State Forestry Reservation........ ....Chas. Piper Smith
30. Notes Upon Some Little Known Members of the Indiana Flora, 10m ....Chas. Piper Smith
31. The Development of the Spermatozoid of Chara, 10m..D. M. Mottier
32. Further Studies on Anomalous Dicotyledonous Plants, 10m...... ....D. M. Mottier
33. A Crow Roost near Richmond, Indiana, 5m................... ....D. W. Dennis and W. E. Lawrence
34. A New Adjustable Stand for Physiological Apparatus and Modifications in other Physiological Devices, 10m................ ....J. F. Woolsey and John S. Wright
35. An Abnormality in the Nut of *Hicoria ovata*, 5m....John S. Wright

*Paper not presented.

*36. Contribution to the Flora of Indiana, No. VIII, 10m. .Stanley Coulter
*37. On the Germination of Certain Native Weeds, 10m. .Stanley Coulter
38. Revised list of Indiana Plant Rusts, 10m..............J. C. Arthur
*39. Cuban Notes, 10m..............................C. H. Eigenmann
40. Ecological Notes on the Mussels Winona Lake, 10m...T. J. Headlee
41. Ecological Notes on the Birds occurring within a radius of 5 miles of the Indiana University Campus (with photographs by G. C. Littell), 10m........................Waldo L. McAtee
*42. List of Mammals, Reptiles and Batrachians of Monroe County, Indiana, 10m.............................Waldo L. McAtee
43. Birds Nests of an Old Apple Orchard near Indiana University Campus, 10m...............................Gertrude Hitze
44. Nerve end organ in the Pancreas, 5m..................E. O. Little
45. Discoidal Pith in our Woody Plants, 5m..........F. W. Foxworthy
46. New Science Laboratory, Moores Hill College, 5m......A. J. Bigney
47. The Sun or Gunelpiya Medicine Disk.............Albert B. Reagan

---

THE NINETEENTH ANNUAL MEETING OF THE INDIANA ACADEMY OF SCIENCE.

The nineteenth annual meeting of the Indiana Academy of Science was held in Indianapolis, Monday and Tuesday, December 28 and 29, 1903.

Monday 10:45 a. m., the Executive Committee met in session at hotel headquarters.

At 2 o'clock p. m. President Willis S. Blatchley called the Academy to order in general session in the room of the State Board of Agriculture, State House. The transaction of routine and miscellaneous business occupied the first part of the session. Following this, papers of general interest were read and discussed. After the disposition of these, special technical subjects occupied the time until adjournment at 5 p. m

The address of the retiring President, Willis S. Blatchley, was delivered in the auditorium of the Shortridge High School at 8 p. m., before the members of the Academy and a number of invited guests, subject—"The Indiana of Nature; its Evolution."

*Paper not presented.

Tuesday 29, 9 a. m., the Academy met in general session before which the remaining papers of the program were read and discussed. Following the disposition of the papers unfinished business was considered.

Adjournment.

THE FIELD MEETING OF 1903.

The field meeting of 1903 was held in Madison and Hanover, Thursday and Friday, May 21 and 22. Thursday evening a well attended public session was held in the auditorium of the Madison High School; the program consisted of musical numbers and addresses. President W. S. Blatchley spoke on the mineral fuels of the State and Dr. Stanley Coulter on forestry work in Indiana. After the adjournment of the public session a short business meeting was held in the Madison Hotel.

At 8:30 a. m., Friday the 22d, the members left hotel headquarters for the field, proceeding by carriages over the Hanover road to the mouth of the gorge which leads to Clifty Falls. The remainder of the trip to the Falls was made on foot over territory of great interest to naturalists, especially to geologists and botanists. Clifty Falls was reached about noon. Luncheon was served here, after which a cross-country drive was made to Hanover College. The remainder of the afternoon was spent in viewing the college buildings and equipment, and in enjoying the magnificent scenery of the vicinity. At 6 o'clock dinner the visiting members of the Academy were guests in the homes of the members of the Hanover College faculty.

At 8 o'clock a public meting was held in the college chapel, addresses were made by Drs. Stanley Coulter, J. C. Arthur, M. T. Cook, N. A. Kent and A. F. Foerste. After this session an enjoyable reception was tendered the Academy at the home of President Fisher. The return to Madison was made that night, after which a very brief business meeting was held in the hotel headquarters. Adjournment, 12 o'clock, midnight, Friday, May 22.

The spring meeting of 1903 will be remembered as one of the most successful and enjoyable in the history of the Academy. The weather was delightful and the locality interesting from every standpoint. The Academy gratefully acknowledges its obligations to the Madison Commercial Club and to the members of the Hanover College faculty, especially to Professor Culbertson, for their generosity and thoughtful courtesies which anticipated every want of the excursionists.

PRESIDENT'S ADDRESS.

The Indiana of Nature; Its Evolution.

By W. S. Blatchley.

Afar out in the limitless realms of space a planet moves—propelled onward by an unseen, uncontrollable force around its parent orb, a sun. For millions, perhaps billions, of years, as man counts time, that planet has moved in the same pathway, meanwhile undergoing most wonderful changes in bulk and form. At first a vast, irregular mass of burning, gaseous matter, thrown off from that sun about which it still revolves, the planet gradually cooled, condensed, and assumed a spheroidal form. Its gaseous elements rearranged themselves to form new compounds, at first liquid, then solid, until in time it came to be a solid globe, or at least one with a solid but uneven crust. The processes of cooling and contraction still continued. The ocean of vapor which formed a large portion of the atmosphere about the planet condensed and fell and formed an ocean of water which filled the depressions in its crust. Above the rim of this ocean there showed in places large areas of land—bare igneous rock, absolutely devoid of life—as, for millions of years, the temperature of both rock and ocean remained too high for living things.

When the mean temperature of its oceanic waters by continued and oft repeated evaporation, cooling and condensation, was reduced to about 150° (degrees) F., there occurred the grandest event in the history of that planet. *In some unknown, unknowable manner, Life came to be.* Within the waters of its ocean there was brought about a combination of matter—a living thing—which could take from the water and from the air above certain elements, and by their aid increase in size and reproduce its kind. The first lowly parasites upon the face or surface of the planet were thus aquatic plants—algæ, fungi and kindred forms. In the course of ages there evolved from them other and higher plants which could live on land; for the decay and erosion of the igneous rocks, added to the remains of the aquatic plants thrown upon the beaches of the ocean, produced a soil from which the higher land plants could derive a part of their nourishment. As the centuries and the æons rolled by, the plants—true parasites that they were—found their way to every part of the planet's surface. Onto the tops of the loftiest mountains, into the abysses of the deepest oceans, they made their way; their province being the conversion of inorganic matter—earth, air, water—into a form of food suitable to the needs of a higher type of parasite which meanwhile was coming into existence upon the planet's surface. For, as the temperature of the ocean gradually decreased, the Era of Animal Life was ushered in.

The first animals on the planet were also lowly aquatic forms—scarcely differing from the first plants, but possessing a freedom of motion which enabled them to procure a better supply of air and water. Then, evolving into higher and more varied forms as they became adapted to new environments, they spread far and wide through ocean's depths and over plain and mountain, until the whole surface of the planet was peopled, too, by them. But, ever and always, from the time the first animal came to be upon that planet, until the last one finally disappears into the darkness of everlasting night, the *growth* of animal life will depend upon *living food* prepared by the plant—the *motion* of animal life upon *energy* stored within the cells of the plant.

That sun, which in the beginning first cast off the matter of which the planet is formed, still controls it—still rules over it and its destinies with an iron will. Both plant and animal parasite must forever bow before its power. Of the vast floods of energy which stream forth from that sun's disk, in the form of heat and light, an insignificant fraction falls upon the surface of its satellite. Of the minute portion that the planet thus arrests, an equally insignificant part is caught up by its plants and used directly in their growth. Yet the entire productive force of the living portion of that planet turns on this insignificant fraction of an insignificant fraction.

The vegetable cell is thus a storer of power—a reservoir of force. It mediates between the sun—the sole fountain of energy—and the animal life on the planet. The animal can not use an iota of power that some time, either directly or indirectly, has not been stored in the plant cell. Thus, of the two great groups of parasites upon the surface of the planet, the plant must, perforce, have preceded the animal.

For thousands of centuries each type of animal and plant parasite upon that planet was content if it could secure food enough to reach maturity and then a mate to reproduce its kind. All the energies put forth—all the variations in organ and form—all the adaptations to modified environment—were but means toward the better accomplishment of these two ends. Sometimes a type would reach a culmination or highest point, beyond which it could not advance. Then a degeneration would occur along side lines, or, in many instances, even total extinction of the race or group. Finally, after the planet was hoary with age, a race of animal parasites evolved from the lower forms, whose variations were ever concentrated toward the head or cephalic region. During untold ages their brains slowly but surely increased in size until, in time, they became possessed of the power of reason and of abstract thought. In that age the "prince of parasites" was born. From then on he began to rule not only the other animal and plant parasites about him, but to discover and control the powerful forces of nature, heretofore wholly latent. As he grew in brain power, he grew in greed, in egoism. He came to think that the planet, on which he was but a parasite, was created for him alone; that all other plants and animals were put there for his especial benefit, though many of them out-dated him by millions of years. He began to modify the surface of the planet in all ways possible—to change, as it were, its every aspect to conform to his ideas. He imagined, vain creature that he was, that he could improve upon the works of Nature. In time he divided up the entire land surface of the planet by using sometimes imaginary lines and again natural boundaries. Acres and sections, townships and counties, states and republics, kingdoms and empires were the terms he used to denote his subdivisions, and over all lands, and even seas, he proclaimed himself chief ruler. For that planet is the earth. That "prince of parasites" is Man.

To 36,350 square miles of the earth's surface, lying between the imaginary lines 37° 41′ and 41° 46′ north latitude, and between 84° 44′ and 88° 6′ west longitude, man, in time, gave the name "Indiana." How came this area to be where it is? Of what kind of matter is its surface composed? What was its condition at the time of the advent of the white race? These are questions which should be of interest to every resident of the Hoosier State.

The oldest known rocks on the American continent are those of Archæan Time laid down during the Azoic or lifeless æon of the earth. They are known as the Laurentian System of Rocks and consist mainly of coarse granites, thick-bedded gneisses and syenites, serpentines, schists and beds of modified sandstones, limestones and clays. They were formed from the debris of other rocks still older than themselves; these in their turn having been derived ages ago from those original igneous or primary rocks whose molten sands rose first above the boiling floods and cooled and crusted into a chaotic continent. For Archæan Time comprised those millions of years which elapsed while the crust of the earth was cooling down to a point where life was possible.

The Laurentian rocks are thus devoid of fossils or contain only the remains of the simplest aquatic forms. In North America they comprise the surface of a vast, V-shaped area of 2,000,000 or more square miles which lies, filled with wild lakes, pine clad, rugged, almost impassable, spread in savage sleep from Labrador to the Arctic Ocean. This area embodies the general form of the North American continent and was the nucleus of all the land which was afterward added to it. From these old Laurentian rocks came the debris and sediment which was laid down in the bed of a shallow ocean to form the first rocks comprising the surface of what is now "Indiana."

At the close of the Azoic or Lifeless æon, during which the Laurentian rocks were formed, the Paleozoic or "Æon of Ancient Life" was ushered in. At its beginning the entire area of what is now known as Indiana was covered by a broad ocean which stretched far away to the southwest, while to the north and northeast it extended beyond the present sites of the Great Lakes. This ocean is known to geologists as the "Interior Paleozoic Sea." Into it was carried the sediment derived from the erosion and destruction of the old Laurentian rocks by water and air, which agencies then, as now, were ever at work. The Potsdam sandstone of the Cambrian era, which probably underlies the Trenton limestone of the Lower Silurian beneath the greater portion, if not all, of Indiana, was one of the first strata to be laid down in this sea. But as none of the surface of Indiana is represented by the Potsdam stone, it will be passed with this mere mention.

Following the Cambrian came the second grand sub-division of Paleozoic Time, the so-called Lower Silurian or Ordovician Age. At its beginning the sea covering Indiana and the area to the north and east was of course more shallow, as 1,000 feet or more of Potsdam sandstone had been deposited on its floor. The first great stratum of Ordovician rock to be laid down in this sea which is of interest to us was the Trenton limestone, which, during the past two decades, has become so noted in Indiana as the source of natural gas and crude petroleum.

It is a well known geological fact that most, if not all, limestones owe their origin to the presence of minute organisms in the water in which the limestone was formed. The animals from whose remains the Trenton limestone was, for the most part, derived, were probably very low forms —the polyps and bryozoans of the ancient Silurian seas. In untold numbers they existed, and the carbonate of lime, which makes up 80 per cent. of the unmodified Trenton rock, is largely the remains of their secretions and incrustations. Associated with these lower forms were myriads of higher ones—crinoids, brachiopods, trilobites, gastropods and even fishes. The presence of such swarms of animal life made necessary the existence of an abundance of plants; since the plant must ever precede the animal and gather for the latter the energy, and form for it the food—the living protoplasm—necessary to its existence. These plants were mostly marine algae or seaweeds and fucoids, though doubtless many other forms existed of which no remains have been preserved in the rocks of that age.

The Trenton limestones were evidently formed in rather clear waters, at moderate depths. Near the bottoms of these shallow seas great beds of calcareous sediment were gradually collected, and were swept to and fro by the tides and currents. Rivers from the older Cambrian rocks brought down their eroded particles and added to the thickness of the ocean floor. Within these beds of sediment both plants and animals found a grave—their bodies in vast numbers being buried beneath the slowly accumulating deposits of centuries. Once buried in such deposits, they did not decay, as do animals on land, because by the waters above and the calcareous ooze around them, they were shut off from free oxygen, which is the chief agent in decay. Gradually this ooze or fine sediment was, by the agency of the sea water, cemented and consolidated into limestone. In this manner that great layer of Trenton rock which underlies at variable depths the whole of Indiana, was formed. From it has been derived, directly or indirectly, more wealth than from any other one formation, either underlying or forming a portion of the surface of the State.

In time the waters of the ocean containing this vast stratum of Trenton limestone, with its enclosed accumulations of undecayed plants and animals, became turbid, and instead of calcareous sediment, deposited mud and clayey sediment in thick beds on top of the limestone strata. These deposits of mud and silt were afterward, by later deposits, compressed into the fine-grained, impervious Utica shale, 100 to 300 feet in thickness, which thus effectually sealed the Trenton limestones and so retained within them the oil and gas derived from their enclosed organic remains. This oil, and its more volatile portion, the natural gas, was not formed in a short time, but is the result of a slow decomposition or destructive distillation, carried on through thousands of centuries. Accumulating in vast reservoirs—the more porous portions of the Trenton limestone or mother rock—it there remained until man came with his iron drill and furnished a vent through which it could rise. Then by combustion he caused it to yield up the stored energy, conserved since the sun's rays fell on the plants of the old Silurian seas.

After the Utica shale had been laid down as a thick, impervious cover above the Trenton limestone, there followed the Hudson River epoch during which 200 to 600 feet of alternating beds of shale and limestone were deposited in the old sea bottom where now is Indiana. These form the uppermost division of the Lower Silurian age. During the myriads of years necessary to their deposition marine forms were excessively abundant and the advancement in the scale of animal life was correspondingly great. All the principal groups of marine invertebrates which came into existence during the Trenton epoch were represented, but the species were widely different. In addition to life in the sea, there came also to be life on land. Acrogenous plants—forerunners of the ferns and mosses—harbingers of the vast forests of future centuries—came into being along the moist waterways of the growing continent, while insects, the first winged creatures, began to traverse the air.

As yet no part of Indiana was above old ocean's level, but at the close of the Ordovician, after the Hudson River limestones and shales had been laid down, a great upheaval. caused by some subterranean force, brought above the sea a large island of Ordovician rock which ever since has been dry land. This upheaval was greatest over the point where Cincinnati, Ohio, is now located, and the "Cincinnati Uplift" is the name given by geologists to the island and the broad belt of shallowly submerged land which extended from its northern shore in a northwesterly direction, diagonally across the area of the future Indiana. The main portion of that island comprised the southwestern corner of what is now Ohio and a part of northeastern Kentucky. It also included a small part of what is now Indiana and formed the first and oldest portion of the surface of our State. The area whose surface rocks belong to this Hudson River formation comprises part or all of Wayne, Union, Fayette, Franklin, Dearborn, Ripley, Ohio, Switzerland and Jefferson counties.

Over this area the exposed rocks are composed of a series of bluish, thin-bedded limestones intercalated with bluish-green limey shales, while at the top are massive sandy limestone beds of a brownish color The shales are soft, easily weathered and very fossiliferous, while the bluish lime-

stones are in places largely composed of fossils. As a part of an island, therefore, upheaved from the Ordovician seas, was the first born land of Indiana; and to that little corner all other portions of our noble State were added in their turn by the workings of nature's forces during after ages.

At the end of the Ordovician or beginning of the Upper Silurian age, the Interior Paleozoic Sea had greatly diminished in area. A broad belt of land had been added to the southern border of the old Laurentian crest, especially over what is now Wisconsin and a portion of northern Illinois; while, extending from what is now Labrador down to Georgia, was another broad belt, following the general trend of the present Alleghany mountains. By the raising of several large islands above its surface at the time of the Cincinnati Uplift, aided by the broad belt of shallowly submerged land already noted, the area of the Interior Sea was still further diminished and to that portion covering what is now the northeastern part of Indiana and the greater part of Ohio, West Virginia, New York and Pennsylvania, the name of "Eastern Interior Sea" is given. This was simply a great bay or eastward extension of a greater "Central Interior Sea" which, at that period, covered most of Indiana, southern Michigan, Illinois and a large portion of the present United States west of the Mississippi River. The most northeastern limits of the Eastern Interior Sea were the present sites of Albany and Troy, New York. The rock-making material which was deposited on the floor of both it and the Central Interior Sea was derived in part from the land along their borders, but mainly from the limey secretions of the life within their waters. The dry land draining into them was small in area and hence there were only small streams for the supply of sediments. Yet, in the course of countless years, sufficient material was deposited to form the thick layer of Niagara limestone which now forms the surface rock over much of northern and eastern Indiana.

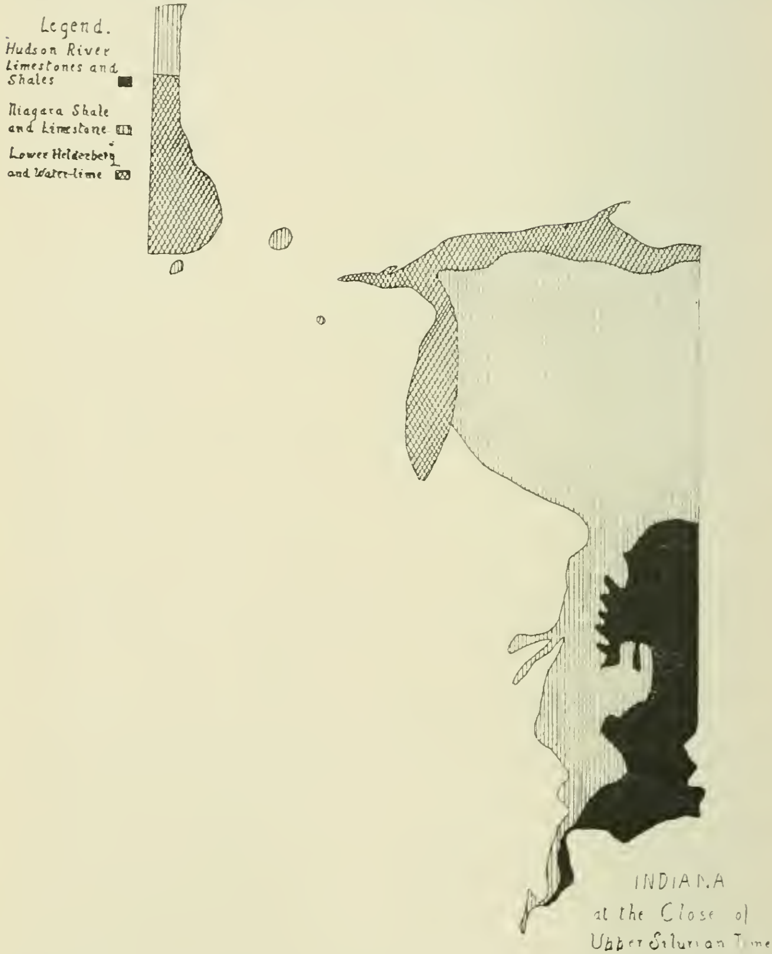
The epochs of the Upper Silurian age, as represented in Indiana, are three in number, viz., the Clinton, the Niagara and the Water Lime, or Lower Helderberg. Each is represented by its characteristic rocks, bearing the peculiar fossils of its time. The Clinton epoch is represented in the State by a close-grained, salmon-colored limestone, varying in thickness from a few inches only to about seven feet. It outcrops in a very narrow strip along the western edge of the area of the Hudson River limestone, already mentioned as the oldest rock in Indiana, and overlies that formation beneath the surface of at least the eastern third of the State. It has no economic importance and serves only as a line of demarcation separating the older Silurian rocks from those great beds of Niagara limestone which were afterward laid down in the Upper Silurian seas.

At the beginning of the Niagara epoch the waters of the Central and Eastern Interior Seas were laden with sediment and beds of bluish-green shales, known as the Niagara shales, and varying in thickness from two to forty feet, were first laid down. Owing to gradual changes in the level of the sea bottom, and a consequent shifting of its tides and currents a clearer, deeper water then resulted, within whose depths there existed life of great variety. Corals and bryozoans were especially represented, and from their remains and those of other marine forms were gradually constructed those beds of gray and buff Niagara limestone, varying in thickness from 100 feet along the Ohio River to 440 feet in the northern and northwestern portions of the State.

Near the close of the Niagara epoch a gradual uprising of a portion of the Eastern and Central Interior Seas took place. From their bottoms there emerged a long peninsula-like strip of land, whose general trend was northwest and southeast. In the former direction it was imperfectly attached to those portions of Wisconsin and Illinois which had come into existence during the Ordovician era. At its lower extremity it merged with that old island of the Cincinnati Uplift which had formed the first land of our present State. The surface rocks of the northwestern corner of Indiana, a narrow and probably interrupted strip extending diagonally across the State, a wide area in the central third and a narrower southern prolongation along the western border of the pre-existing Hudson River group, were thus, for the first time, brought above the level of the sea.

It appears that the force which caused this upraising of the Niagara sea floor was more pronounced at certain points than at others, and so caused a number of dome-like ridges or crests resembling true upheavals in the Niagara beds. These domes are present in an area extending from the Illinois line in Newton County, through the Upper Wabash Valley nearly to the Ohio line, being especially prominent near Wabash, Delphi, Monon, Kentland and other points in the region mentioned. In them the Niagara strata, elsewhere nearly horizontal, are strongly tilted and show other evidence of a true upheaval. These domes were at first probably small islands whose crests remained permanently above the surrounding sea. They thus formed, for a long period, a more or less broken or interrupted connection between the larger area of the Niagara to the southeast and that area in northwestern Indiana which was from now on a part of the continent proper.

The Water Lime and Lower Helderberg are two closely related limestones of the Upper Silurian age which, in Indiana, so merge as to be difficult to distinguish. They represent an epoch between that of the Niagara limestone and the lowest or oldest rocks of the Devonian era.



Their texture and composition shows them to have been laid down in very shallow seas close into the shores of the recently upraised Niagara limestone. The Water Lime is an impure magnesian hydraulic rock, ranging in thickness in Indiana from 20 to 90 feet. It outcrops near Kokomo where have been found numerous fine examples of its most characteristic fossils—gigantic crustaceans, two feet or more in length, closely related to the king crabs of the present seas. Over the extensive mud flats of the closing period of Upper Silurian time they were the undoubted rulers, while in the nearby waters sported descendents of those mail-clad fishes which first appeared in the Trenton period of the Lower Silurian era.

The Lower Helderberg represents the final epoch of Upper Silurian time. In Indiana its rocks form a buff to gray cherty limestone, 25 to 250 feet in thickness and often irregular and uneven in its bedding. It directly overlies the Niagara limestone where the Water Lime is absent. Outcrops occur at Logansport and other points to the northwest, and drill holes sunk for oil and gas show that it probably forms a portion of the surface rock beneath the deep drift-covered area of the northern third of the State.

The advance in life during the Upper Silurian era was not proportionally as great as that of the preceding age. The earliest of Arachnids, the scorpions, came to be, their first remains being in the Water Lime, showing that they were neighbors of the giant Eurypterid crustaceans. Cockroaches and progenitors of dragonflies were also present, but remains of other terrestrial forms are few or lacking. Among marine invertebrates, Cephalopods reached the acme of their development, the gigantic Orthoceratites of this group, whose remains are so common in the Niagara limestones of Wabash and adjoining counties, being worthy of especial mention.

We have seen that by the beginning of the Devonian Age or Era, which succeeded that of the Upper Silurian, the waters of that great bay known as the Eastern Interior Sea, had become farther separated from those of the Central Interior Sea by the uprising of the Niagara limestone area of eastern Indiana and western Ohio, and also by the deposition along the margin of this formation of the sediment comprising the Water Lime and Lower Helderberg limestones. A probable connection still existed between the waters of these two basins across the broken or interrupted strip connecting the main body of Niagara limestone in eastern Indiana with the main land area of the same formation in northwestern Indiana and northern Illinois.

The Devonian rocks of Indiana may be roughly classed as representing two great epochs, the Corniferous and the Genesee, the former being represented by beds of more or less pure limestone, ranging up to 55 feet in thickness; the latter by beds of black or brownish bituminous shales, which reach a known maximum thickness of 195 feet. The waters in which the materials of the Corniferous limestone were deposited were clear and comparatively pure, and in them sponges, corals, crinoids, trilobites and lower animal forms existed in great profusion. From the lime secreted by these marine forms the upper and purer beds of the Corniferous rock are mainly composed. The great abundance of coral life during the period is grandly shown at the Falls of the Ohio, opposite Louisville, Kentucky, where the Corniferous beds have a notable outcrop. Here "the corals are crowded together in great numbers, some standing as they grew, others lying in fragments, as they were broken and heaped up by the waves; branching forms of large and small size being mingled with massive kinds of hemispherical and other shapes. Some of the cup corals are six or seven inches across at the top, indicating a coral animal seven or eight inches in diameter. Hemispherical compound corals occur, five or six feet in diameter. The various coral-polyps of the era had, beyond doubt, bright and varied coloring like those of the existing tropics; and the reefs formed therefore a brilliant and almost interminable flower garden."

Near the close of the Corniferous epoch deposits of silt, mud and sand began to becloud the clear waters and put an end to the life of many marine forms. The upper beds of rock then laid down, known as the Hamilton, contain in places quite a percentage of magnesia and clay, and embody those vast deposits of hydraulic limestone which, in southern Indiana, have been so extensively used in making natural rock cement.

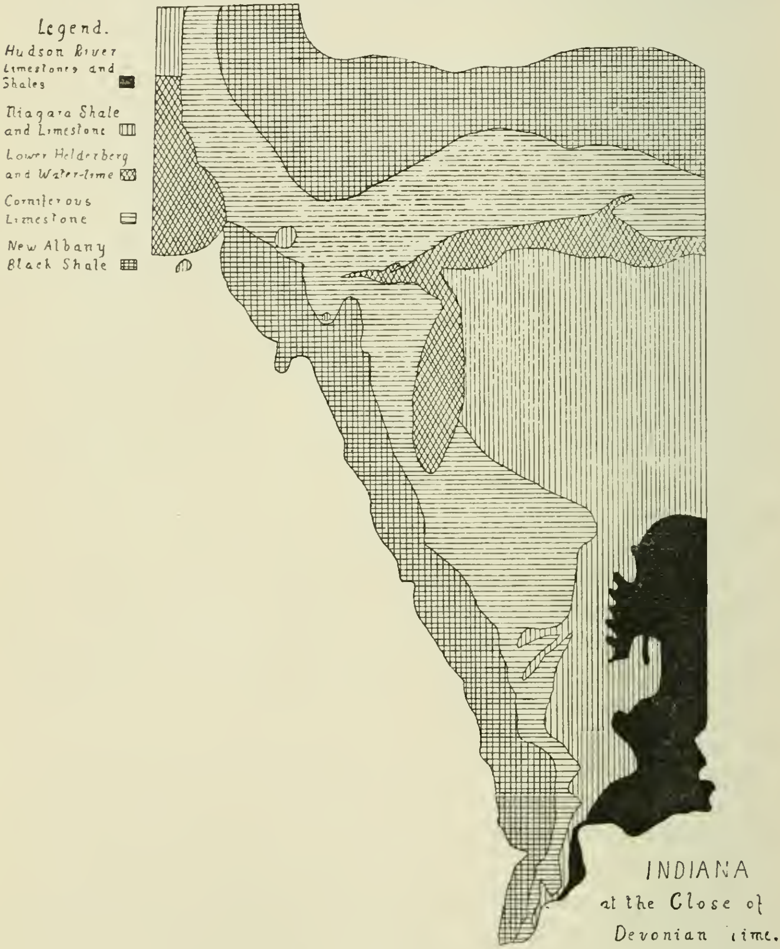
The Corniferous rock, when raised above the surface and added to the pre-existing land of the State, formed along the western margin of the latter an irregular strip 5 to 40 miles in width, extending from the present bed of the Ohio River at Jeffersonville northward to the present sites of Logansport and Monticello. North of the Wabash it has been found to be the surface rock in a number of the deep bores sunk for oil, but on account of the thick mantle of overlying drift, its exact limits are unknown. It is probable, however, that at the close of the Corniferous epoch a strip 20 miles or more in average width and extending nearly across the State was, in this region, raised above the floor of the old Devonian sea, to become a part of the permanent land of the future State.

During the latter part of the Devonian Era those lowly acrogenous plants known as Rhizocarps flourished in vast numbers in the fresh waters and brackish marshes of the time, and their spores by countless millions of tons were carried out as sediment into the surrounding seas. Mingling with the mud and silt and sand, brought down by erosion from the rapidly increasing land surface, they formed those vast mud flats which have since, by age and pressure, been consolidated into the thick beds of brown and black, finely-laminated shales which form the rocks of the Genesee epoch in Indiana. At New Albany the outcrops of this shale are 104 feet in thickness and especially prominent, so that the local name, "New Albany black shale," has been given it by geologists of the State. Along the western edge of the Corniferous limestone this shale forms a continuous strip, 3 to 35 miles in width, reaching from the present site of New Albany north and northwesterly to Delphi and Rensselaer. Over much of this strip it is covered by a thick mantle of drift, but everywhere within the area wells or the eroding streams have proven it to be the surface rock. The black shale has also, by deep bores, been found to be the rock immediately underlying the drift over much of the area embraced within the two northern tiers of counties in the State.

The Genesee shale is rich in bitumens, derived from the spores of the ancient Rhizocarps, which also gave it color. When kindled, it will burn until they are consumed, and it is therefore, by the uninitiated, often mistaken for coal. These bitumens are, by natural processes, sometimes separated from the shale and in the form of gas or petroleum are collected in reservoirs in it or in the underlying Corniferous limestone.

During the thousands of centuries of the Devonian Period, a great advancement took place in the flora and fauna of the times, especially in the vegetation of the land and the development of the higher aquatic vertebrates. Among the acrogens growing on land, ground pines, tree ferns and equiseta or horse-tails came into existence and flourished in vast numbers. Their remains are often found in the Corniferous limestone, into the sediment of which they were drifted and preserved. The first Phanerogams, conifers of the yew and cycad families, were also evolved, their leaves and branches being found in the upper or Hamilton beds of the Corniferous epoch. As the land plants increased in number and variety, insect life became more varied and numerous.

Mayflies abounded and the first musicians of the earth appeared in the form of Orthopterans which, by means of their shrilling organs, enlivened the solitudes of the strange old Devonian forests with their love calls and wooing notes. Among fishes, the Ganoids and Selachians,



of which our gar-pikes, sturgeons and sharks are degenerate descendants, reached the acme of their development; while gigantic species of Dipnoans or lung-fishes, now only represented by the dog-fish or "John A. Grindle," abounded in the bays and bayous about the ancient Genesee flats.

At the beginning of the Lower or Sub-Carboniferous Era, which followed the Devonian in regular sequence, we find more than half of Indiana above the level of the sea. By the deposition and subsequent raising of the rocks of the Corniferous and Genesee epochs, the gap between the large area of Niagara limestone in the eastern part of the State and the mainland to the northwestward had been filled and that portion of the future Indiana became for the first time a part of the slowly growing North American continent. The rocks which were afterward added on its western side were deposited on the sloping floor of the Central Interior sea which stretched far away to the southwest, and they consequently have a notable dip in that direction.

The lowermost stratum of the Sub-Carboniferous rocks in Indiana is a thin but very persistent bed of greenish limestone, known as the Rockford Goniatite limestone. It is but about two feet in thickness at its most notable outcrops, and hence forms but a very narrow area of the surface rocks of the State. It serves well, however, as a line of demarcation separating the Upper Devonian shales from the thick beds of Knobstone which represent one of the early and important epochs of Lower Carboniferous time.

These Knobstone rocks consist at the base of a series of soft, bluish shales, which gradually become more arenaceous or sandy, until toward their western horizon they merge into massive beds of impure grayish sandstone. The formation ranges in known thickness from 440 to 650 feet. The name "Knobstone" was first given it by that eminent geologist, David Dale Owen, because its siliceous strata weather into those peculiar conical "knobs" or hills which are so prominent a feature of the topography in the southern unglaciated portion of its area. By the deposition and upraising of the Knobstone a strip of territory, 3 to 38 miles in width, extending from the Ohio River southwest of New Albany north and northwesterly to a point a few miles south of the present site of Rensselaer, Jasper County, was added to the existing land of the future State. Deep bores have also shown the Knobstone to immediately underlie the drift in a strip of varying width along the extreme northern border of the State. By its deposition and subsequent upraising over this area, all of the northeastern portion of the State became for the first time dry land, and the waters of the Eastern Interior Sea were forever banished from the future Indiana.

Over much of the northern part of its main area in Indiana, the Knobstone is at present more or less covered by glacial debris, its strata being exposed only in the stream valleys. The shales of the basal or eastern third of its unglaciated portion are excellently adapted to the making of vitrified wares, as paving brick, sewer pipe, etc., as well as for the clay ingredient of Portland cement; though as yet their possibilities of service for these products have been largely ignored.

Following the Knobstone epoch came that of the Lower Carboniferous limestones. Four distinct horizons of these limestones are recognized in Indiana, viz., the Harrodsburgh, Bedford, Mitchell and Huron, in the order named; each representing a distinct period of deposition in the slowly retreating Central Interior Sea. Their total thickness is nearly 600 feet, and together they form the surface rocks over an area 40 miles wide on the Ohio River, but which gradually narrows northward until it disappears beneath the drift in the vicinity of Crawfordsville, Montgomery County.

Of the four horizons that of the Bedford is by far the most noted, since from it is obtained that famous Bedford or Indiana oölitic limestone which is now widely recognized as the finest building stone on the continent of America. It is mainly composed of the globular shells of microscopic foraminifera or Rhizopods—minute one-celled animal organisms—which must have swarmed in untold myriads in the sea waters of the time. The shells or cell walls of these animals were composed of a very pure carbonate of lime, and when they died and sank on the old sea bottom these shells were cemented together by the same material. Under the lens they resemble a mass of fish eggs soldered together, hence the name "oölitic," meaning "like an egg." The Bedford stone is noted among architects for its strength and durability, and for the ease with which it may be sawed or carved into any desired form. For many years it has ranked as one of the principal natural resources of the State.

The "Mitchell limestone" overlying the oölitic is composed of a series of close-grained limestones, shales and cherts. Its outcrop—5 to 30 miles in width—is a fairly level plateau which is pitted with a great number of sink holes, many of which form the openings into underground caverns and the beds of subterranean streams. The thick beds of Mitchell limestone, taken in connection with the underlying Bedford and Harrodsburgh limestones, afford a series of rocks which are more or less jointed, and therefore easily eroded by underground waters. As a result, large caves, some of them possessing great vaulted rooms,

deep pits, high waterfalls and streams of water large enough to allow the ready passage of a boat, are found throughout this area. All of these caves are due to the action of water—that greatest of nature's solvents and abraders—its work of a day, a year, a century, upon the solid limestone not appreciable to the eye—yet by slow unceasing action through the ages which have elapsed since that limestone was raised above the sea, it has carved every room and passage, constructed every pillar and stalagmite existing beneath the surface of southern Indiana.

The Huron limestone or Huron group of rocks represents in Indiana the latest epoch of the Lower Carboniferous Era. It is composed of three beds of limestone with two intervening beds of sandstone, their combined thickness being about 150 feet. The sandstones carry in places concretions of iron ore and thin beds of coal, the latter being the fore-runners or harbingers of those vast veins of stored energy which, in southern Indiana, represent the Carboniferous and final era of Paleozoic time.

The Carboniferous Era is noted as one of gentle oscillations in the surface of those shallow seas bordering the land, these "causing successive more or less wide emergencies and submergencies, the former favoring the growth of boundless forests and jungles, the latter burying the vegetable debris and other terrestrial accumulations beneath fresh water or marine deposits."

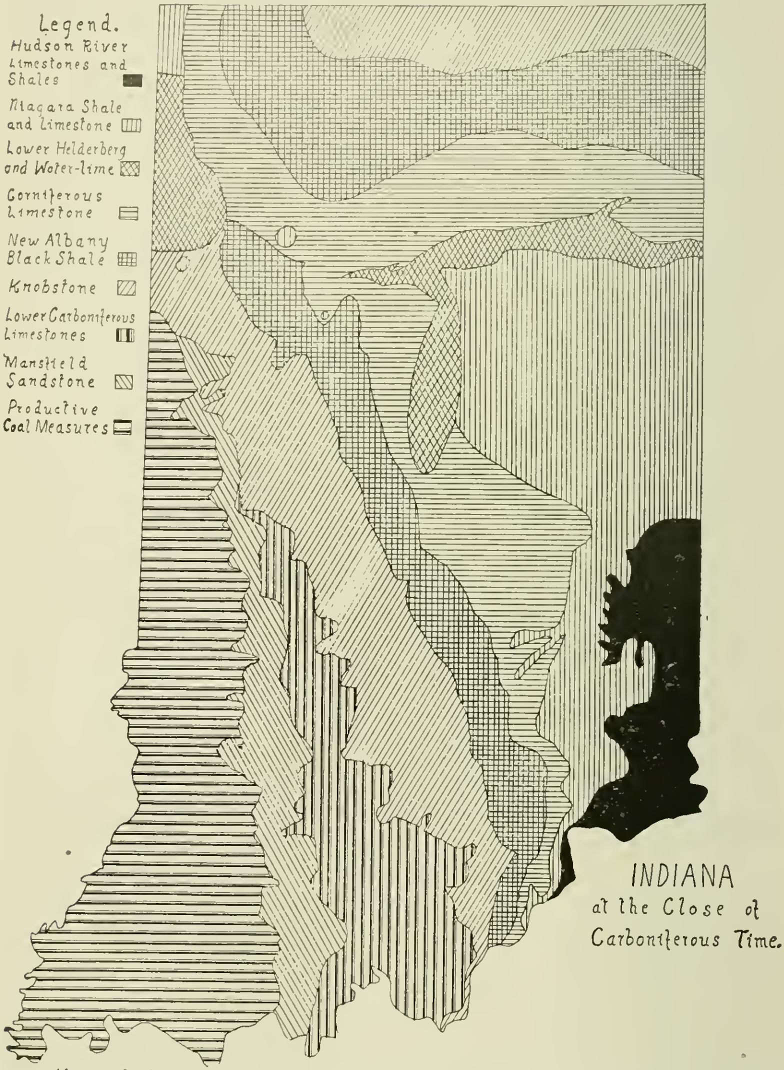
During the era, that cryptogamous land vegetation which had sprung into existence in the Devonian Era, advanced with wonderful strides. The temperature was mild; tne atmosphere moist and heavy laden with carbon dioxide. As a result the vast lowland marshes were overgrown with great trees of Sigillaria, Lepidodendron and Calamites; while at their base grew dense thickets of fern underbrush, inhabited only by insects and amphibians. For the first examples of the latter evolved during this period from some mud-loving, fish-like creature. No flowering plant had as yet unfolded its petals. No bird had, as yet, winged its way through the buoyant air. No mammal was, as yet, a denizen of earth or sea. Those dim watery woodlands were flowerless, fruitless, songless, voiceless, unless the occasional shrill of a cricket or grasshopper could be called a song. Yet in the cells of the semi-aquatic plants and trees of those old forests there was stored that heat which was destined in after ages to be freed by man and used in doing the work of the world.

The rocks laid down during this era were alternating beds of sandstone, shale, clay and limestone with occasional beds of compressed vegetation which, during after centuries, has been changed into coal.

The basal formation of the Carboniferous Era in Indiana, as generally elsewhere, is a bed of coarse-grained sandstone, known as the Mansfield sandstone or "Millstone Grit." It has a total thickness of 150 feet and forms the surface rock over a strip 2 to 22 miles in width, extending from the northern part of Warren County in an east of south direction to the Ohio River, a distance of 175 miles. In Martin and Orange counties it occurs with an even, sharp grit, furnishing a most excellent material for whetstones and grindstones.

Above this sandstone are the Productive and Barren Coal Measures, which comprise 7,500 square miles of the land surface of the State. At the time of their deposition or formation the area which they cover, as well as a large part of Illinois, was a great basin or depression, but little above the level of the sea, and surrounded on every side except the southwestern by the higher lands of the older formations. By successive alternations of upheaval and subsidence—carried on through thousands of years—this depression was at times an area of the southwestern sea, again a fresh water lake, and then, for a period, a vast swamp or marsh. When raised high enough to form a marsh, the luxuriant vegetation, above mentioned, sprang up from the ooze and mud at its bottom, flourished for centuries, the newer growths springing from between the fallen masses of the older, as in the peat bogs of today, and so formed a mighty mass of carbonaceous material. By subsidence, the level of the marsh was, in time, lowered until it became a lake into which rivers from the surrounding highlands flowed, bearing with them millions of tons of clayey sediment and disintegrated quartz, the remains of the older decayed rocks. This sediment was spread out over the mass of submerged vegetation, compressing it into the hard, mineral coal; the clayey sediment itself being in time compressed into vast beds of shale, and the particles of quartz into sandstone. In some places a more prolonged subsidence took place, sinking the floor of the lake below the level of the sea, and allowing the waters of the latter with their accompanying forms of marine life to flow in. In time beds of limestone were then formed over those of the shale or sandstone, but none of these cover an extensive area or are of great thickness.

After each subsidence, with its resulting beds of coal, shale and sandstone or limestone, had taken place, an upheaval followed. The floor of sea or lake was again raised so near the surface that the semi-aquatic vegetation for a new coal seam could spring up and, in time, the processes above detailed were again undergone. Such, in brief, was the origin and



formation of those five great veins of coal which form today the chief mineral wealth of our State, and of those vast beds of overlying shale which, in recent years, have come to be used for so many varied products.

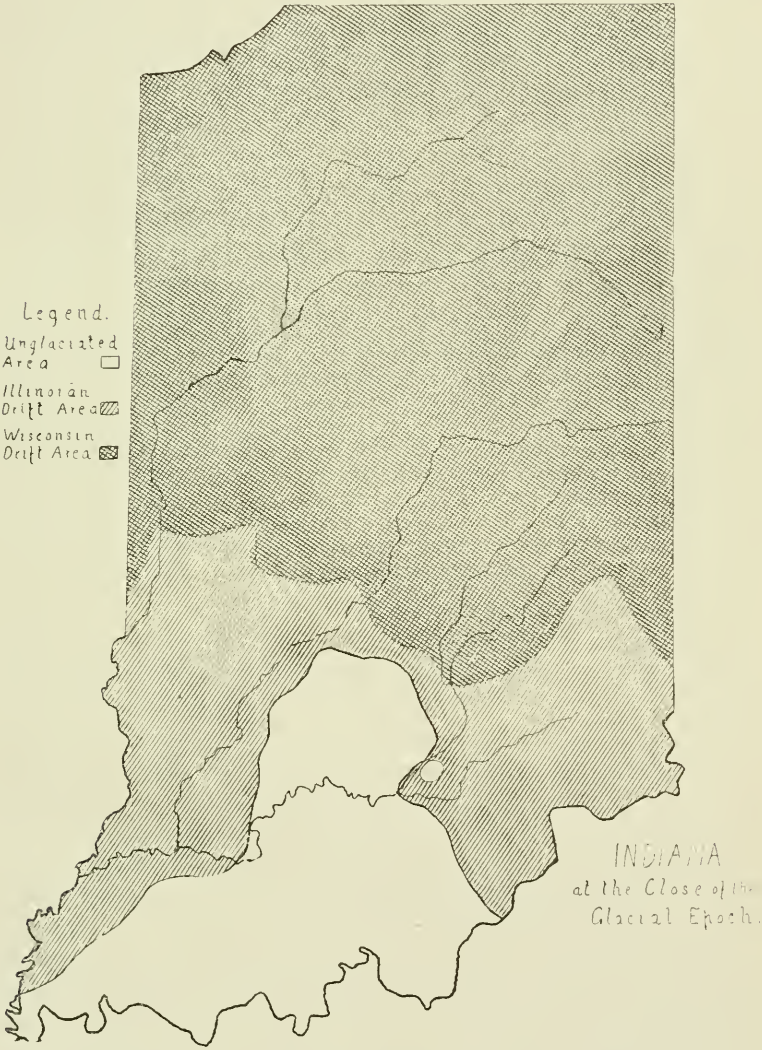
We have now traced the growth of the area comprising Indiana through Paleozoic time. We have seen how that area gradually appeared above old ocean's rim. But it was not yet the "Indiana of Nature"—the finished product of the ages ready for the advent of man. Centuries untold had yet to come and go before it was complete—centuries during which changes of momentous importance were to come to pass. For, as yet, no palm, no angiosperm or flowering plant with seeds, no osseous or common fish, no reptile, no bird, no mammal had come to be upon the surface of the earth. All these were evolved from pre-existing forms during the age or era immediately succeeding the Carboniferous or final period of Paleozoic time. This age is known as that of the Mesozoic or Middle Time, represented by the Triassic, Jurassic and Cretaceous eras. For our purpose there may be combined with these eras the Tertiary of Cenozoic or recent time. During the myriads of years ascribed to these eras, while vast changes were taking place in other parts of the American Continent, the surface of Indiana probably remained above sea level. On it there grew the plants and over it there doubtless roamed, in their turn, the animals of each successive era, but as its surface was above the sea, they left no fossil bone or footprint to tell us of their presence.

All this time, however, the silent processes of nature were unceasing in their labor, and wrought great changes in the surface of the future State. Decay and erosion were in action then as they are today. Sunshine and rain, wind and frost, trickling rills and strong streams were ever at work, softening and sculpturing and wearing down the exposed rocks, forming clays and sand and gravel and bearing them away to lower levels. At the close of the Tertiary Era, the entire surface of what is now Indiana resembled that of today in the driftless area of its southern part, being cut up by erosion into a complex network of valleys, ridges and isolated hills. In certain portions of the northern half great streams, of which there are now no surface indications, had worn their channels a half mile in width, 200 feet or more down into the solid Niagara limestone. The Ohio River valley, a trench from one to six miles wide and 400 feet deep, was mainly eroded during this period, as was also the greater portion of the Wabash Valley, from Huntington to its mouth. Everywhere over the surface was a thin soil, formed from decaying rocks and vegetation, poorer, perhaps, than much of that which at present covers the surface of the driftless area, where the underlying limestones and shales have been the parent rock. In this soil grew the cedar and the sassafras, the willow and the maple, the oak and the beech, while over its surface spread many of the coarser grasses, sedges and mosses of the present day.

During these long periods of erosion and decay, mild climatic conditions had prevailed. But near the close of the Tertiary a change in these conditions came gradually to pass—a change which was most sweeping and far-reaching in its final results. For some, as yet unknown, reason, the mean annual temperature of the northern hemisphere became much lower. The climate of the regions to the east and south of Hudson's Bay became similar to that of Greenland of today, or even colder. The snow, ever falling, never melting, accumulated during hundreds of centuries in one vast field of enormous thickness. Near the bottom of this mass a plastic, porous sort of ice was gradually formed from the snow by the pressure from above. This ice mass or glacier took upon itself a slow, almost imperceptible motion to the south or southwestward, until it covered three-fourths or more of what is now Indiana. As it moved slowly southward great masses of partly-decayed rock and clay from hillsides and jutting cliffs rolled down upon it and were carried on and on until, by the melting of their icy steed, they were dropped hundreds of miles from the parent ledge. Large irregular masses of rock from the region in which the glacier was formed were either frozen into its nether portion or rolled along beneath it, and as the ice sheet moved they served as great stone drags, grinding down and smoothing off the hills and ridges and filling up the valleys, until the irregular, uneven surface of the old preglacial rocks was planed and polished.

From the striæ formed by these imprisoned boulders and from other evidence which it is difficult to otherwise explain, it is now believed that there were several distinct epochs in the glacial period. The great ice sheet, which was at first formed, several times advanced and as often—by an increase of the temperature of the region which it entered—melted and receded; its retreat or recession being each time as gradual as its advance had been. Like a great army which has attempted the invasion of a country and has been compelled to withdraw, it would again assemble its forces and start in a slightly different direction. But, perchance, before it had reached the limit of its former invasion a force of circumstances would render a retreat necessary. Its advancing margin was thus not in a straight line, but in lobes, or long, gradual curves.

When the first ice sheet reached its greatest advance into the region now comprising Indiana, the ice "was at least 500 or 600 feet deep over



the present site of Terre Haute and nearly as deep over that of Indianapolis, and it thickened gradually northward. If an observer could have stood on one of the hills in Brown county at that time, he would have seen to the east of him the great wall of the ice front extending south toward Kentucky, while toward the west it would have been seen in the distance stretching away toward the southwest. For hundreds of miles to the east and west, and for 2,000 miles or more to the north, the glaring, white desert of snow-covered ice, like that seen in the interior of Greenland by Nansen and Peary, would have appeared, stretching away out of sight, with not a thing under the sun to relieve its cold monotony."

By the incursions of the various ice sheets all the so-called "drift soils" of northern and central Indiana were accumulated where they lie. Derived, as they were, in part, from the various primary and igneous rocks in the far north, ground fine and thoroughly mixed as they were by the onward moving force of a mighty glacier, they are unusually rich in all the necessary constituents of plant food. Principally to them does Indiana owe her present high rank as an agricultural state. All the level and more fertile counties lie within this drift covered area, and its southern limit marks, practically, the boundary of the great corn and wheat producing portion of the State. But few of the present inhabitants of Indiana realize how much they owe to this glacial invasion of our domain in the misty past. It not only determined the character of the soil, the contour of the country and the minor lines of drainage, but in manifold other ways had to do with the pleasure, the health and the prosperity of the present population.

When the final ice sheet gradually receded from the area now comprising Indiana, the surface of the glaciated portion was left covered with a sheet of drift or till composed mainly of clay, gravel and boulders, and varying in thickness from one to 400 feet or more. Over the greater portion of this area the surface of the drift was comparatively level, but in the northern fourth of the State it was in numerous places heaped up in extensive ridges and hills, due to irregular dumping along the margins and between the lobes of the melting ice sheets. In the hollows or low places between those ridges and hills the waters of the melting ice accumulated and formed those hundreds of fresh water lakes which are today the most beautiful and expressive features of the landscape in the region wherein they abound. At first all of those yet in existence were much larger than now, while for every one remaining a score have become extinct.

A new vegetation soon sprang up over the land left desolate and barren by the retreating ice. The climate gradually became much warmer than it is today. The great expanse of water in lakes and rivers, aided by the increase in temperature, gave rise to excessive moisture. Fostered by the rich soil and the mild, moist atmosphere, a vast forest of deciduous trees spread over the larger portion of our State. Through this forest and about the margins of the lakes and marshes there wandered for centuries the mammoth and the mastodon, the giant bison and the elk, the tapir and the peccary, the mighty sloth and that king of rodents, *Castoroides ohioensis*. Preying upon these and smaller mammals were the great American lion, and tigers and wolves of mammoth size. The bones and teeth of all of these species of extinct animals have been found buried beneath the surfaces of former bogs and marshes in various portions of the State. It is not improbable that with them was also that higher mammal—man—in all the nakedness of his primitive existence.

But over this phase in the evolution of the future Indiana there came again a change, for nature knows no such thing as rest. The great rivers which had borne south and southwestwardly the floods and debris of the melting glaciers gradually diminished in size and filled but a small portion of their former valleys. Extensive shallow lakes in the northwestern part of our present area gave way to marshes and these, in time, to wet prairies, possessing a rich black soil derived largely from the decay of aquatic vegetation. The climate gradually grew less moist, more cool. The mammoth, the mastodon and contemporaneous mammals disappeared, and in their stead came countless thousands of buffalo and deer. With them came, too, that son of Nature—that descendant of the naked barbarians of centuries before—the noble Red Man. From out of that dark night which hangs forever over all we know or shall know of early America he came—a waif flung by the surge of time to these later ages of our own.

With the advent of the Red Man the "Indiana of Nature" was complete, was perfect. It possessed that primeval savage beauty of a world unmarred by man. Lakes, streams, forests, prairies, stored fuel, noble game—all were here. For centuries the Indian lived in peace within its bounds. The forest yielded him bear and deer—the prairies, buffalo and wild fowl. On the higher ridges, overlooking the larger streams and lakes, he had his principal village sites. Over their placid waters he paddled his birch bark canoe. From their depths he secured with spear and hook fishes sufficient to supply his needs; while the skins of muskrat, otter and beaver which he trapped about their marshy margins furnished him protection against the cold. Through the forest glades, when returning from the chase, his cries of triumph were echoed. Here, in a land of plenty, his wants were few and easily satisfied; his ambitions lowly, his hopes eternal.

But to this, as to all things peaceful, there was an end. From across the seas came that "prince of parasites," the white man—self-styled heir to all the ages—so-called conqueror and civilizer—but in reality the greatest devastator that Nature has ever known. First as a discoverer came he. Then as a trapper and trader among the Indians; last as a settler of the future State. His first permanent hamlets or settlements were, like those of the Indians, located on the larger streams. From these he penetrated farther and farther the forest, building his cabins wherever a spring purled forth from a hillside to furnish water. In less than two centuries—a mere second as compared with those measureless eternities before he came—the white man has changed beyond recognition the "Indiana of Nature." Only its outlines remain as they were.

From its bounds he has driven forever the buffalo, bear, panther, elk, deer, wild turkey, ivory-billed woodpecker, paroquet and wild pigeon, together with the noble Red Man, the one-time contemporary and lord of them all. From its surface he has cleared that dense forest of tall trees—of which no domain could boast a better—leaving in its stead a mere remnant of what would have been termed underbrush a century ago. Following the felling of the forests came, as a direct result, the drying up of springs and the dwindling to mere rivulets of former creeks and streams. To gain control over a few more acres of mother earth, he has dredged deep ditches and so lessened greatly the size or brought about the total extinction of 90 per cent. of those crystal lakes which once gave variety and beauty to the northern fourth of the State.

He has caused the picturesque trails and woodland paths of the Indian to disappear, and in their stead we find, at intervals of a mile or two, those broad unshaded roadways, many of which are floods of dust in summer and seas of mud in winter. As a complement to these he has, in nearly every county, leveled hills, filled up valleys, bridged streams, and stretched long bands of steel spiked to wooden ties. Drawn by the harnessed forces of Nature, he rushes over these at almost lightning speed; while along them he sends, with many a roar and rumble, those necessities and luxuries of his artificial life.

Not content with his destruction of the natural beauty of the surface of the State, he has delved deep into its depths, in search of those riches of stored power, there hidden since the sun gave up its heat and light to the plant cells of the old Silurian seas and Carboniferous marshes. With his iron drill he sunk, in eighteen years, ten thousand vents to the Trenton rock. Through these there poured natural gas valued, even at the extremely low price at which it was sold, at $77,618,189. So greedy was he, so ignorant of the real value of this gaseous fuel and the manner of its formation, so reckless in its consumption, that at the end of less than a score of years there remains only the dregs of the plenty that has been.

As with natural gas, so with its mother liquid, crude petroleum. Since 1891, 16,975 bores have been sunk within the limits of the State, for it alone. Through these 55,172,755 barrels of oil, valued at $42,757,834, have reached the surface. But few years will elapse before the stored supply of it, too, will have vanished. A priceless gift of nature—hundreds of millions of years in forming—it will be sacrificed to the greed of the white man in less than the life of a generation of his kind.

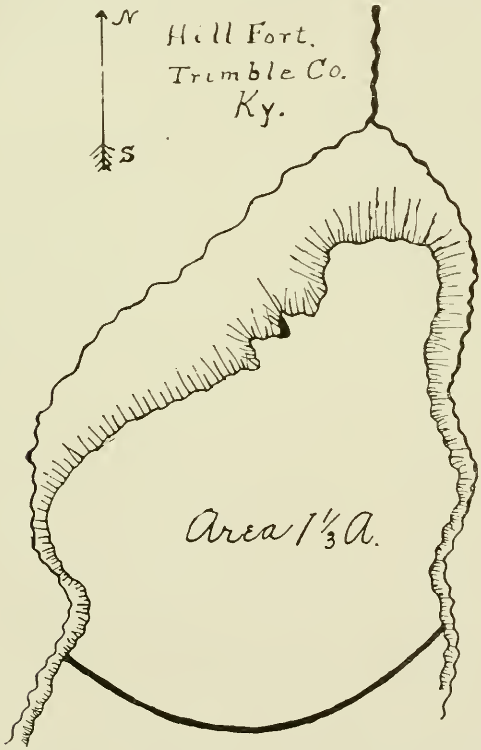
More valuable than either gas or oil, closer to the surface and, therefore, more easily secured, are those vast veins of coal which underlie the southwestern area of our State. For sixty years man has sunk his shafts and pitholes to their levels, and tunneled miles along their courses, until the output has risen above nine million tons per annum. Less than two centuries will see the end of this stored fuel, and Indiana will then have been raped of all those riches which, in the ages past, were formed beneath her surface.

But why continue? Examples manifold could yet be given of the changes wrought by man since first he gave the name Indiana to the area in which we dwell—changes which one and all have but marred the face of nature and left everywhere the signs of his greed, his egoism. Only the great blue ethereal dome—the sun which shines and rules over all—the moon, cold and lifeless—the stars, gleaming from their heights in the realms of space—the clouds which oftentimes hide even these from view—seem as they were when the Indiana of Nature was first perfected.

A Prehistoric Fortification Near Madison, Indiana.

By Glenn Culbertson.

On the farm of Mrs. James Snyder in Trimble county, Ky., and at the head of Broadway Hollow, so-called because it is directly across the Ohio river from Broadway in Madison. Ind., is located a prehistoric fortification. To a few people in the immediate vicintiy this fortification is



known as the Indian fort, but to my knowledge it has never been described, although it is one of the most interesting remains of prehistoric people in all that region.

The hills in the vicinity of Madison are approximately four hundred feet above low water level of the Ohio river. They are capped by the resistant Niagara and Clinton limestones, underlaid by the soft Hudson shales. Hence bluffs and precipitous slopes are not at all infrequent. The fortification, mentioned, is situated about a half mile back from the bluffs and steep slopes facing the Ohio, and between the two principal tributaries of the stream which occupies Broadway Hollow. These streams have eroded deep but narrow valleys which in the upper portions are enclosed in part by perpendicular cliffs.

The fortification, as may be seen from the map, is roughly triangular in shape and is bounded by cliffs some 75 feet high near the apex at the north end. These cliffs become lower gradually as the south side of the fortification is approached. At the southwest angle the height is still some thirty feet, while at the southeast angle the height of the cliff is at present not more than eight or ten feet.

The neck of land beeween the two streams at the south was fortified by means of a stone and earth wall, with a ditch or moat on the outside. The remains of the wall, except on the steeper slopes near the ends, form a mass of earth and stones some ten feet wide at base and three or four feet high. The ditch outside is still six or eight feet wide and has a maximum depth of two or three feet below the original surface. The wall was about one hundred and twenty yards long and strongly curved outwards. The area of the fortification proper is about one and one-third acres, and as the site of the fort has never been cleared of its forest growth, it is still covered with thick underbrush and small trees.

The fortification is admirably located for the purpose of defense. On two sides of the triangle it would be almost impossible for an enemy to enter the fort even if undefended, except, perhaps, at the southeast angle, where in all probability a supplementary wall was built. The stone and earth wall across the neck may have been, and probably was, surmounted by a stockade, as was done in case of many of the prehistoric fortifications in Ohio. There are, at present, however, no evidences of a stockade visible.

Of the different kinds of prehistoric fortifications now known and recognized, viz., signal and observatory stations, stockade forts, hill forts and stone forts, this one should probably be classified as a hill fort, and was intended as a place of retreat on the approach of an enemy. The tribe or clan using the fort probably cultivated the fertile bottom lands near, and fled to the fort as occasion demanded. This fortification may have been used as an observatory and signal station, also, but was not one of a series known to extend along either side of the Ohio River, since from this point it is impossible to see or be seen from the Ohio at any distance either up or down. The site is an admirable one, however, for signaling across to the headwaters of Indian Kentucky creek, in Indiana, along which are found many evidences of prehistoric inhabitants. There are no visible ash or charcoal remains in the vicinity of the fort, so the signal theory remains unproven.

A Note on the Breeding Habits of the Common or White Sucker.

By Glenn Culbertson.

While fishing on Big Creek in Jefferson County, Ind., last April the writer had an opportunity to observe at short range the spawning habits of the common White Sucker (Catostomus teres). It is the habit of this fish to spawn in the swiftly flowing water of ripples rather than in the still water of pools, and if I am not mistaken during the night rather than the day.

In the case under observation there was a school of suckers, some twenty or twenty-five in number, and ranging in size from nine or ten inches to thirteen or fourteen inches in length. The location was a short reach of swift water some three or four inches in depth, between two large pools. The ripple was close to a steep bank and was overhung by the branches of trees, making the place rather dark even at noon. The fish with few exceptions were constantly swimming about, now in the deeper water and, again for a short time in the shallow water of the ripples. A few were lying quietly on the bottom in the swift water.

My attention on observing the school for a few minutes was soon attracted to a large female, thirteen or fourteen inches in length and two males about ten or eleven inches long. Whenever this particular female swam from the pool above down into the swift water, the two males, which always swam approximately side by side, and some five or six inches apart, would endeavor to pass one on either side of the female. In the one case where the actual spawning occurred, the two males reached positions close to and on either side of the female and with the anterior portions of their heads some two inches farther back than that of the female, the heads of all being upstream. While thus stationary in this position the males struck the female each with head and then tail, alternately, and with great rapidity. This motion was continued some four or five seconds. At the same time, the swift water of the ripple below the spawning fish became of a milky white color, due to the spermatic fluid of the males. On taking the same female a few minutes later the spawn was found to be abundant and to pass very readily from the body. On taking two or three of the males the usually smooth portion of the heads was found to be covered with numerous tubercles from one to two millimeters long. The tail fins of the males were also found with rows of similar tubercles along the rays. No tubercles were found on the female.

The spawn could have done nothing else than to have floated off into the still water of the pool below, where some may have found lodgment among the water plants.

Whether polyandry, or perhaps more exactly diandry, if the term may be so used, is always the habit of the female sucker I am unable to say, but in this case it certainly was.

Notes on the Caves of Cuba.

By J. W. Beede.
(By title.)

Effect of Ultraviolet Light on the Action of the Coherer.

By Arthur L. Foley.
(By title.)

The Life of Radium.

By Arthur L. Foley.
(By title.)

"Colds" and Cold.

By Robert Hessler.

It is often said that on account of variable weather conditions, that is, sudden and violent atmospheric changes, the climate of Indiana is an unhealthy one and that this is the reason why "colds" are so common among us. Now is this true, especially the deduction?

Most of us, I believe, will admit that changes in temperature are rather sudden at times and that the daily weather conditions are quite variable, but that our climate—that is, the sum total of all weather conditions for long periods of time—is one conducive to the production of "colds," per se, may be denied by some.

Now when I speak of a "cold" I am assuming that everybody knows what that means. A cold—why, yes, of course. Everybody knows what a cold is.

As a matter of fact many think they know—which is something entirely different. We all know the dictionary definition: "Cold.—An indisposition commonly ascribed to exposure to cold; especially, a catarrhal inflammation of the mucous membrane of the nose, pharynx, larynx, trachea, bronchi, or bronchal tubes." (Century.)

Physicians use the term very freely in conversation or consultation with their patients. There is good reason for this. When the patient comes to the physician he not only wants a medicine or a prescription but he also wants to know about his disease or affection; he will want to know the name at least, and very likely also the cause. We all want an explanation of what is wrong when we are sick, and the simpler the explanation the better. If the physician wants to be exact and gives the explanation in technical terms that have a definite meaning, then he must explain the terms themselves, all of which takes a lot of time—and so the busy practitioner has recourse to a number of terms and phrases which have long been in use and with which the laity are familiar. When, therefore, the anxious patient asks for the common name of his disease or for its cause, and the knowing physician answers assuringly and perhaps authoritatively the magic word "cold," all is serene. Such words as cold, rheumatism, malaria and the like are timesavers. Such terms are often used both in the sense of cause and effect.

Well, I don't see where I got my cold or caught my cold, the patient will say. Well, I don't either, the physician may reply, while he writes the prescription or puts up the bottle of medicine. In the meantime the patient will mentally go over the events of the past few days until he finds where, as he thinks, he has exposed himself to cold, perhaps to a draught or went out bareheaded; and then he is able to account for his illness or for his "cold." This is all very simple.

Now, as a matter of fact the term cold as ordinarily understood as an ailment, or even as a cause for an ailment, has practically gone out of use among physicians themselves, and the word is seldom seen in the best medical literature of today.

But let us return to the popular use of the term. Colds in the human body have a most varied form of manifestation. A cold in the head is perhaps the most common. We often hear of colds settling in certain parts of the body or of traveling about from one organ to another. A cold which begins in the nose may travel down into the lungs or down the alimentary tract. Affections with different names may follow, such as catarrh, or tonsilitis, bronchitis or pneumonia, or congestion of the stomach or liver or kidneys; we also hear of colds in the eyes and ears.

Now a "cold" in the sense of a bodily ailment is by many of us intimately connected with cold in the physical sense, that is, the absence of heat or a lessened amount of heat in the atmosphere. An ingenious explanation that I once heard was this: A sudden alternation of heat and cold acts on the mucous membrane as it does on glass—it causes it to crack, and then disease results. This would be a simple explanation why Indiana, with its great and sudden variations in temperature, is unhealthy.

Now, this sounds plausible, and yet we are told by arctic explorers that they are singularly free from colds—and acute respiratory affections generally—while in the far north, notwithstanding that they go from their warm huts or cabins out into the intense arctic cold, where the contrast is much greater than any changes in Indiana. It would seem that if a cracking of mucous membranes takes place at all it would certainly take place there, and disease result.

It is a common observation that colds are most prevalent among us during the cold season, and so we naturally associate cold with "colds," yet explorers tell us that "colds" are practically unknown in the far north —there must need be some other explanation.

Our domestic animals with an anatomy and physiology closely resembling our own are not subject, at least to any extent, to diseases of the respiratory tract or to colds.

If our State is unhealthy, I believe we must look elsewhere than to the climate to account for the prevalence of respiratory diseases, and especially colds. The old pioneers and the farmers at the present time living in thinly-settled districts do not complain of the climate; they have been and are healthy.

The use of natural gas and overheated rooms is a fruitful cause of colds, we are told. Fires burn day and night and dry out the atmosphere, and this causes the respiratory mucous membranes to become dry and inflamed. This sounds reasonable, but, we may ask, why do not the inhabitants of dry, arid plains or deserts—with an exceedingly hot and dry atmosphere, exceeding that of our rooms—why do they not suffer from inflammations and colds? The Bedouins are said to have such delicate or sensitive mucous membranes that they can not bear the odor of a city; however, at times of windstorms they get nose and throat full of sand and dust and yet they are none the worse the day after.

Physicists tell us that the amount of moisture the air is capable of holding depends on its temperature; the higher the temperature the more moisture it can hold. A very cold air may be a very dry air which may take up considerable moisture on coming in contact with the respiratory membranes—yet it is known that in an otherwise pure atmosphere no harm results. On the other hand, a hot, dry desert atmosphere may take up considerable moisture from these membranes, and this is readily supplied as long as the body contains sufficient fluid or where there is no excessive thirst. We see practically the same conditions in an iron foundry or rolling mill. In this excessively hot atmosphere the respiratory membranes of the men may suffer very little because they give off the fluid so freely supplied the body as drink. Membranes keep themselves moist in a dry atmosphere just as the skin keeps itself moist. As a matter of fact, the amount of moisture or the dryness of the air has nothing to do with the production of colds—other things being equal.

A variation of this hot-air and dry-room theory is that it is necessary to come in contact with the outer raw air before inflammation results; that this first brings on a congestion and this in turn is followed by the inflammation or the cold. We may also be told that improper clothing plays an important part; that we either bundle up too much or that we do not dress warmly enough. Some persons account for their colds by the underwear used, both as regards material and texture.

Now, it is well known that individuals who in town are subject to colds will be free from them on going to the wild woods. The experience of hunters far away from civilization is of interest in this connection; they will undergo all sorts of hardships and exposures, get wet and cold, leave their little cabin with its red hot stove and step out into the cold winter air and back again, and yet they do not take cold.

Taking it all in all, it would seem that we will have to look elsewhere than to exposure to physical cold for the production of the affection we know as a "cold." It is not to be denied that we do take colds after an exposure, as we all know from experience, but there must be some other factor involved. Indeed, long ago that patient scientist and philosopher, Benjamin Franklin, arrived at this conclusion. In his autobiography are recorded a number of observations that he made on colds, and he came to the conclusion that simple exposure to cold was not a sufficient cause. What this something, this unknown factor, is he did not know—in fact we are just beginning to find out. I am almost inclined to believe that if Ben Franklin had been a physician or had had the education of a physician we would have known long ago.

Now, we have been using the term "a cold" without any real definition of its meeting; we assumed that everybody knows what a cold is, but as a matter of fact there is a whole list of words used by the laity in a loose way which all stand for the same thing. A cough or a running nose, headache, sore throat, catarrhal affections, tonsilitis, stiff neck, pleurisy, rheumatism, neuralgia, lumbago, gout, fever, malaria, inflammation or soreness of the kidneys and so forth, are either synonyms for a cold or are said to be due to cold or that a cold has settled in some particular part of the body.

For instance, the significance or meaning of the term malaria as ordinarily used may at first sight seem obscure, but it is very frequently used in those cases of "cold" where there is considerable fever and perhaps some chills. As a matter of fact, real malarial fever is a comparatively rare disease and is practically absent during the winter months. It can be definitely diagnosed by an examination of the blood, and cases usually require active medication, that is, the use of some antiperiodic like quinine, before recovery takes place. Self-diagnosed cases of "malaria," that is "colds," usually get well in a short time, and without the use of large doses of quinine.

Popular medical terms are used in a very loose way and physicians using them among each other are constantly compelled to define them or explain just what is meant—and we all know of the proverbial doctors' quarrel.

Now, if a physician speaking before a medical society or in writing for a first-class medical journal used the term "a cold" and had to give a definition he likely would find it a difficult task. Perhaps on examining the underlying facts we may arrive at some definite conclusions and perhaps be able to make a definition. It would likely be something after this fashion: A cold is the reaction of the body toward some irritant or infective matter, the amount of reaction depending on the amount of this matter and its localization in the body; the reaction may be general or local; it differs from the specific fevers by its history.

During a cold some irritant substance is in the body. This irritant may differ in different forms of cold. The inhalation of certain gases or chemicals or vegetable substances may be followed by a transient cold. Some forms are regarded as due to the inhalation of pollen, as rose cold and hay fever; other forms occur in diseases like measles, scarlet fever and the like. A common cold differs from these special forms by its history.

As to causes: "Getting chilled" or "overheated," or "getting the feet wet" are not real causes of common colds—they are regarded as simply exciting causes or of opening up the avenues for the real cause. They stand in about the same relation as the plowing of the field does to the sowing of the seed--you can plow and harrow and prepare the ground as much as you please, but no crop will follow unless you seed the prepared ground. A "cold" will not follow an exposure to cold in the physical sense unless the seeds are present—and this is why arctic explorers are free from colds. Moreover, we know from experience that we can catch a cold in the hot summer days as well as in the winter time.

This brings up the question: Where do we get the seed of a cold? As elsewhere, we get the seed from a previous crop. We get our colds from persons who have colds especially that aggravating form of cold known as catarrh.

How is it transmitted? may next be asked. Through the agency of the dust we inhale, is the answer.

A short time ago we spoke of infective matter; this infective matter is the seed, placed in the dust by persons who have colds.

Now, this is all theory, some will exclaim. Let us admit it is a theory. Now, a theory is of value if it explains phenomena and in proportion as it explains it becomes a true theory; moreover, a working theory has value in enabling us to predict.

Let me cite a few instances or examples and see how this infective dust theory, if you choose to call it so, works out.

Men who in towns are constantly afflicted with colds and catarrhs, with pains and aches in the joints, and with headaches, are often singularly free from these complaints while in the country for an extended period. It is true that mode of life has something to do with this; the exercise, the plain food, etc., all contribute to their well-being, but one factor stands out above all others—the pure atmosphere with the absence of infective dust.

It has long been noticed by those susceptible to colds that a cold often follows a ride on the railway, and it is usually ascribed to some draught—to some open window or door. In reality it is due to the highly contaminated air of the car—the aisles at times resemble in filthiness the habitation of some domestic animal.

Since interurban cars have come into use a new phase of this question of railway colds, so to speak, has developed. The open car furnishes an abundance of fresh air while the closed one in the winter season may not differ greatly from the steam road cars in regard to the polluted atmosphere. Susceptible persons have often been puzzled how they catch cold on a closed car on a comparatively warm day and do not catch cold in an open car on a cold, raw day, say in the fall before the open cars are taken off. The one is all draught and the other has practically no draught. The discerning individual will readily see that the air of one is pure, while that of the other is not.

Individual susceptibility of course varies greatly. Some persons seem almost immune, or succumb only after an unusual exposure; the attack itself may be slight or severe.

Some men habitually employed in situations with infected dust seem almost immune. Railroad passenger conductors are usually the picture of health. This is easily explained: it is simply the action of the law of the survival of the fittest. The managers of our railways are careful whom they employ and still more careful whom they advance. A conductor reaches his position by successive advancements, or the man best suited to the position gets the place. A consumptive conductor or one with a red, inflamed nose or watery eyes, or subject to chronic hoarseness, is almost an anomaly on our large railways—if such a man did not resign of his own accord because of his inability to adapt himself to the conditions, it certainly would not take long until the management "fired" him.

This weeding out process plays a most important part throughout life. The most susceptible perish early; long lived individuals are found mainly in thinly settled regions. It is often said of the backwood mountaineers of some of our Southern States that they do not die; they simply wither up of old age.

It is not to be understood that everybody is susceptible to dust infections: as in all other diseases, there are always some persons who escape, or who are attacked so slightly at the time of the prevalence of an epidemic that we can scarcely consider them affected. On the other hand, some individuals complain severely after each exposure, after a railway journey, or after the prevalence of a windstorm or after attending a crowded hall with poor ventilation, in fact any place where the atmosphere is contaminated. The cold may show itself the same day or not for several weeks, as in the case of pleurisy. With many persons about who are infected, the chance of becoming infected is of course greater.

The habit of sweeping and dusting a closed room while persons are compelled to be in it is a most reprehensible one—the dust stirred into the air irritates the respiratory mucous membranes, to say the least, and the feather duster is a fruitful source of coughs and colds; it is too often brought into action to dust the seats and furniture in a room or hall just prior to the arrival of an audience.* The accumulated dust of a week or more may be suspended in the air ready for inhalation, and we think little about it, although a thick layer of dust on a chair we are about to occupy strongly attracts our attention, and yet it is infinitely worse to inhale the dust than it is to get it on our clothing. It is evident that this stirred up

*Note.—To my certain knowledge this very thing occurred in the room where the Academy met; dust which lay thickly on the chairs was stirred up with a feather duster half an hour before we met. The amount of coughing and sneezing at the time this paper was read was so noticeable that the newspapers called attention to it.

dust is redeposited on our respiratory mucous membranes and only too often with evil results.

I have had many persons under observation who are subject to this dust infection, and where the source of their cold could be readily traced, and who, moreover, suffered less after it was explained to them how they catch cold—and in proportion as they have been able to avoid the inhalation of an infected dust atmosphere they have found the climate of Indiana a healthy one.

City and town people are, of course, the worst sufferers, and a sedentary life with a body habitually overloaded with food and waste products is a contributing factor—such a life places the body at a disadvantage in warding off or in resisting disease. Colds, moreover, often allow the entrance and spread of other diseases. We can frequently trace a dangerous disease back to the time of a "cold."

The subject is a serious one. According to the recent report of the Indiana State Board of Health last year, a total of 7,607 persons found their death breathing dust-laden air. Indeed, if the whole truth were known the total number would be even greater. The number of persons who are simply affected, made sick, and who do not die from the attacks of cold and diseases traceable to colds, is an extremely large one.

The experience of arctic explorers in the far north has already been referred to. Although severely exposed to cold, they are free from colds, and now it should be added that the moment they return to civilization they suffer most acutely.

We might be tempted to ask: Are "colds" a product of civilization? It would seem so. Civilized countries, however, differ greatly in the prevalence of colds and catarrhs and a host of infections due to infected dust—a number of which have already been mentioned. The inhabitants of many European countries suffer but little; inhabitants of the United States suffer greatly, and in our State colds and catarrhs are almost universal. I believe it was Charles Dickens who remarked about the accurate aim of the American in spitting, and travelers from the old world are amazed at the condition of our sidewalks and floors of public halls and railway coaches.

How far do we have to go to find the cause for the so-called unhealthy condition of Indiana It would seem that if our State is unhealthy, man himself has made it so.

I might stop here, but I am inclined to think that some one will say that the term "infective dust" is rather vague. A pathologist or bacteriologist would demand something more definite. He will likely call our attention to the little bits of yellowish or greenish matter which we so frequently spit up and which is coughed up in large quantities by persons severely afflicted with inflammation of the respiratory tract. He will tell us that this matter is made up mainly of white cells from the blood which have been killed off in the struggle with this so-called infective matter, and he will mention a lot of big names that are Greek to 999 in every 1,000 persons.

Now, I have purposely refrained from making use of the term microbe. A wise sanitarian has said that as long as you speak of infective matter you come in for very little criticism, but the moment you mention microbes the newspapers jump on you and ridicule the idea that dust is dangerous or that it is dangerous to spit whenever and wherever we choose. The newspapers are great factors in disseminating useful knowledge, and if they will not speak ill of infected dust but will antagonize any statements based on microbes, it seems to me that we would best stop and let the bacteriologist continue the discussion.

A Method of Determining the Absolute Dilation of Mercury.

By Arthur L. Foley.

(By title.)

What Bacteriology Has Done for Sanitary Science.

By Severance Burrage.

Sanitation, the science of disease prevention, has been practiced variously and in varying degrees from time immemorial; but it was of little importance and remained in comparative obscurity and impotence until the birth of bacteriology in the latter part of the nineteenth century. The establishment of this new science by Robert Koch in 1881 marked a most important epoch in the history and practice of preventive medicine. Sanitation at once became transformed from a puny, uncertain, "hit or miss" science into one of the most important factors in modern civilization. The causes of many diseases being positively known, the possible causes of many others being inferred, the sanitarian had the most important key in his possession for the prevention of those diseases. In other words, he became much better fitted to practice his profession. Furthermore, each separate branch of sanitary science has received from the bacteriologist definite knowledge which has made it far more exact and practical, and correspondingly more efficient.

Take for example the subject of disinfection. This science in various forms has been practiced for many centuries. Ovid states with regard to it, that sulphur was used by the shepherd of his time for purifying wool from contagious diseases. At the time of Hippocrates sulphur was used as a preventive against plague. While good results were often obtained by pursuing these and other such practices, the exact reasons for the results were not understood. Today, however, the bacteriologists have shown by exhaustive and conclusive experiments that certain specific disease germs are destroyed by certain disinfectants under certain conditions. They have also shown that the spores of certain bacteria will not be killed by the same processes which destroy the vegetative forms of the same species. Thus they are able to tell us that some of the ancient practices were entirely useless, others were quite unnecessary, while still others were very efficient.

More than 400 years B. C., Hippocrates advised that all polluted water should be boiled and filtered before being used for drinking purposes. Today we know what constitutes dangerous pollution, and the bacteriologist tells us precisely what the processes of boiling and filtering do to this pollution in the water. He can very readily detect a polluted water by analysis, and aside from showing the presence of pathogenic bacteria, he can show the presence as well of those bacteria which come only from sewage. Along this same line bacteriology is indispensable to the sanitary scientist in testing the efficiency of water filters, both large and small. In the matter of sewage disposal, he has shown the effects of the soil bacteria in destroying the infectious material in filth which is spread over the surface of the ground, or upon filter beds; and again, in the putrefying action in the septic tank, he has shown an efficient purification.

It is now known through the researches of the bacteriologists that the typhoid bacillus and other pathogenic bacteria can and do resist the freezing temperatures for many weeks. Hence the freezing of water does not necessarily purify it of all of its disease-producing agencies.

It has been shown that the changes which occur in milk are wholly due to bacteria. Hence the bacteriologist has pointed out the necessity of bacteriological cleanliness in and about the dairies. Oftentimes disease germs may be found in the milk, pointing to the need of inspection of dairies and the careful supervision of our public milk supplies.

Putrefactive changes in meat and other foods, due to bacterial growths, result oftentimes in the production of ptomaines. Therefore care should be exercised in the sale of meat and other foods. Fruits and vegetables are known to harbor germs on their outer skins, and, when handled by infected persons, may result in spreading disease. Undoubtedly this is the source of many so-called sporadic cases of disease. Experiments have shown that the typhoid bacillus may remain alive in the stomach of the living oyster for several weeks. Serious epidemics of typhoid fever have been spread through the agency of oysters which were fattened in sewage polluted waters.

The masterly researches of Pasteur, Tyndall and Lister resulted in the protection of wounds from infection, and made it possible to undertake previously impossible surgical operations. They simply proved the presence of germs in the dust of the air, and showed the necessity of keeping this germ-bearing dust away from the vicinity of the operating table.

Bacteriology assists materially in the prompt diagnosis of many of the contagious diseases, such as diphtheria and tuberculosis, making early isolation and quarantine possible.

The old idea that consumption was a constitutional disease has been exploded. Dr. Koch, in 1882, declared this to be a germ disease. Experience has shown that there are as many as two million bacteria in a single expectoration. It is undoubtedly through the medium of the sputum that most of the consumption is spread, and these facts point out the necessity and importance of precautionary measures.

There have been many recent discoveries made by bacteriologists showing that certain diseases are due, not to bacteria, but to animal parasites, protozoa. There are many cases in which these animal parasites appear to be carried through the agency of insects. An example of this is the carrying of malaria germs by the mosquito. This has led the sanitarian to make important crusades against the mosquito, destroying their breeding places, and in this way checking a spread of the disease.

Experiments with the common house fly have shown that these insects carry infected material on their legs and probosces. Hence the need of disinfecting all germ-bearing material which may come within the reach of the fly. Also the destruction of their breeding places so as to reduce as far as possible the numbers of these insects.

The discovery of antitoxic serums, the direct or indirect products of bacterial action and growth, have been a great advance in bacteriology and medicine, not only for the curing of disease, but, more important, for protection against disease as well. The use of protective serums is now in its infancy, and I look forward to the time when the bacteriologist shall have discovered or manufactured, with the assistance of the bacteria, a serum or mixture of serums with which we may be inoculated, and thereby protected against all diseases, perhaps throughout life. That would indeed be a great factor in preventive medicine.

These facts show briefly the great and incalculable assistance given to sanitary science by one of the youngest of the many "ologies." That the sanitary scientists have taken advantage of this aid is evidenced by the attention which they everywhere receive, and the importance which is now attached to their dictum and doings. They can now compel legislation to enforce safeguards against disease, and it is a benighted community that does not respect these measures. These measures protect the state, municipality and the home; they affect schoolhouses, public buildings, foods, and street cleaning; in fact, there is hardly a phase of social or industrial life that is not reached by the arm of sanitary precautions. Further evidence is shown by a study of vital statistics during the past fifty years, wherein may be seen a marked reduction in the deaths from all preventable diseases. All of this has come about, and much more is yet to come, I believe, through this renaissance period in the science of sanitation, marked by the establishment of the germ theory of disease and the birth of bacteriology. From that time the bacteriolcgist and the sanitarian have marched hand in hand in their grand fight against disease and death.

On the Use of Nickel in the Core of the Marconi Magnetic Coherer.

By Arthur L. Foley.

The magnetic detector of electric waves, described and used by Marconi,* consisted of a "core or rod of thin iron wires on which were wound one or two layers of thin insulated copper wire. Over this winding insulating material was placed, and over this again, another longer winding of thin copper wire contained in a narrow bobbin." One terminal of the inside winding was connected to earth, the other to an elevated conductor. The ends of the outside winding were connected to a telephone. A horseshoe magnet, suitably placed, was moved by clockwork so as to cause a continuous change or successive reversals of the magnetism of the iron core. Electric oscillations of suitable period appeared to reduce the effects of magnetic hysteresis, hence the magnetism of the iron core increased or decreased suddenly with each spark of the transmitter, inducing a current in the outer winding connected to the telephone. Marconi had (June, 1902) used this apparatus for some months in the reception of wireless telegraph messages over a distance of 152 miles, and with less power employed at the transmitting station than would have been required had he used a reliable coherer instead of the magnetic detector.

Marconi noticed that "the signals in the telephone are weakest when the poles of the rotating magnet have just passed the core and are increasing their distance from it, whilst they are strongest when the magnet poles are approaching the core." To obtain more definite results on this point I arranged to use a ballistic galvanometer instead of a telephone, and to take readings for various determined positions of the magnet and core.

The core, which was 5 cm. long, consisted of twenty-six pieces of annealed piano wire, .063 cm. in diameter. Over this was wound a single layer of two hundred turns of silk insulated copper wire No. 36, giving a total diameter of core and coil of approximately .4 cm. One end of the coil was connected to a vertical wire 200 cm. long; the other end was put to earth.

*Note on a Magnetic Detector of Electric Waves, by G. Marconi, Proceedings of the Royal Society, Vol. LXX, No. 463, July 29, 1902.

The outer or secondary coil, consisting of one thousand turns of No. 30 wire, was wound on a wooden spool of such dimensions that the coil itself was 1.7 cm. long and .6 cm. in diameter (inside). The terminals of this coil were connected to a Rowland D'Arsonval galvanometer through a key arranged to short-circuit the galvanometer after each throw of the needle. This brought the needle to rest very quickly, and permitted the position of the magnet to be changed without affecting the galvanometer.

The induction coil (one inch) of the transmitter was operated by a storage cell and was adjusted to give a 2 mm. spark between two small brass spheres, one connected to a vertical wire 200 cm. long, the other to earth. The distance between the transmitter and receiver was varied from two meters to twenty meters. The results given in this paper were obtained when the distance was made five meters. No effort was made to "tune" the circuits.

The magnet was made from a bar of steel 1.6 cm. square and 3.7 cm. long, bent so as to make a horseshoe magnet about 16 cm. long with parallel legs 4.8 cm. apart. The primary and secondary coils were fastened in place on a board grooved and graduated so that the magnet could be slid back and forth in the same horizontal plane with, and in a direction at right angles to, the iron core, and placed at any desired distance from it. The graduations extended from 0 to 12 cm., zero distance corresponding to contact between the ends of the magnet and the core.

To get a reading the galvanometer was first short-circuited and the magnet placed in position. The short circuit was then broken, the transmitter operated as long as the deflection of the needle was increasing, and the throw observed.

Table I gives the throws of the galvanometer for the given distances between the magnet and core.

A. When the magnet is placed 10 cm. from the core and moved one space nearer each successive reading.

B. When the magnet is placed in contact with the core and is moved one space farther from it each reading.

C. When the magnet is removed some distance after each reading and the transmitter operated before the magnet is placed in position for another reading.

D. When the magnet is turned over (the field reversed) between readings.

TABLE I.

Distance.	A	B	C	D
0.0 cm	2.0 cm.	....	....	7.6 cm.
0.5 "	2.3 "	0.8 cm.	4.0 cm.	7.9 "
1.0 "	2.0 "	0.9 "	3.2 "	6 1 "
2.0 "	1.3 "	1.0 "	2.0 "	3.5 "
3.0 "	0.4 "	0.9 "	1.2 "	1 6 "
4.0 "	0.3 "	1.0 "	1.0 "	1.1 "
5.0 "	0.2 "	0.6 "	0.5 "	0.8 "
6.0 "	0.1 "	0.4 "	0 3 "	0.6 "
7.0 "	0 0 "	0.3 "	0 2 "	0.4 "
8.0 "	0.0 "	0 2 "	0 2 "	0.3 "
9 0 "	0.0 "	0.2 "	0.1 "	0.25 "
10.0 "	0.0 "	0.1 "	0.1 "	0.2 "

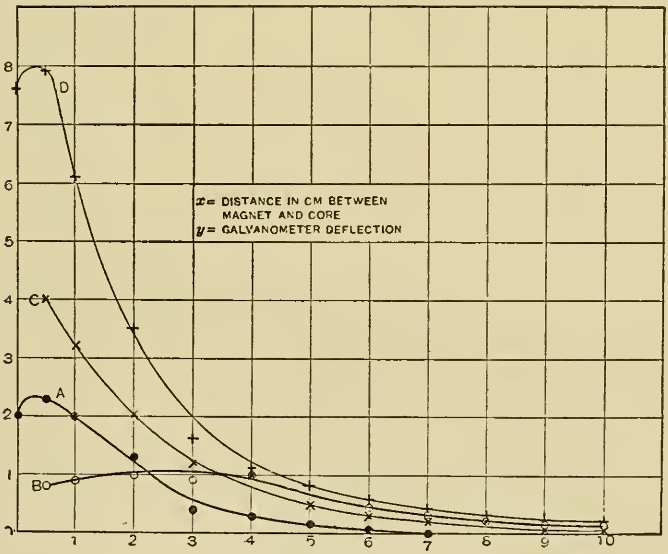


Fig. 1.

The data of Table I are plotted in Fig, 1. A comparison of curves A and B shows that the sensitiveness of the magnetic detector depends upon both the distance and direction of motion of the moving magnet. When the magnet is near the core the detector is more sensitive when the magnet is approaching, but when some distance from the core the detector is more sensitive when the magnet is receding. Both curves indicate a maximum of sensitiveness at a distance from the core, the distance being less when the magnet is approaching than when receding.

Removing the magnet and operating the transmitter tended to demagnetize the core. Then when the magnet was placed in position and the transmitter again operated, as in Curve C, there was a relatively greater change in the magnetism of the core than was obtained under the conditions of Curves A and B. Hence the deflections in column C are greater than those in A or B. It is evident that the relative change in the magnetization of the core would be greater still where the magnetic field is reversed after each reading, as in Curve D.

Since nickel is more susceptible than iron in weak magnetic fields, and less susceptible in strong fields, it occurred to the writer that a more uniform sensibility for varying distances between the moving magnet and core might be obtained by making the core of nickel.

Four cores were made, each one being 5 cm. long, approximately .4 cm. in diameter, and being wound with two hundred turns of No. 36 copper wire.

Core 1 consisted of 26 pieces of piano wire, .063 cm. in diameter.

Core 2 of 10 pieces of piano wire and 10 pieces of nickel wire, .082 cm. in diameter.

Core 3 of 2 pieces of piano wire and 13 pieces of nickel wire.

Core 4 of 14 pieces of nickel wire.

Table II gives the deflections at various distances between the magnet and each of the four cores, the magnet being moved one space at a time and having its poles reversed after each reading. The data for three of the cores is plotted in Fig. 2.

TABLE II.

Distance.	Core 1. Fe.	Core 2. Fe & Ni.	Core 3. Fe & Ni.	Core 4. Ni.
0.0 cm	7.6 cm.	10.2 cm.	7 5 cm.	6.1 cm.
0.5 "	7.9 "	9.5 "	7.5 "	9.0 "
1 0 "	6 1 "	8.0 "	7 2 "	8.9 "
2.0 "	3.5 "	4 6 "	4.0 "	4 7 "
3.0 "	1 6 "	3 0 "	2.0 "	1 35 "
4.0 "	1 1 "	1 7 "	1.0 "	0 7 "
6.0 "	0 6 "	0.5 "	0.4 "	0 35 "
8 0 "	0 3 "	0 2 "	0 2 "	0.2 "
10.0 "	0.2 "	0 1 "	0 1 "	0.1 "

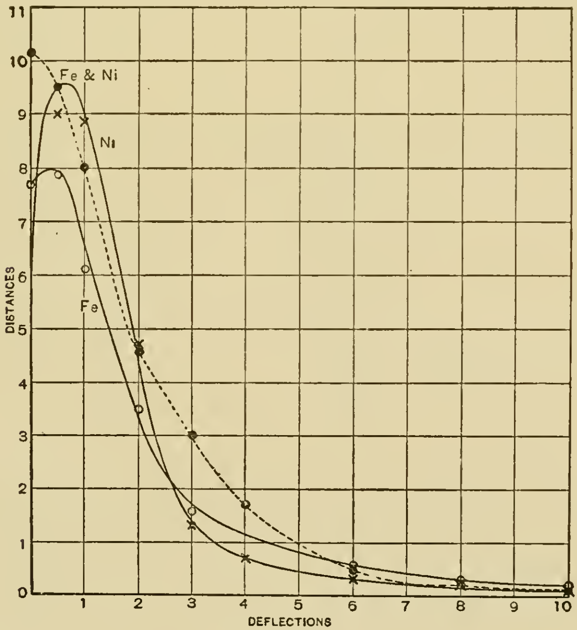


Fig. 2.

The sensitiveness of the detector with a nickel core was not very different from the sensitiveness when an iron core was used. Contrary to expectations, however, the sensitiveness with the nickel core appeared to be the greater in strong fields and with the iron core in weak fields. Both showed a maximum of sensitiveness at a short distance from the magnet, the maximum for nickel being the farther removed. The nickel core proved to be more sensitive than the iron core for distances up to 2.5 cm.

When the detector was worked with the mixed core of iron and nickel wires the deflections of the galvanometer increased as the magnet approached the core, even up to the point of contact. The curve (Fe & Ni, Fig. 2) lies above the Fe curve at all points and above the Ni curve at most points, showing that a mixed core consisting of annealed piano wire and hard-drawn nickel wire produced a more sensitive detector than was obtained by using a core of piano wire only.

The detector gave small deflections of the galvanometer when I used an antimony core; also when I used a core of iron filings contained in a thin-walled glass tube. In both cases deflections were obtained only when the magnet was near the core. A core of bismuth gave no deflection.

It is probable that the form of the curve of Figs. 1 and 2 depends upon other points than those considered in this paper, as for instance, the frequency and intensity of the oscillations sent out by the transmitter and the annealing of the steel wires used in the core.

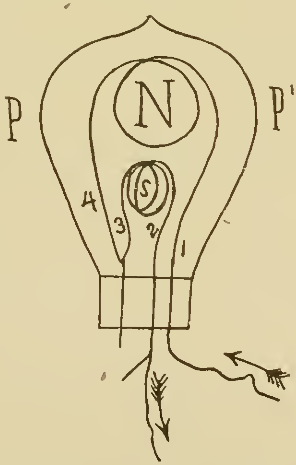
Since electric oscillations appear to "have the power of reducing the effects of magnetic hysteresis," it has occurred to the writer to test their effect upon the hysteresis loss of transformers, armatures, etc. Some experimental work on this subject has been done, but I am not yet ready to announce results.

Physics Laboratory of Indiana University, April, 1903.

The Edison Effect in a "Hylo" Lamp.

By Arthur L. Foley.

The figure is a diagram of a "Hylo" turn-down incandescent lamp in which N and s represent (when the current is in the direction indicated) the north and south ends respectively of the 16 c.p. filament (F) and the 1 c.p. filament (f), the former consisting of two and the latter of three turns. Whatever be the direction of the current the filament coils are of opposite polarity, the potential difference between legs 3 and 4 is small, and that between legs 1 and 4 a maximum. When f is burning F is in series with it, but the current is insufficient to render the latter luminous. When F is burning f is short-circuited, but has the same potential as leg 4 of F.



Let P and P′ be points on the globe at the ends of a diameter through the plane of the filaments, and NS and sn be points on the globe where the axes of the filaments F and f meet it. At P there is a deposit from one to two cm. wide, while the globe is perfectly clear on either side. At P′ the conditions are exactly reversed, the central region being dark with clear glass on each side. At n, also at s, there is a small circular deposit about half the area of a turn of f. This deposit is surrounded by another in the form of a ring about 1 cm. wide and 2 cm. in diameter, the ring being open next the base of the lamp. Between the central deposit and the ring the glass is clear. There is no deposit within 2 cm. of the base of the lamp, and very little on the crown.

The theory of molecular shadows and the Edison Effect, so thoroughly worked out by Fleming* and others, explains the general character of the deposit, but seems to fail to explain the definiteness of it. In general the deposit is of uniform density and quite dark, while the clear places are perfectly clear, the line of separation being as definite as if the deposit had been laid on with a brush.

The weak magnetic field of the small filament was sufficient to concentrate the deposit at the ends of its axes, leaving certain regions perfectly clear. It seems that it should be possible to keep clear any desired part of the wall of a vacuum tube.

The peculiarity of the deposit above described was noticed but a few weeks since, hence the incompleteness of this investigation. An attempt to age a number of similar lamps by running at an excessive voltage resulted in a practically uniform deposit.

---

*Molecular Shadows in Incandescent Lamps. Philosophical Magazine, Vol. 20, 1885.
A Further Examination of the Edison Effect in Glow Lamps. Philosophical Magazine, Vol. 42, 1896.

On the Use of Manganese Dioxide in the Generation of Oxygen from Potassium Chlorate.

By R. R. Ramsey.

The statement is sometimes made in texts on chemistry that the part played by manganese dioxide in the generation of oxygen from potassium chlorate is one of conduction only, that any other oxide, or ordinary sand, which would come in intimate contact with the potassium chlorate, would do as well. Since the black oxide, although not expensive, is more expensive than sand, the use of sand would to some extent diminish the cost of oxygen when generated from potassium chlorate.

To test this point Prof. Foley and the writer, at the suggestion of the former, made the experiments as described below.

The potassium chlorate, mixed with a definite proportion of black oxide or other material, was placed in an ordinary sheet-iron generating retort which was heated with a large Bunsen burner. The oxygen was led through a lead pipe coiled inside a calorimeter. From the calorimeter it passed through an experimental gas meter reading to 10 c.c. By this means the total volume of oxygen generated and the generating rate could be determined directly, and from the rise of temperature of the contents of the calorimeter the approximate temperature of the gas could be determined. Experiments were made with manganese dioxide, powdered silica, sand, and Venetian red.* In no case except with the manganese dioxide, did the amount of gas given off compare with that computed from the chemical formula. In fact the rate of generating, when using substances other than manganese dioxide, was so slow that calorimetric determinations could not be made. The following table will give a general view of the results:

*Equal parts iron oxide and calcium sulphate.

	Substance.	$KClo_3$	Generating Time.	Volume. Observed.	Volume. Calculated.	t	
1	50 gms. MnO_2	250 gms.	8 min.	73 Liters.	74.4	22°	
2	200 " "	1000 "	18.5 "	257 "	296.5	18	Gas lost.
3	186 " Silica	930 "	24 "	56 "	273	19	Exploded.
4	500 " Sand	500 "	20 "	16.7 "	147.5	21	
5	120 " MnO_2	600 "	11 "	137.5 "	177.5	21	Gas lost.
6	65 Venetian red	325 "	25 "	21.9 "	97.6	25	

The first column gives the amount and name of substance used; 2d, amount of potassium chlorate; 3d, duration of the experiment in minutes; 4th, the volume of gas liberated as shown by the gas meter; 5th, volume of gas as calculated from mass of potassium chlorate and temperature and pressure of gas in the meter; 6th, temperature of gas in meter.

In the third experiment with powdered silica heat was applied steadily for twenty-four minutes until suddenly the delivery tube connecting the retort to the calorimeter was blown off and a stream of blazing molten silica was shot a distance of fifteen feet across the room. Upon cleaning the retort it was found that the mass of chlorate and silica had been in a foaming semi-fluid condition filling the entire retort and forcing itself through the delivery tube. In the case of sand (from the shore of Lake Michigan) heat was applied for twenty minutes with a very small amount of oxygen given off. In every case with manganese dioxide the gas had been entirely driven off in a shorter time with a flame greatly reduced from the normal. In fact a considerable amount of gas bubbled through the meter owing to the rapid rate of generation. With Venetian red a very small amount of oxygen was obtained, although the temperature was raised to the point where the entire mass was fused. Subsequent experiments performed in a test tube showed the temperature of fusion to exceed 360° C., while the temperature at which oxygen is liberated from the manganese dioxide mixture as shown by Mahin [Proc. Ind. Acad. Sci., P. 170, 1902] does not exceed 180° C. Calorimetric computations and direct observation in test tubes show the temperature of the gas to be from 65° to 100° C. It would seem that there is a lowering of temperature at liberation analagous to the fall of temperature when water vapor is driven from a salt solution.

In conclusion, it seems that manganese dioxide serves for more than a distributer of heat, that it has a catalytic effect upon the potassium chlorate, permitting the oxygen to be liberated at a much lower temperature than when potassium chlorate is used alone. Powdered silica, sand, and Venetian red do not produce this effect, at least not to the same extent, at low temperatures, as black oxide of manganese.

Double Salts in Solution.

By P. N. Evans.

In a paper presented to this Academy four years ago, the author called attention to numerous apparent exceptions to the rule that an electrolyte is less soluble in a solution of another electrolyte with an ion in common with the first than in water alone. The evidence presented at that time was that many saturated solutions fail to give precipitates on addition of second electrolytes having ions in common with those already in the solutions.

Since that time some of the cases then noted have been further investigated, and it has been proved, as then suspected, that in these cases the electrolyte is more instead of less soluble in a solution of a second electrolyte with a common ion than in water alone.

The substances chosen were lead chloride and nitrate, and barium chloride and nitrate. The method of investigation was the determination of the solubility at zero centigrade of one compound in solutions of the other of varying concentrations up to saturation, one hundred cubic centimeters of the solution being used in each case for analysis.

Lead chloride was estimated by determining chlorine in the solution volumetrically, beginning with pure water and ending with a saturated solution of lead nitrate, after saturating with lead chloride. It was found that the solubility of the chloride increased with the concentration of the nitrate, the curve being a straight line within the limits of experimental error. The solubility of lead chloride in water was found to be 0.5426 grams in one hundred cubic centimeters of the solution; in saturated lead nitrate solution, 1.83 grams.

The solubility of lead nitrate in solutions of lead chloride was not determined, on account of the very limited solubility of the latter.

Barium chloride was estimated by determining chlorine in the solution. It was found in this case also that the solubility of the chloride increased with the concentration of the nitrate, the curve again being a straight line. The solubility of barium chloride in water was found to be 33.89 grams in one hundred cubic centimeters of the solution; in saturated barium nitrate solution, 37.42 grams.

Barium nitrate was estimated by determining barium in the pure water solution, barium and chlorine in the solutions containing chloride, and considering the excess of barium over chlorine to be present as nitrate. Again the curve was a straight line, showing an increasing solubility of nitrate with higher concentrations of chloride. The solubility of barium chloride (anhydrous) in water was found to be 5.11 grams in one hundred cubic centimeters of the solution; in saturated barium chloride solution, 9.38 grams.

These results all agree with the assumption that double salts are formed when these salts are mixed in solution, as lead chloride-nitrate and barium chloride-nitrate.

A single instance of this kind has been noticed by other observers, potassium nitrate and lead nitrate by LeBlanc and Noyes. In this instance it is interesting to note that the common ion is the anion, while in the new cases here presented it is the kathion.

These exceptions to the general rule are apparently not uncommon and deserve more consideration in the text-books on physical chemistry, where they are rarely mentioned at all.

In conclusion, the author desires to express his appreciation of the careful experimental work performed by Mr. R. W. Duncan, B.S., at that time a student in Purdue University.

Lafayette, Indiana, December, 1903.

Ionic Friction.

By P. N. Evans.

The velocity of a moving body is proportional to the impelling force and inversely proportional to the resistance offered by the surroundings. In the case of dissolved particles moving through a solution the resistance is of the nature of friction.

The movement of ions through solutions may be observed in the diffusion of dissolved electrolytes from positions of higher to those of lower concentrations, and also in the migrations of the ions during the electrolysis of solutions. The impelling force in the first case is the osmotic pressure; in the second, electric tension. The resistance in both cases is the friction against the other particles—mostly those of the solvent. That this resistance or friction is enormous is seen in the force necessary to overcome it—three hundred and two million kilograms will move a gram of hydrogen ions in water with a velocity of one centimeter per second.

It has been observed that the addition of a non-electrolyte to a solution of an electrolyte increases the resistance to the passage of the electric current. This might be due to either or both of two causes—the number of ions or carriers of the current might be diminished by the non-electrolyte's causing a partial deionization of the electrolyte, or the resistance of the solution to the migration of the ions—the ionic friction—might be increased. The second of these two hypotheses has been shown to be the correct one when only moderate quantities of the non-electrolyte are added, though the first also becomes appreciable with larger quantities.

The lines of reasoning and experiment leading to this conclusion have been of two kinds. First, the degree of ionization of the electrolyte in pure water and in water containing the non-electrolyte was determined in the usual way, based on the conductivity at some definite concentration compared with that at infinite dilution and found to be the same when moderate quantities of the non-electrolyte were present. Second, the increase in the resistance to the passage of the electric current and to the movement of ions by diffusion due to osmotic pressure has been found to be approximately proportional to the increase in internal friction measured by the rate of flow through a capillary, indicating friction as the immediate cause.

The purpose of the investigation here reported was to attack the problem by a method not hitherto used apparently in this connection. The freezing point method was employed, and the solutions examined were those of hydrochloric acid and sucrose. The freezing points determined were those of water, of twice-normal and twentieth-normal water solutions of hydrochloric acid, of water solutions of sucrose containing 1, 5, 10, 25 and 35 grams in 100 cubic centimeters, and of water solutions of hydrochloric acid and sucrose of corresponding concentrations. The ordinary Beckmann apparatus was used.

It was found that the lowerings of the freezing point produced by known weights of acid and sugar mixed in a given quantity of water was equal to the sum of the lowerings produced by the same weights of acid and sugar each dissolved separately in the same quantity of water. This result harmonizes with those found by the other methods mentioned above in showing no effect of the sugar on the degree of ionization of the acid, and leading to the conclusion that the increase in resistance to the current observed in corresponding solutions of hydrochloric acid on addition of sugar, was due wholly to an increase in the friction between the ions and the solutions.

The author desires to express his appreciation of the experimental work done by Mr. H. E. Bachtenkircher, B.S., at that time a student in Purdue University.

Lafayette, Indiana, December, 1903.

A New Problem in Hydrodynamics with Extraneous Forces Acting.

By Edward Lee Hancock.

The solution of most problems in hydrodynamics depends upon the proper combination of the equations of motion of the fluid interior of a given closed surface with the differential equation of the surface, or with the equations expressing the boundary conditions.

Lord Kelvin has shown that the differential equation of the surface for both compressible and incompressible fluids has the following form:

$$u.F'(x) + v.F'(y) + w.F'(z) + F'(t) = 0$$

where (t) is a variable parameter of the equation

$$F(x, y, z, t) = 0.$$

In the treatment of problems of the motion of incompressible fluids in three dimensions, where the surface under discussion is spherical or nearly so, the usual particular solutions of Laplace's equation ($\nabla^2 \phi = 0$), such as, zonal, tesseral and spherical harmonics, are adequate, since in these cases the velocity-potential satisfies Laplace's equation. The solution used in any particular case depends upon the symmetry of the boundary conditions. Where the surface differs much from the spherical form as in ellipsoids, ellipsoidal harmonics are used. Problems of this kind have been extensively investigated.

In discussing the anchor ring Mr. W. M. Hicks[1] has derived modified forms of the zonal, tesseral and spherical harmonics by means of which the potential both outside and inside the ring may be completely investigated. The same problem has been solved by Mr. F. W. Dyson[2] by using elliptic integrals.

The problem is much simplified when the motion takes place in a single plane, in which case, if the boundary consists of a straight line, two parallel straight lines, or is rectangular, the velocity-potential may be expressed as a Fourier's series or a Fourier's integral.

1. Phil. Trans. 1893.
2. Phil. Trans. 1881, Part III.

In other cases there is no direct method of procedure. The inverse process of finding what boundary conditions will give known solutions of Laplace's equation is used, with the hope of finding the desired solution. The method of images is also applicable to some cases, more especially perhaps in the case of rotational motion.

For the irrotational motion of a perfect liquid there always exists a velocity-potential which satisfies the equation

$$\nabla^2\varphi = 0.$$

The potential φ and the rectangular velocities u, v and w may be found from the given conditions, for all points of the interior. The potential being always least at the boundary the lines of flow and equipotential lines begin and end there. This is true whether the motion is "steady" or not and true, therefore, when the extraneous force is gravity.

Much work has been done on the motion of many of the regular solids immersed in a liquid, when acted upon by a system of impulsive forces and also by constant forces. The motions of the liquid in the neighborhood of such solids has also been discussed. Both tidal waves and waves due to local causes have been investigated and their properties discussed to some extent. The related problem of the effect of high land masses upon neighboring bodies of water has been worked out by Professor R. S. Woodward and others.

Perhaps the most familiar problem of the effect of an extraneous force upon a body of liquid, is the "Torricelli Theorem" on the efflux of a liquid from an aperture in the side or bottom of the containing vessel. There the vessel is kept filled to a constant level the motion becomes steady making $\frac{du}{dt} = 0$, $\frac{dv}{dt} = 0$ and $\frac{dw}{dt} = 0$; and giving the well-known result $q^2 = 2\,gz$, where q is the velocity. In case the liquid rotates under the influence of gravity angular velocity is introduced, giving $\frac{dv}{dx} - \frac{du}{dy} = 2w$. Showing that a velocity potential does not exist, and that such motion could not take place in a perfect liquid.

Cases of motion where no extraneous forces are acting have been completely worked out by methods of conjugate functions and the theory of images. iIn these cases the lines of flow and equipotential lines are orthogonal systems of curves, and methods of plotting such are easily devised. But when extraneous forces are acting these lines no longer belong to orthogonal systems of curves and no method has yet been devised by means of which the lines could be drawn under specified conditions.

It was hoped that some graphical method applicable to all cases might be found in connection with the present work, but thus far none has been discovered that is at all general. I have found the equipotential lines and lines of flow for a rectangular area where a constant extraneous force is acting.

Taking the liquid as incompressible since the external forces is constant the motion is steady and the velocity potential may be made to satisfy the equation

$$\frac{\delta^2\phi}{dx^2} + \frac{\delta^2\phi}{dy^2} = 0$$

$$\text{and} \frac{\delta\phi}{\delta x} = ku, \quad \frac{\delta\phi}{\delta z} = kw.$$

A constant must be added to one of these velocities to express the effect of the constant force. This is more clearly seen perhaps in the case of vertical motions due to the force of gravity. In this case the constant to be added to w is of course g and since this is a constant Laplace's equation is still satisfied. The lines of flow and equipotential lines are no longer orthogonal, but are, as we shall presently see, inclined at different angles, being tangent at some points of the interior.

If the area be taken in the sphere of attraction of the earth and near enough so that the attraction may be taken as constant we shall have

$$u = k \frac{\delta\phi}{dx}$$

$$v = k \frac{\delta\phi}{dz} + k\rho g.$$

where ϕ satisfies Laplace's equation.

Professor C. S. Slichter[1] has shown that the motions in an area A B C D, Fig. 1, filled with sand and having water flowing through it, entering along A B and flowing out along A D—the sides B C and C D being impervious—may be fully discussed by replacing the sand and water by a perfect liquid having a velocity potential, and that the velocity potential in this case would be identical with the pressure function. This being true, it is possible to find the pressure at any point in the interior as well as the component velocities at these points, just as soon as the

1. 19th Annual Report, U. S. Geological Survey, Part II.

boundary conditions are known. Accordingly in what follows the velocity potential will be replaced by the pressure function.

If the section be horizontal, the problem may be treated in the usual way, but in case the section is vertical the extraneous force, gravity, gives a system of curves which are not orthogonal.

Let D C = a and A D = b, and suppose the head of water along A B zero. The boundary conditions then to be satisfied are:

$$P = 0 \text{ when } x = 0$$
$$P = 0 \text{ when } x = a$$
$$P = h \text{ when } z = b$$
$$w = 0 \text{ when } z = 0$$

And since the area is a rectangle P, u and w are expressed as Fourier's series:

$$P = \frac{4g\rho a}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\sinh \frac{n\pi(b-z)}{2a}}{n^2 \cosh \frac{n\pi b}{2a}} \cdot \sin \frac{n\pi x}{2a}$$

This differentiated with respect to x and z for u and w gives:

$$u = \frac{4g\rho k}{\pi} \sum_{n=1}^{n=\infty} \frac{\sinh \frac{n\pi(b-z)}{2a}}{n \cosh \frac{n\pi b}{2a}} \cdot \cos \frac{n\pi x}{2a}$$

$$w = \frac{4g\rho k}{\pi} \sum_{n=1}^{n=\infty} \frac{\cosh \frac{n\pi(b-z)}{2a}}{n \cosh \frac{n\pi b}{2a}} \cdot \sin \frac{n\pi x}{2a} + g\rho k$$

In the above equations *n* represents each of the successive odd numbers, a and b being the sides of the rectangle may have any desired value. But for simplicity they were in the present case taken equal to ten, and for the same reason $g\rho k$ was taken equal to unity.

Making these changes the equations become:

$$P = \frac{80}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\sinh \frac{n\pi(10-z)}{20}}{n^2 \cosh \frac{n\pi}{2}} \cdot \sin \frac{n\pi x}{20}$$

$$u = \frac{4}{\pi} \sum_{n=1}^{n=\infty} \frac{\sinh \frac{n\pi(10-z)}{20}}{n \cosh \frac{n\pi}{2}} \cdot \cos \frac{n\pi x}{20}$$

$$w = \frac{4}{\pi} \sum_{n=1}^{n=\infty} \frac{\cosh \frac{n\pi(10-z)}{20}}{n \cosh \frac{n\pi}{2}} \cdot \sin \frac{n\pi x}{20} + 1$$

From these equations the values of P, u and w were found at each of the one hundred points given in the area. This was done by computing the series for x = 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 when z = 1, and then when z = 2, 3, 4, 5, 6, 7, 8, 9, 10, i. e., by making one hundred computations of each series. The value of u and w being found for each point it was not difficult to determine the resultant in both magnitude and direction. This gave the flow at each of the points of the area. We find from Fig. 1 that there is actual motion throughout the whole area.

The motion, indeed, at some points is very slight, but there is no point in the entire area where there is no motion. This is important if we regard this as an immense area in homogeneous ore-bearing rock. It indicates that at every point of the area the water is continually moving and coming into contact with new rock surfaces, thus increasing its capacity for dissolving the mineral salts from the area. From the length and direction of the arrows it is seen that at the corner D the lines are crowded down closer together than at A. This shows that the constant force gravity has distorted the field, causing the lines of flow to be concentrated at the bottom, and showing that underground waters must take very long journeys before reaching their destination and so come in contact with a very great area of rock surface.

As before stated, the relations of the equipressure lines to the lines of flow differ from that found in horizontal planes. From Fig. 1 it is seen that the angle between the systems of curves varies from nearly a right angle to two right angles, that is, to tangency. In fact, there is in the area what may be called a line of tangency meeting the sides A D and D C. These lines of flow as before indicated taken at equal distances along A B crowd near each other down near D, showing the effect of gravity upon them. If we cause the constant force g to cease to act in the case under consideration, the lines of flow would be arcs of circles cutting A B and A D at equal distances from A. The effect of gravity then is to pull these arcs of circles out into cycloidal-like curves crowding near D C. As a matter of fact the curve drawn from $x = 5$, $z = 10$ is nearly a cycloid. Those in the upper left-hand corner being too low and long and those in the lower right-hand corner too short and high for cycloids.

The lines of pressure are hyperbola-like curves drawn for pressures, 1, 2, 3, 4, etc., all the curves beginning and ending in the boundary.

It is easy to see that we may take a similar area a b to the right of A B C D and leaving an open face similar to A D and an impervious bottom and water at zero pressure along the top. We should then have these two areas one on each side of B C with the liquid flowing in opposite directions. The liquid in each area flows directly down B C and so the motion will not be interrupted if B C be removed. That is, the method of images is applicable horizontally. If, however, a similar area to A B C D be taken just below C D we can not say that the method of images as usually applied holds true. We may regard A D in the upper area as an absorbing slit and A D in the lower area as a similar slit and the position C D between them as a mirror the corresponding parts of A D in the upper and lower slits are not found at equal distances above and below C D. They are found drawn down by gravity so that the method of images must be modified for vertical distributions. By integrating u with respect to z between the limits b and $\frac{9}{10}$. b; $\frac{9}{10}$ b and $\frac{8}{10}$. b, etc., the amount of flowage from each of the ten equal divisions of A D may be calculated. And in a similar way the amount of liquid going in at each of the ten equal divisions of A B is obtained by integrating w with respect to x between the limits a and $\frac{9}{10}$. a; $\frac{9}{10}$. a and $\frac{8}{10}$. a, etc. The equations for the flowage and the amount absorbed are then:

$$f = \int_c^d u\,dz = \frac{8ag\rho k}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\cosh \frac{n\pi(b-z)}{2a}}{n^2 \cosh \frac{n\pi b}{2a}} \cdot \cos\frac{n\pi x}{2a}\Big]_c^d$$

$$a = \int_c^d w\,dx = \frac{8ag\rho k}{\pi^2} \sum_{n=1}^{n=\infty} \frac{\cosh \frac{n\pi(b-z)}{2a}}{n^2 \cosh \frac{n\pi b}{2a}} \cdot \cos\frac{n\pi x}{2a}\Big]_c^d \; g\rho k x\Big]_c^d$$

where c varies from $\frac{9}{10}$. b or $\frac{9}{10}$. a down to zero, and d varies from a or b down to $\frac{1}{10}$. b or $\frac{1}{10}$. a. Solving the ten equations for the ten different values of f and a, we get the following table:

No....	1	2	3	4	5	6	7	8	9	10
a	.958	.875	.800	.726	.664	.611	.566	.535	.512	.502
f	.042	.126	.216	.315	.424	.556	.716	.935	1.24	2.07

TABLE I.

It will be seen from the table by counting the divisions from A as 1, 2, 3, etc., that nearly half the water flows through the first three divisions and that there is a gradual decrease toward B. The relative value of f from the different divisions shows a very slight flowage from the first division with a rapid increase from each of the succeeding divisions until the two lower divisions at D carry off one-half of the amount absorbed. This shows in a very vivid way the pronounced effect of gravity or any constant external force upon a liquid. The amount going in along A B is of course equal to the amount flowing out along A D, since the equation of continuity must hold true.

It is interesting to note that the curve given by plotting the flowage from A D is very nearly a tractrix or antifriction curve. See Fig. 3. It would undoubtedly be an exact tractrix had the number of divisions of A D been taken small enough, i. e., if twenty or thirty equal divisions had been taken instead of ten.

In Fig. 3 the line O X corresponds to the distance A D in Fig. 1, and the y-coördinates of the curve are given by the values f taken from Table I.

Fig. 4 shows the distribution of absorption into the area A B C D along A B, the line A B of the figure corresponding to the line A B of the area. The y-coördinates of the curve being taken from Table I as the different values of a.

Figs. 3 and 4 then show the distribution of absorption and flowage along A B and A D.

Extending this method by taking A B one hundred and keeping A D ten, we get approximately an artesian well area. The values of f and a for this case are given below:

No....	1	2	3	4	5	6	7	8	9	10
a	5.51	1.44	.139	.044	.028	....	....	....	....	.005
f	.040	.162	.210	.348	.446	.616	.762	.981	1.32	2.53

TABLE II.

It will be seen that the amount flowing in at the first division of A B is about two-thirds the total amount flowing into the entire area, and that this supplies the flowage for the first nine divisions of A D while the tenth division of A D gives out the water from $\frac{9}{10}$ the distance A B. If the rock in the area be soluble it is easily seen that the water flowing from this lowest division of A D will be very highly charged with mineral matter, while the remaining two-thirds that flows out above will be very slightly charged. This is more especially evident when the long sweeping paths of the water are considered compared with the very short paths of the waters of the first division of A B. We have this represented graphically in Fig. 5, where the lines of flow are drawn for the case where A B = 100 and A D = 10, or a typical artesian area. If A D be a crevice in the rock it is evident that this place will be favorable for the deposition of the mineral salt dissolved in the water since the pressure is released at this point and there is apt to exist some reagent that will cause a precipitate of the ore. This reagent may exist in the crevice itself or in the opposite wall.

In Fig 6 the curve has been plotted for the flowage from A D for the case A D = 10 and A B = 100. This does not differ much from the case where A D = 10 and A B = 10, except that the convexity downward is somewhat more pronounced, making the curve less like the tractrix.

Ten equal divisions were taken along A D and the values of y taken from Table II corresponding to different values of f.

The absorption curve for the case A D = 10 and A B = 100 is given in Fig. 7. Here the scale has been somewhat changed due to the large value of A B. The distance A B was divided into one hundred equal divisions, while the same vertical scale was used for y as in the preceding cases. The values of y were taken from Table II, being the different values of a in that table.

The rapid fall of the curve at first and then more gradual fall corresponds to the values of a found in Table II and also emphasizes the relative slowness of the motion of the water in the right-hand half of the area A B C D, Fig. 5, as compared with that of the left-hand half.

The method used in the preceding cases might be extended to areas of different dimensions, but the results would not differ much from those already stated.

If A B be taken greater than one hundred, while A D remains ten, or if we have any similar relation between the two, it will be more advantageous to use the Fourier's integral instead of the Fourier's series, since for such a difference between A B and A D the area may be considered as an infinite strip.

The results obtained are especially interesting in connection with the motion of ground water, because of their bearing on the theory of ore deposits, artesian wells and drainage flumes. The fact that sand through which water is flowing, as before indicated, can be replaced by an ideal liquid having a velocity-potential which is identical with the pressure opens a new field of investigation in hydrodynamics from which many important results will be obtained.

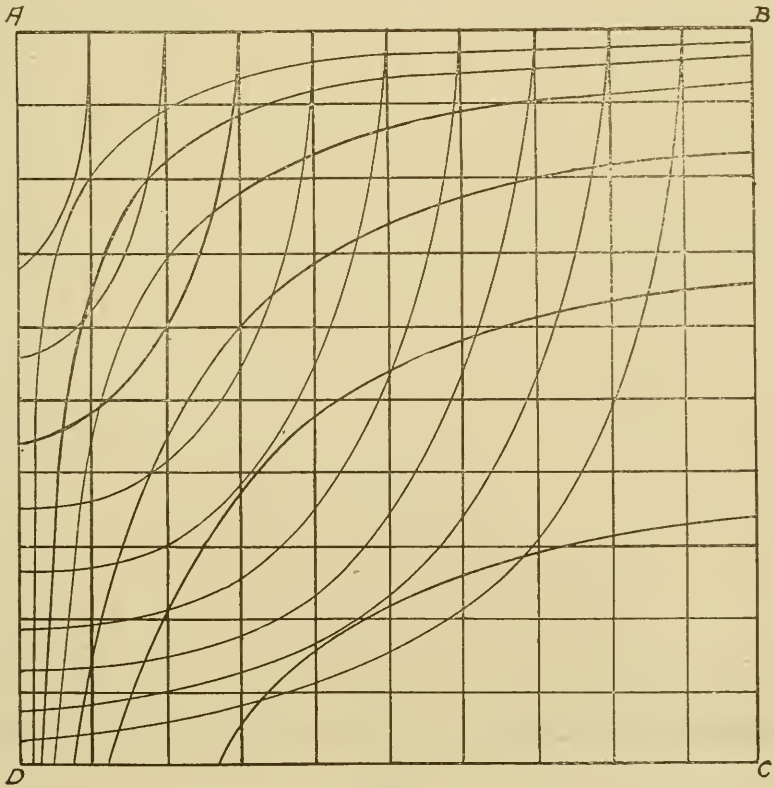


Fig.–1

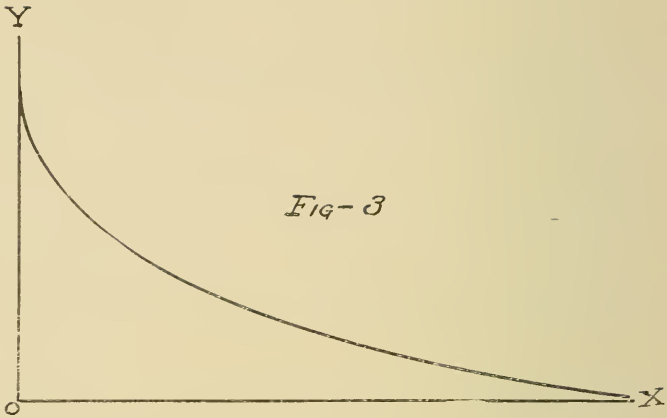


Fig- 3

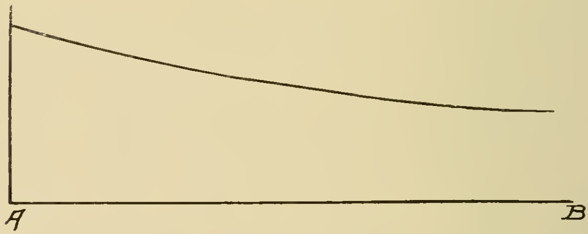


Fig. — 4

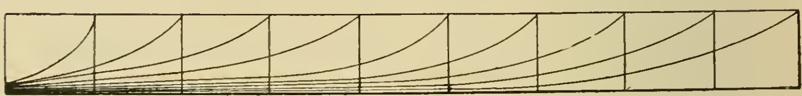


Fig.—5

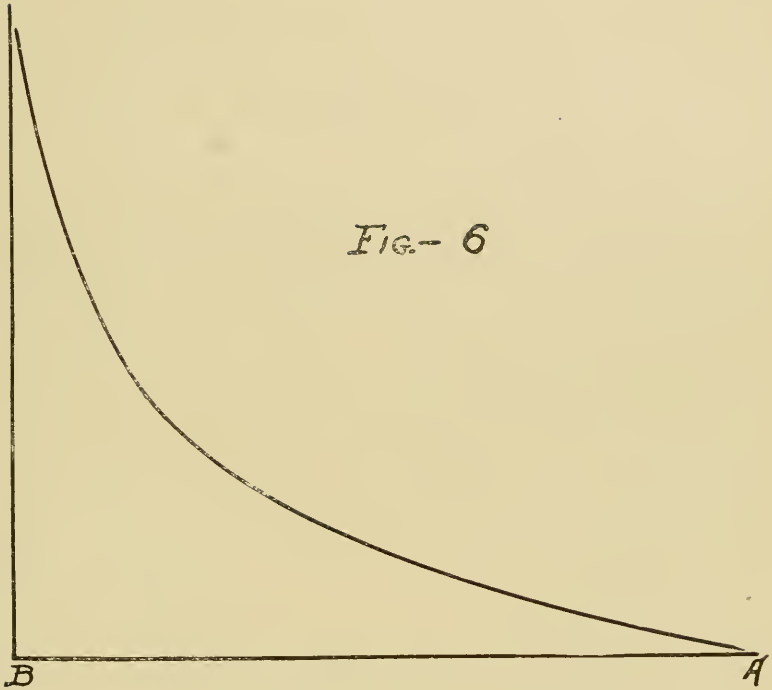


FIG.— 6

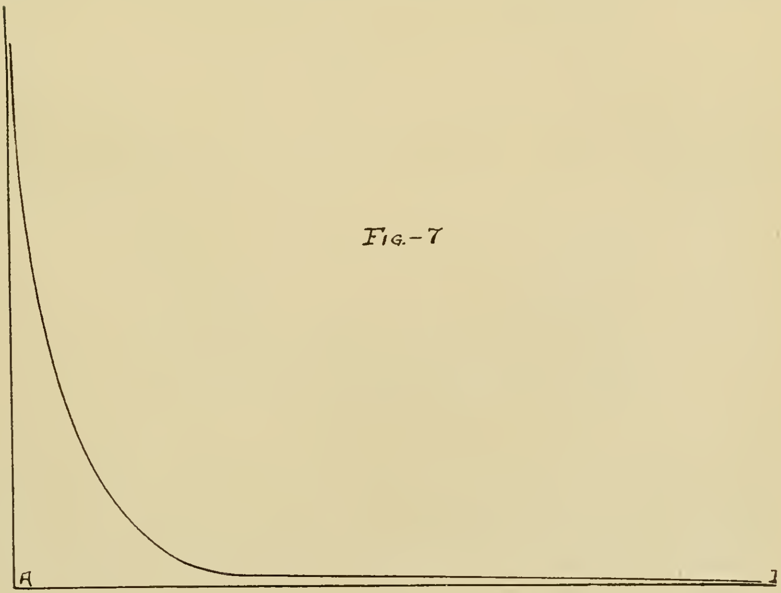


FIG.—7

A Topographic Result of the Alluvial Cone.

By A. H. Purdue.

An alluvial cone that is composed mainly of more or less finely comminuted material would not last long enough after the area covered by it ceases to be one of deposition to produce an enduring topographic feature. It would soon succumb to the agents of erosion and transportation. Even if composed of coarse material, its life might be short if the lithological character and climatic conditions were such as to bring rapid disintegration. But if the cone be composed mainly of coarse material that can withstand the weathering agencies, there is every reason to believe that it would have lasting topographic results.

In transverse section, alluvial cones are higher in the middle than on the borders next the escarpment, as shown in Fig. 1, so that the tendency

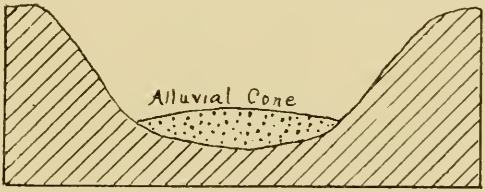


Fig. 1.

is for the streams which form them to shift either to the right or to the left, running along the base of the escarpment. If such a stream is not overloaded at this point, it becomes a cutting stream, and the profile, that

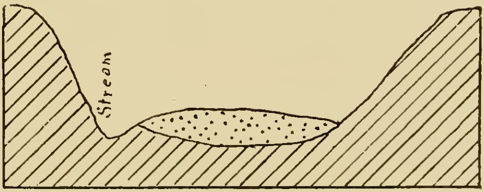


Fig. 2.

shown in Fig. 2. Should the cone be formed immediately below the junction of two streams, as in Fig 3, both streams might shift, one to either

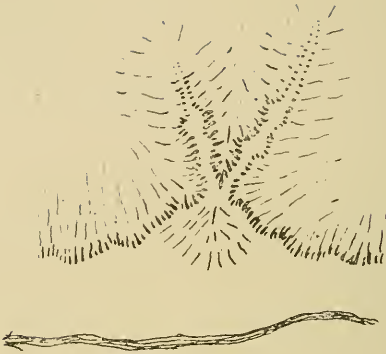


Fig. 3

Fig. 4.

side, leaving the cone between them, as in Fig. 4, and with the profile as shown in Fig. 5. The writer has in mind a case of this kind, where the shifting has recently taken place.

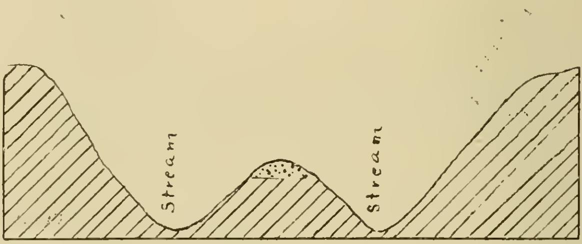


Fig. 5.

In the Boone chert region of northern Arkansas, there are many alluvial cones, composed almost entirely of fragmentary chert. This chert withstands weathering to a remarkable degree. It readily permits the rainfall to pass through it, thus preventing erosion, and forming an ideal protection for the underlying rocks.

Also, over this region, there are numerous knobs of the character shown in Fig. 6. These knobs are capped with fragmentary chert, resting upon the magnesian limestone that underlies the Boone chert. The surrounding geography is that shown in Fig. 4. Nearly all the capping material is angular, but close search will often reveal water-worn pebbles.

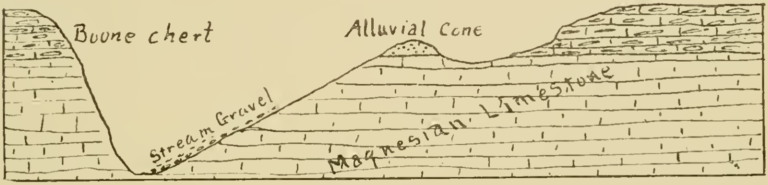


Fig. 6

The writer is of the opinion that the capping material is that of alluvial cones, and that the preservation of the rock beneath from erosion, is due to the protection afforded by the cones. Such knobs are sometimes 500 feet above the valleys beneath. The small number of water-worn pebbles is accounted for in the fact that the débris of the cones was transported but short distances, and there was not time for much rounding. Besides, the material is hard, and would wear slowly.

The material of these old cones must not be confounded with the gravel that is common in this region, and which occurs on the hill sides (see Fig. 6) often extending up to the height of 200 feet or more above the present stream level. This material, unlike that capping the knobs, is all water-worn, and was left on the inside curve of the streams as they shifted laterally.

Progress in Locomotive Testing.

By W. F. M. Goss.

It is now fourteen years since the initial steps were taken to install at Purdue University a locomotive testing plant. Plans which were then formulated were rapidly worked out, and in the fall of 1891, the completed plant was put into operation. It consists of a mounting mechanism, upon which any locomotive can be operated in much the same manner as upon the road, while retaining its fixed position in the laboratory; and of such accessory apparatus as is needful in measuring its power and in determining its efficiency. A locomotive mounted upon the testing plant can be fired as if upon the road and can be run at any speed and under any load, its action being controlled in precisely the same manner as when in actual service, while its fixed position in the laboratory allows the attachment of delicate apparatus, and permits great accuracy in the methods employed in studying its performance.

The practical value of the Purdue plant was at once recognized. It had long been understood that in testing a steam engine, the maintenance of constant conditions was of prime importance, whereas the operation of a locomotive on the road is attended by a great variety of changes in conditions which affect its action. Again, upon the road, so great are the limitations governing the attachment of apparatus that observations had necessarily been of a very elementary sort. Difficulties in testing arising from these and other causes were entirely overcome by the advent of the testing plant. By its use it became possible to apply to the locomotive the same accurate methods in observing the performance of a locomotive which had previously been elaborately developed for testing stationary engines. Mechanical engineers and superintendents of motive power visited the laboratory to witness the operation of the Purdue testing plant, from many parts of our own country, and from several foreign countries. Other plants were soon proposed. In 1896 the Chicago & Northwestern Railway Company equipped its Chicago shops for locomotive testing, and more recently, Columbia University has supplied a locomotive testing plant for its engineering laboratory. Other institutions have plants in contemplation. Meanwhile, the work of the Purdue plant has proceeded steadily from the beginning. Besides serving in the instruction of hundreds of students, it has supplied the means for conducting a number of important researches, the results of which have been duly published and important problems are now in process of solution under the patronage of the Carnegie Institution. This, while in terms too brief to be entirely complete, gives a fair picture of the present status of locomotive testing from a laboratory point of view.

Just at this time, all who are interested in locomotive design or performance have their faces turned to the Louisiana Purchase Exposition. Engineers have always looked upon a great exposition as serving in many ways to advance the practice of their profession. It has often happened that in addition to the far-reaching influence of their general exhibit, such expositions have given occasion for a considerable amount of highly scientific work. At the Centennial Exposition at Philadelphia, in 1876, a system of steam-boiler testing was developed. The Columbian Exposition at Chicago in 1893 had its engineering congress, and it is of interest to know that the Louisiana Purchase Exposition at St. Louis is to be emphasized by the working out of extensive plans for locomotive testing.

It has been announced that the Pennsylvania Railroad Company is to make a locomotive testing plant the central features of its exhibit at St. Louis, and is to conduct tests upon locomotives throughout the period of the Exposition. To this end, it is now installing in the Transportation Building at the Exposition, an elaborate and most beautifully designed testing plant. The undertaking is being directed by Mr. F. D. Casanave, acting as special agent in charge of the company's exhibit, with whom the various technical departments of the railroad are co-operating. That the work of testing locomotives may be free from all taint of selfishness, and that it may serve as large a purpose as possible, the company has invited the American Society of Mechanical Engineers and the American Railway Master Mechanics' Association to have a part in giving direction to its work. Each of these organizations, in accepting the invitation has appointed a committee of three to represent it, which committees, acting together, constitute what is now known as the Advisory Committee of the Pennsylvania Company for Locomotive Testing. The writer's connection with the work is that of a member of the Advisory Committee.

It has been planned to test twelve locomotives, a number of which will be of foreign manufacture. One is to be a de Glehn balanced compound, which has been ordered by the Pennsylvania Company and will be imported from France for use on the testing plant. German manufacturers are to send locomotives equipped with superheaters. The coming to this country for the purpose stated of these typical foreign locomotives is a matter of more than ordinary significance. The American locomotives selected for test will represent different types of modern freight and passenger engines.

It is expected that a test will be started each day between eight and nine o'clock in the morning, and will be continued for from two to four hours, depending upon the conditions of running. Any engineer, therefore, interested in locomotive testing may see a test in progress by visiting the Transportation Building during any morning of the Exposition.

It is proposed to have the results obtained from all the tests given publicity by means of bulletins, which will be issued from time to time by the Pennsylvania Company, and which will be sent to the technical press and to individuals under conditions yet to be announced. Bulletin No. 1, describing the organization and the methods has already been issued.

Additions to the Flora of Indiana.

By Herman B. Dorner.

The plants given in the list below, are some which were collected, by the writer within the past three years, and have not, as yet, been included in the State flora.

It was thought best, in presenting this list, to add such notes as might be of interest to botanical workers of the State.

The nomenclature used is that of "Britton's Manual of the Flora of the Northern United States and Canada."

1. *Panicum Columbianum* Scribn. Tippecanoe County.

Collected, in 1902, along the Wabash Railroad east of Lafayette.

2. *Panicum Lanuginosum* Ell. Tippecanoe County.

This species was collected, during the season of 1902, in three localities. It was first collected along the Wabash Railroad, east of Lafayette, and again on a wooded hillside about three miles east of the city. The third collection was made about three miles north of the city, along a shaded roadside.

Britton gives as the range of this species, "from southern New Jersey to Florida and Alabama."

3. *Panicum oligosanthes* Schult. Tippecanoe County.

This was first collected, in 1901, along the Wabash Railroad east of Lafayette. Observations in this locality, during the succeeding years, show that it is gradually spreading over more territory.

In 1902, it was again collected south of the city, along Wea Creek.

Britton gives for its range. "Virginia to Georgia and Mississippi." Its introduction into the State is probably due to the railroads.

4. *Sporobolus longifolius* (Torr.) Wood. Tippecanoe County.

This occurs in Tippecanoe County in several localities. It was first collected south of Lafayette, along the banks of Wea Creek. Later it was found on a dry, open hillside. about three miles east of the city.

It is quite abundant where found.

5. *Bromus patulus* M & K. Tippecanoe County.

Quite common on Purdue farm and on State Street, West Lafayette.

All attempts to determine this species referred it to *B. squarrosus* but the description did not seem to fit it. Specimens were then sent to Prof. Hitchcock who determined it as *B. patulus* M. & K. In regard to it he says, "It is allied to B. *squarrosus*, but has a more loose and open panicle. It is not described in the manuals, as it seems to be introduced in only a few places in this country."

A description of this species will be found in Mr. Shear's "Revision of the Genus Bromus," published as bulletin 23 of the Division of Agrostology.

The plant seems to be well established in this locality.

6. *Hordeum pusillum* Nut. Tippecanoe County.

This species was collected along the Wabash Railroad, east of Lafayette, where it seems to be well established.

It was first collected in 1900 and specimens have been taken each succeeding year.

This species was probably introduced in refuse, thrown out from cattle-cars.

7. *Tradescantia brevicaulis* Raf. Tippecanoe County.

Found very commonly, about Lafayette, on partly shaded hillsides.

8. *Asarum acuminatum* (Ashe) Bicknell. Tippecanoe County.

Very common in woods and on shaded hillside, east of Lafayette. *A. Canadense* F. with which it is confused was also found in the same locality.

9. *Allionia linearis* Pursh. Tippecanoe County.

First collected along the Wabash Railroad in 1901. Observations since then show that it has become well established and is slowly spreading.

10. *Geranium pussillum* Burm. f. Tippecanoe County.

In the summer of 1902, this was found growing among the grass on the Experiment Station grounds.

This one collection, however, without any additional observations is hardly enough to admit it to the State flora.

11. *Androsace occidentalis* Pursh. Tippecanoe County.

Found growing somewhat abundantly in lowland near Wea Creek.

This is listed on page 606, of the Catalogue of the Flowering Plants of Indiana, by Prof. Coulter, as a doubtful member of the State flora.

Specimens of all the plants listed above have been deposited in the herbarium of Indiana plants at Purdue University.

In conclusion, the writer wishes to acknowledge his indebtedness to Prof. Stanley Coulter, for much kind help in his work, and to Prof A. S. Hitchcock, of the Department of Agriculture, for help in the determination of the grasses.

Botanical Notes.

By Moses N. Elrod.

Tecoma radicans (L.) D C. The trumpet-flower presents many peculiar characters that are of great value in securing cross-fertilization, and it seems to be constructed on a plan admirably adapted to meet the needs of the humming-bird.

One among the first things in its structure to attract attention is the nearly horizontal position of the flower, its short, unexpanded lower lip, the opposite of the arrangement in many flowers dependent upon insect visitors for fertilization, and the manner in which the filaments are twisted right and left so as to bring the dehiscing anther on the same plane with their backs against the upper lip of the corolla. This grouping of the anthers is effected by the outer and longer pair of the angular, dimorphous filaments making one turn on their axes and the inner pair making a half turn. The pistil is a little longer than the stamens and terminates in a two-branched, foliaceous, spatulate stigma.

In July, 1902, I noticed that the stigma is sensitive. While searching in my pocket for a magnifying glass the lobes of a plucked flower had closed so that the stigmatic surfaces were in close contact. The use of force failed to separate them for more than a moment and when one of the thin lobes was cut away the other curled up into a loose roll. At the time, I supposed that I had made a discovery, but soon found that I had been anticipated. In Müller's "Fertilization of Flowers" it is stated that when the stigma of *Bignonia* has been "touched by an insect visitor they then close up immediately." He also quotes the experiments of his brother on a South American species, showing that successful fertilization was secured only when the pollen applied came from a plant growing "at a distance." It was to test the sensitiveness of the stigmas and the conditions under which cross-fertilization was effectual that my observations of *Tecoma radicans* were made.

The stigmatic lobes of a flower which had just come into bloom, when irritated with the point of a knife-blade or any other hard substance, closed in five seconds, and those of the faded flowers in thirty seconds. A drop of water acted as an irritant when applied soon after the stigmas had matured, but a warm rain had no effect. Fresh flowers placed in a refrigerator were not affected by the reduction of the temperature, while those exposed to cold rains seemed to have their irritability diminished. The application of pollen from the same or another flower had no effect when care was exercised not to roughly touch the stigma. Pollen was applied one evening to the tip of the lower lobe, which is the larger and longer of the two lobes, and it did not hinder their opening next morning. After closing up from the use of an irritant alone they opened again in about two hours. But if the irritation had been accompanied with the application of pollen from the same or another vine they rarely opened again, and never if the ovary was fertilized.

More than fifty experiments to determine the effects of pollenization with pollen from the same flower as the stigma treated, or from another flower growing on the same stock, gave negative results. In some cases the ovary seemed to swell and remained attached to the vine longer than those not pollenated, but they all turned black or dropped off within fifteen days.

All the stigmas treated, to determine their irritability, and the effects of pollen applied to them coming from a distance, grew on vines in the back yard of No. 823 Washington Street, Columbus, Indiana. Six strong stocks, coming from the same root, cover the fence and an old apple tree. In the autumn of 1901 they produced many matured capsules. August the 19th and 20th, 1902, eleven stigmas were pollenated from flowers collected two and one half squares distant. Six of these began to develop in fine style, but came to naught. September 9th and 10th, six stigmas were treated with pollen from a vine found growing outside the city limits, one-fourth mile west on the Nashville road. As a result, the ovary, in one instance grew to be one inch long and then withered. The others were failures and their ovaries did not appear to have grown a little bit. The season closed with nothing to show for my work and the distance theory unverified. The vine in my yard began blooming again July 1st, 1903, and the first experiment of that year was made to see how much influence the soil in which the vine grew had to do in determining the final results of cross-fertilization. July 5th, I collected flowers from a vine growing in the rich bottom land of Clifty Creek, two miles south of the city, and twenty stigmas growing in my yard were pollenated. The flowers treated, were in all stages of blooming, from those just opening to others that were fading, but none where the lobes of the stigma did not promptly close when irritated. These experiments resulted in twelve full grown capsules. July 31st and August 3d eighteen stigmas were pollenated from flowers found growing on clay soil, one mile south of the city, which resulted in three mature capsules. August the 14th and 18th, nineteen stigmas were treated with pollen from a vine growing in clay soil one-half square north of my vine, and three mature pods were the result. Ten stigmas were pollenated August 19th from a vine growing in clay soil, at the root of a large elm tree, about one square northwest of the home vine, and eight mature capsules were the result.

Summarized, the results show that sixty per cent. of the pollenations made with pollen from a vine growing in rich loam were successful; fifteen and sixteen per cent. were successful when the pollen came from clay soil, and the vines grew in the open, under conditions nearly the same as that of my back yard, and eighty per cent. as the result when the pollen came from a vine whose roots were planted in clay soil and entertwined with those of a big elm. From this it seems that the soil in which the vine grows, has some influence on the fertilizing power of its pollen. The pollen used in the 1902 experiments, which resulted in failures, came from vines growing in the open and rooted in clay soil. The idea that pollen coming from the big elm tree vine is in some way peculiarly efficacious in producing seed is confirmed by the fact that a vine within one hundred yards of it, and favorably located to encourage humming-birds to visit between the two, has borne an abundant crop of capsules for the past two years.

The only insects noticed on the trumpet-flowers were robbers, whose visits were without compensating advantages. Black ants and little sweat bees came early and stayed late; the ants to get nectar, and the bees to collect pollen. Sometimes they found an entrance between the lobes of the corolla limb before the flower was open. The bees made short work of collecting all the pollen in sight—half of it going within fifteen minutes. When the pollen was knocked down into the tube they did not seem to be in any way put out, but went on collecting until all was gone. As many as six bees were seen together in a corolla, very busy, crowding and fighting for place. Had they found any pollen on a stigma they would have taken it. During a drouth conical holes were found in the calyx, of many flowers, that reached down to the ovary, and as mud-dauber wasps, *Sphegidæ*, were seen about the holes they were charged with making them. After rain came they disappeared, and may have done the drilling to get at the nectar as food, or as a substitute for water in tempering their building material. Humble and honey-bees occasionally were seen prospecting around the flowers, but they rarely stopped for more than a moment.

It is remarkable, while the mechanism of *Tecoma* is peculiarly effective in preventing self-pollenation, that its pollen is impotent except when applied to the stigma of another plant under restricted conditions, and that the humming-bird is its only visitor of service in its fertilization.

Impatiens aurea Muhl. The pale touch-me-not is a common plant in Indiana, growing best in the damp, rich soil of the shaded river bottoms.

The mechanism of the flower is generally understood, but the part played by the scales, on the inner side of the filaments, is not so well known. The filaments are so arranged as to form a group, which is held together by the coherent scales. With reference to the mouth of the spur the posterior part of the group is closed by a single filament and the sides by two filaments, leaving the front with a larger opening between the anterior pair than elsewhere. The scale of the posterior filament is divided into two parts which are continuous with the coherent scales of the sides. The two resulting appendages are symmetrical, and are in close contact, on an antero-posterior line, so as to form a roof or hood over the end of the stigma. On the under side of the hood is a pocket into which the stigmatic end of the ovary is inserted. The end of the ovary is marked by a slight papilla near the anterior end of the dividing line of the hood. The pocket is so placed with reference to the plane of the hood that the end of the ovary does not push at right angles, but in an oblique direction. The filaments cease to grow when the flower opens, while the ovary continues to increase in length, and by this arrangement with reference to the hood it pushes against it without protruding, until the filaments are broken from their attachment to the receptacle. When the connection with the receptacle is broken the filaments curl backward with such force as to often cause the cap of withered anthers to fall to the ground. If this does not happen, the cap is easily displaced by the first insect-visitor that attempts to enter the spur.

When it is recalled that the touch-me-not flower is suspended from the end of a slender peduncle, and bobs and swings with every breeze or touch of an insect, the function of the hood in excluding self-pollenation becomes evident. Observations show that the hood is frequently covered with pollen that has sifted through the chink between the anthers, or has been carried to it by small insects. But the stigmas are not always so well protected as the foregoing might indicate. As the season advances flowers begin to appear in which the stigmatic end of the ovary is exposed. On the 16th of September a patch of *I. aurea* was visited and the ovary found protruding in a majority of those examined. That this change was due to the waning vigor of the plant seems to be shown when, at a later date, after rain and continued warm weather, only one out of twenty-five flowers was found with the stigma exposed. Examination with a microscope showed pollen adhering to the papillæ of the stigma. Soon after the exposed stigmas are seen cleistogamous flowers begin to appear.

Just over, or anterior to the protuberance, made on the hood by the end of the ovary, is an erect, membranous appendage, composed of two pieces about one line long. Its function is not obvious, but it may serve as an increased protection to the stigma against self-pollenation. So far as seen it is peculiar to *Impatiens aurea*.

Impatiens biflora, Walt. After two years of observation, I am led to believe that the spotted touch-me-not produces its crop of cliestogamous flowers in the spring only, before the conspicuous flowers begin to appear. This fact has led some writers, who looked for them in autumn, to state that this species does not produce concealed flowers. Last spring hundreds of them were examined and concealed flowers found in the axils of the leaves of all the plants over six inches high. The glaucous stem of the *I. aurea* distinguishes the young plant of that species before it blooms, but to make sure of the species, they were again visited after conspicuous flowers had become abundant. The first conspicuous flowers had the stigmas exposed through a hole in the hood. But this exposure of the stigma was confined to the spring flowers. The first normal flower seen in my yard came into bloom June the 9th, and produced a seed-bearing capsule. The distance at which this plant grew, from any others then in bloom of the same species, probably excludes the possibility of cross-fertilization. Those blooming a few days later had holes in the hood.

The touch-me-not is cross-fertilized through the agency of bees. Rarely a humming-bird poises over a flower, but does not seem to find anything to detain it long. Its bill is too long and slender to make it a good instrument for carrying pollen. Humble-bees become numerous about the flowers late in the season, and by their size and clumsy movements, not only detach the anther cap, but frequently manage to bring themselves to the ground imprisoned in a withering corolla. Other smaller bees, in search of honey, enter the spur without touching the anthers.

Claytonia Virginica L. The movements of the stamens and stigmas of this plant are curious and somewhat puzzling. When the petals first open the pistil is longer than the proterandrous stamens, but of the same length after the branches of the stigma are recurved. In some flowers the stamens remain clustered around the style and closed stigma for a time after the petals have opened, and while in this position, the under part of an insect-visitor readily becomes dusted with pollen. Later the stamens are bent backward until the anthers rest on the face of the horizontal pistils. When this outward movement of the stamens takes place the lobes of the stigma are also bent outward and in position for cross-fertilization. Quite often it happens that it can scarcely be said that the stamens are proterandrous, all the movements before described occurring at the time the anthers become dehiscent. When this takes place the insect-visitor has little chance of collecting pollen, but it leaves the stigma in an ideal position for cross-fertilization. Flowers can be found in all of these stages at the same time; and the honey-bee in making its rounds soon becomes dusted with pollen, without having to depend on the recurved stamens for a supply.

Unlike many flowers that are in part or wholly dependent on insects for fertilization, the spring beauty lasts but one day. It comes into bloom early in the season and its day is past before insects become numerous, hence, as might be expected, there is a provision which assures self-pollenation. The petals that open in the morning begin to close in the afternoon, and by night are gathered into an imbricated roll. If the day has been cold and the lobes of the stigma have not become fully recurved, so as to bring their papillae on a level with the anthers, the process of recurvation is completed before they are caught by the closing petals. Examination shows that after closing the anthers with pollen still adhering are in close contact with the stigma. Pollen was found at night on the papillae of the old flowers that was not there before insects ceased to fly that afternoon. No insect other than the honey-bee was seen about them, and, as its visits were rather rare, the numerous and well filled capsules must have been the result of self-pollenation.

Hydrophylum appendiculum Michx. is proterandrous. When the flower first comes into bloom the pistil is about one-half the length of the mature stamens. The dehiscing anthers are gray with pollen, which disappears within six hours. By the time the pollen is gone the pistil has grown to the same length as the stamens, the two lobes of the stigma are recurved and ready for cross-pollenation. Bees are the pollen carriers, which they get from the anthers of flowers that bloom at irregular hours throughout the day. A plant in my yard began to bloom early in May and was still producing a few flowers August 8th. During dry weather in July, the flowers were less than one-half the normal size, the tube very much shortened, and in others the corolla changed from campanulate to rotate.

Polemonium reptans L. The stamens are not as long as the pistil. Dehiscence begins when the corolla is about half open, and before the lobes of the stigma are recurved. Later the stamens are bent outward and the pistils left to occupy the center field. Honey-bees enter the half-blown flowers and come out well dusted with pollen, which they carry to the older flowers. Invariably, when a bee comes to a plant, it pays its respects first to the half-blown flower, and may not visit the older ones at all. It seems to know that they have been exhausted of nectar. As it enters the slenderly supported flower it clasps all the organs at once, and its movements are about as graceful as those of the humble-bee.

The pistil of *Lysimachia quadrifolia* L. and of *L. terrestris* (L.) B. S. P. when the flowers first open are sharply curved to one side by a bend near the middle of the style. After the anthers have shed their pollen the pistil is erected and the stigma in position for cross-fertilization by the insect-visitor. That this may be accomplished, the blooms last for several days.

The stigmatic lobes of *Sabbatia angularis* (L.) *Pursh.* are as long or longer than the supporting style and the whole pistil only about one half the length of the stamens when the flower first opens. To make it doubly sure that self-pollenation shall not occur, the lobes are closely twisted together until the coiled anthers have unrolled and shed their pollen. In the meantime the pistil has increased in length and the lobes curved back at right angles to the style. The lobes are stigmatic along the inner side, and remained twisted after they are recurved, so that an insect passing over or under them with pollen on its back or under parts, would be likely to effect fertilization. Many of the flowers are in bloom at the same time, are quite handsome, fragrant, and stay in bloom a week or more. It is curious that finding the plant in a certain locality one season is no sign that it can be found there next year.

Taraxacum Taraxacum (L.) Kerst. While watching the effects of temperature on the dandelion in June a number were found which were not producing pollen, the heads were perfect in every way, but had no pollen on the styles or branches of the stigmas when the bees were excluded.

The connate anther-tubes, which were of the normal form in all stages of development, were examined under the microscope and not a grain of pollen found in them. The sterile heads were of a uniform pale yellow and lacked the golden tinted center of the fertile heads found growing near by. Bees indifferently passed from one kind to the other. Seed was formed on the sterile heads, but there were more aborted achenes than usual.

The dandelion is very sensitive to change of temperature, while the absence of sunshine has very little effect. Early in the season the same heads may be exposed as often as three days in succession, and the involucre not be opened for more than two or three hours at any one time. As the temperature increases they stay exposed from early morning until shut up by the falling temperature of the afternoon, and may not open again next day.

Ruellia strepens L. produces a large crop of cleistogamous flowers during late summer and autumn. The flowers are clustered in the axils and hidden by the long segments of the calyx. The change from conspicuous to concealed flowers involves more than a change from gamopetalous to apetalous. The stamens are reduced in length to that of the ovary with a small pollen-producing surface at the tip, which is in close proximity to the sessile stigma. The resulting capsules are numerous and well filled with seed.

Falcata comosa (L.) Kuntze sends forth long, slender, stoloniferous runners in early summer that produce apetalous flowers before the conspicuous blooms appear. Not only is the form of the flower quite different from that of those coming later, but the early, ovoid, single-seeded, fleshy pod is very unlike the three-seeded, bean-like pod of the later flowers. The mature single-seeded pods are found on or near the ground after the conspicuous flowers have come into bloom.

If *Oxalis stricta* L. produces cleistogamous flowers on recurved scapes, at the base of the plant I have not seen them, but have found flowers in

July in which the calyx remained closed over the dwarfed corolla. The only change in structure noted was that the five shorter stamens bore aborted anthers, and that the pollen-bearing anthers were in contact with the stigma. Contrary to what some writers state the stamens of *O. Stricta* are often dimorphic. The self-pollenation of the normal flower is accomplished by the corolla closing after exposure, and pressing the anthers against the stigma.

One of the most interesting changes in structure from a conspicuous to a cleistogamous flower is seen in the violet. The showy flowers are so constructed that the honey-bee is the only insect that I know to be of service in its fertilization, and only a part of the anthers are called into use by it. To reach the spur in which the nectar is stored, the bee, after it settles, has to reverse its position, and force its tongue between the two appendages on the lower stamens. In doing this it comes in contact with the stigma and at the same time is dusted with pollen from the appendaged stamens. The anthers of the other three stamens do not aid in supplying the bee with pollen, and seem to be of very little if any use to the plant. In the concealed flowers, they are aborted. The pistil, of the cleistogamous flowers of *Viola Striata* Ait., is declined, so as to bring the stigma against the end of the ovary, and in contact with the two connivent anthers. Two appendages grow from the fertile stamens, just below the anthers, that are expanded so as to cover the anthers and the whole of the pistil.

V. striata continues to produce showy flowers longer than many other species, and as a consequence its concealed flowers come in summer.

Viola pubescens Ait. develops a few yellow flowers in early spring. It continues to grow until August, and as it grows, concealed flowers are developed in the axils of the leaves.

The abruptness of the change from a showy to a cleistogamous flower was beautifully shown on a plant of *Impatiens biflora* that produced a well-developed, conspicuous flower on one branch of a peduncle and a concealed flower on the other branch.

The fact that the stigma of *Tecoma radicans* returns to its former position in two hours after it has been changed in response to an irritant, unless the irritation has been accomplished by pollen of a certain quality, shows that the process of fertilization begins within two hours after the right kind of pollen has been applied, and that the stigma is endowed with remarkable selective power. The whole process suggests the shadowy beginning that has culminated in the will, and recalls Professor Minot's definition of consciousness, "the function of consciousness is to dislocate in time the reactions from sensations." In *Tecoma* the reaction is not dislocated from the sensation, for there can not be such a thing as sensation in a plant, but there is a curious tendency in that direction.

The calyx of *Scutellaria cordifolia* Muhl. splits back to the base at maturity, and the helmet-like upper lip falls away. Before the upper lip falls the ripe nutlets lie loose in the bowls of the persistent lower lip. A gust of wind strong enough to set the dry leafless stems to swaying will detach the upper lip and send the seeds flying with the wind.

The following plants, which are not included in Professor Coulter's "Flowering Plants and Ferns of Indiana," are known to occur in Bartholomew County. *Quercus Schneckii* Britton is common in the western part of the county, and frequently wherever red and black oaks grow. *Quercus Alexanderi* Britton formerly was abundant on the Knobstone hills of Bartholomew and Brown counties and the north part of Jackson County. Locally it is known as chestnut oak or tan-bark oak. Some years ago the bark was an important source of revenue to the inhabitants of Brown County. Along the line of the Baltimore & Ohio Southwestern Railroad, where it grows in dense forests, it is being shipped for use as telephone poles.

Perilla frutescens (L.) Britton grows on the south side of Columbus, Hope & Greensburg Railroad one-fourth mile east of Lambert's Switch. It is abundant in that locality.

Tradescantia bracteata Small occurs sparingly, and *T. reflexa* Raf., commonly, on the sandhills of Bartholomew and Brown counties. *T. bracteata* blooms in April, and does not last later than May. The oaks above named have been reported as occurring in the State by Professor Coulter, the others are believed to be new to the Indiana list.

Bird Notes From the Indiana State Forestry Reservation.

By Chas. Piper Smith.

During the summer of 1903 I was fortunate in being located, for some five weeks, upon the State Forestry Reservation, in the "Knob" region of southern Indiana. Although engaged in making a survey of the plant life of the Reservation, my ears were ever attentive to the bird voices about me, and a list of the various species heard or seen was preserved. Sixty-one species were noted within Reservation limits, as recorded below. No especial care was taken to study the relations of the birds to the trees and their other natural surroundings; but a few general remarks may be based upon a review of the bare list.

It will be noticed that the birds enumerated include forms characteristic of both woodland and open, though the number of woodland species far exceeds the number of kinds loving the field, sky or orchard. The absence of running water, during the summer and fall months, makes impossible the conditions necessary to attract water and swamp-loving forms; hence the scarcity of such in the list. Of the two thousand acres composing the Reservation, possibly eighteen hundred are wooded. Thus it is apparent why the woodland birds exceed in number of species; and it is likewise true that many of these woodland forms lead in regard to number of individuals. Some four hundred feet difference in elevation exists between the lowlands and the tops of the higher knobs, the deep ravines between the knobs forming tempting bird haunts.

Although not intending to give time to my favorite study, the birds and all that concerns them, I was ready to give heed to Mr. Butler's suggestion to look for the Pine Warbler, *Dendroica rigorsii*, and evidence of its nesting there. As far as known to us, this bird has not been definitely reported as a breeder within our State, although there are several localities which have conditions apparently meeting the demands of this pine-loving little warbler. What evidence I was able to glean is contained in the following testimony, but it is, of course, not equal to the best evidence, namely, the collection of a nest with the eggs and the parents.

I first saw the Reservation on the twentieth of July and I began my list that day. Two days later, while upon the Hollister knob, an unfamiliar bird song diverted my attention from stuffing plants and leaves into my "botany-can," and, forgetting my botanical work for a few moments, I turned aside to seek the singer. The song ceased upon my intrusion, but after a short search, I spied a family of four small dull-colored warblers which seemed not anxious to make my acquaintance. As I had no means of getting one of these into my hand, I was about to pass the group by as too uncertain of identification for recording, when a male Pine Warbler, as easily recognized, joined them and showed himself to be no stranger amongst them. Then resemblances in plumage were noted which removed all doubt on my part as to the identity of the others. Three of the family, in appearance and voice, strongly suggested young of the year, and, before I left them, or rather they left me, I had the pleasure and satisfaction of seeing the supposed female side up to and feed one of the three of juvenile appearance.

Later this song was heard on various occasions, and, on July 21st and August 18th, I had most satisfactory observation of Pine Warblers, both of adult males and their duller-colored followers; but no further evidence was secured as to the breeding of this species there. All my Pine Warbler observations were upon the knob-tops, close to the pine areas. I am anxious to visit the Reservation during some May or June when, I am confident, I could collect more conclusive evidence of the breeding of the Pine Warbler within our State.

As to the other Reservation birds I will limit myself to the mere listing of them, the species recognized being:

1. *Colinus virginianus* (Linn.). Bob-white.
2. *Zenaidura macroura* (Linn.). Mourning Dove.
3. *Cathartes aura* (Linn.). Turkey Vulture.
4. *Falco sparverius* Linn. American Sparrow Hawk.
5. *Megascops asio* (Linn.). Screech Owl.
6. *Coccyzus americanus* (Linn.). Yellow-billed Cuckoo.
7. *Dryobates villosus* (Linn.). Hairy Woodpecker.
8. *Dryobates pubescens medianus* (Swains.). Downy Woodpecker.
9. *Melanerpes erythrocephalus* (Linn.). Red-headed Woodpecker.
10. *Colaptes auratus luteus* Bangs. Northern Flicker.
11. *Antrostomus vociferus* (Wils.). Whip-poor-will.
12. *Chordeiles virginianus* (Gmel.). Nighthawk.

13. *Chætura pelagica* (Linn.). Chimney Swift.
14. *Trochilus colubris* Linn. Ruby-throated Hummingbird.
15. *Tyrannus tyrannus* (Linn.). Kingbird.
16. *Myiarchus crinitus* (Linn.). Crested Flycatcher.
17. *Sayornis phœbe* (Lath.). Phœbe.
18. *Contopus virens* (Linn.). Wood Pewee.
19. *Empidonax virescens* (Vieill.). Green-crested Flycatcher.
20. *Cyanocitta cristata* (Linn.). Blue Jay.
21. *Corvus americanus* Aud. American Crow.
22. *Molothrus ater* (Bodd.) Cowbird.
23. *Sturnella magna* (Linn.). Meadowlark.
24. *Icterus galbula* (Linn.). Baltimore Oriole.
25. *Astragalinus tristis* (Linn.). American Goldfinch.
26. *Poœcetes gramineus* (Gmel.). Vesper Sparrow.
27. *Coturniculus savannarum passerinus* (Wils.). Grasshopper Sparrow.
28. *Chondestes grammacus* (Say). Lark Sparrow.
29. *Spizella socialis* (Wils.). Chipping Sparrow.
30. *Spizella pusilla* (Wils.). Field Sparrow.
31. *Peucæa æstivalis bachmanii* (Aud.). Bachman Sparrow.
32. *Pipilo erythrophthalmus* (Linn.). Towhee.
33. *Cardinalis cardinalis* (Linn.). Cardinal.
34. *Cyanospiza cyanea* (Linn.). Indigo Bunting.
35. *Piranga erythromelas* Vieill. Scarlet Tanager.
36. *Piranga rubra* (Linn.). Rose Tanager.
37. *Progne subis* (Linn.). Purple Martin.
38. *Hirundo erythrogaster* Bodd. Barn Swallow.
39. *Ampelis cedrorum* (Vieill.). Cedar Waxwing.
40. *Lanius ludovicianus* Linn. Loggerhead Shrike.
41. *Vireo olivaceus* (Linn.). Red-eyed Vireo.
42. *Vireo gilvus* (Vieill.). Warbling Vireo.
43. *Mniotilta varia* (Linn.). Black and White Warbler.
44. *Helminthophila pinus* (Linn.). Blue-winged Warbler.
45. *Dendroica vigorsii* (Aud.). Pine Warbler.
46. *Seiurus aurocapillus* (Linn.). Oven-bird.
47. *Geothlypis formosa* (Wils.). Kentucky Warbler.
48. *Geothlypis trichas* (Linn.). Maryland Yellow-throat.
49. *Icteria virens* (Linn.). Yellow-breasted Chat.
50. *Wilsonia mitrata* (Gmel.). Hooded Warbler.

51. *Galeoscoptes carolinensis* (Linn.). Catbird.
52. *Toxostoma rufum* (Linn.). Thrasher.
53. *Thryothorus ludovicianus* (Lath.). Carolina Wren.
54. *Thryomanes bewickii* (Aud.). Bewick Wren.
55. *Sitta carolinensis* Lath. White-breasted Nuthatch.
56. *Bæolophus bicolor* (Linn.). Tufted Titmouse.
57. *Parus carolinensis* Aud. Carolina Chickadee.
58. *Polipotila cærulea* (Linn.). Blue-gray Gnatcatcher.
59. *Hylocichla mustelina* (Gmel.). Wood Thrush.
60. *Merula migratoria* (Linn.). American Robin.
61. *Sialia sialis* (Linn.). Bluebird.

Notes Upon Some Little-Known Members of the Indiana Flora.

By Chas. Piper Smith.

As a member of the senior class in botany at Purdue, during the last spring, I began a season of active field work in botany, which circumstances led me to continue through the summer and autumn.

Five weeks during July and August were spent upon the State Forestry Reservation, in Clark County, the major portion of the season, however, after leaving Lafayette in June being spent about Indianapolis.

Britton and Brown's "Illustrated Flora of the Northern States and Canada" was used as the basis of study, the more recent Britton's Manual not being at hand for comparison.

Dr. Coulter's catalogue of the State flora was always referred to as each plant was handled, and it is in reference to this list that I make the following notes.

Most of the plants here considered have been checked over for me by Mr. Bartlett, of the Shortridge High School, and most of the specimens upon which determinations have been based have been laid before Dr. Stanley Coulter and left in his charge.

Carex Baileyi Britton. Bailey's Sedge.

Common about Indianapolis. Taken by Mr. Bartlett and myself along streams and in wet places. Also taken by me upon the Forestry Reservation, where it was first recognized. Not recorded by Dr. Coulter.

Carex Hitchcockiana Dewey. Hitchcock's Sedge.

Taken by me in Tippecanoe County. Noted but once.

Carex Careyana Torr. Carey's Sedge.

Found once in Marion County.

Carex stipata Muhl. Awl-fruited Sedge.

Taken in Tippecanoe County.

Carex vulpinoidea Michx. Fox Sedge.

Taken in Hamilton County.

Carex sterilis Willd. Little Prickly Sedge.

Taken in Tippecanoe County.

Carex Muskingumensis Schwein. Muskingum Sedge.

Taken in Hamilton County, associated with the next.

Carex scoparia Schk. Pointed Broom Sedge.

Carex cristatella Britton. Crested Sedge.

Common in Hamilton and Marion counties. Heretofore unrecorded.

Juncus marginatus aristulatus (Michx.) Coville.

This form of the Grass-leaved Rush was found upon the Reservation. Not reported in the State catalogue.

Quercus Prinus L. Rock Chestnut Oak.

This species is the chestnut oak of the Forestry Reservation. As Dr. Coulter withdraws the record for Tippecanoe County, this form is not definitely recorded from the State, though I am sure that others have recognized it. I have studied the specimens of *Q. Alexandrii* near Lafayette, as also various specimens of *Alexandrii* and *acuminata* about Indianapolis, and I am sure that the Reservation chestnut oaks should be referred to this species.

Sisymbrium altissimum L. Tall Sisymbrium.

Taken by Mr. Benj. W. Douglass and myself along the "Monon," north of the State Fair Grounds, Indianapolis. One fine, large specimen was the only one found.

Agrimonia pumila Muhl. Small-fruited Agrimony.

Taken upon the Reservation. Not very common. Found with *A. mollis*, which was quite common.

Vicia angustifolia Roth. Smaller Common Vetch.

Taken by Mr. Harley, H. Bartlett and myself along the "Monon," north of the State Fair Grounds, Indianapolis.

Hypericum maculatum Walt. Spotted St. John's-wort.

Reported from only one county (Steuben), but frequent in Marion County, and abundant upon the Reservation. *H. perforatum* was also taken in Marion County, and was used for comparative study.

Sarothra gentianoides L. Pine-weed.

Presumably one of the rarest plants of the State. A small patch of plants was found upon the Reservation.

Lechea racemulosa Michx. Oblong-fruited Pin-weed.

Lechea tenuifolia Michx. Narrow-leaved Pin-weed.

These two pin-weeds are common in certain dry, barren areas on the Reservation, and are always associated where found. *L. racemulosa* has not been recorded from the State.

Angelica villosa (Walt.) B. S. P. Pubescent Angelica.

A common plant on the Reservation. An addition to the State flora.

Scutellaria campestris Britton. Prairie Skullcap.

Noted as common on one barren knob-side upon the Reservation. First record for the State. *S. parvula* was also taken, in moist soil in the lowlands. The hairy form seems to be well defined.

Stachys ambigua (A. Gray) Britton. Dense-flowered Hedge Nettle.

Taken upon the Reservation. First record for the State.

Salvia lanceolata Willd. Lance-leaved Sage.

Found sparingly at a dumping ground along Fall Creek, at Central Avenue, Indianapolis. Identification verified by Prof. W. S. Blatchley. Second Indiana station of this western plant.

Ilysanthes attenuata (Muhl) Small. Short-stalked False Pimpernel.

This easily recognized form was taken upon the Reservation. First record for the State.

The Development of the Spermatozoid of Chara.

By D. M. Mottier.

(Abstract.)

The spermatozoid of *Chara fragilis* is a spirally-coiled body consisting of a nucleus and a specially differentiated part of the cytoplasm, the blepharoplast, existing in the form of a thread, or band, bearing two long cilia. The nucleus occupies the middle part of the spermatozoid. The anterior end of the blepharoplast is thinner than the posterior and tapers slightly toward the extremity. The two cilia are borne some distance back of the anterior extremity. The posterior end is broader and thicker and terminates bluntly. In cross section the blepharoplast is crescentic, being convex on the outside and concave within. With the exception of a strip of granular substance along the concave side of the posterior end, it is of a homogeneous structure. The entire spermatozoid makes two and one-half or three spiral turns.

The blepharoplast arises as a delicate thread-like differentiation of the cytoplasm at the surface of the cell, extending some distance along the cell from the nucleus and on opposite sides of the latter. It seems to be a modification of the plasma membrane. No centrosome-like body, or "Plasmahöcker," was observed from which the blepharoplast might develop as described by Belajeff, Strasburger and others.

The nucleus is transformed from an elliptical or oval body, with a hollow chromatin spirem, to a dense, homogeneous, sausage-shaped structure making one spiral turn or more.

The cilia were always found attached some distance back of the anterior extremity of the blepharoplast. Their origin was not traced to a centrosome-like body, but they seemed to grow directly from the thread-like blepharoplast.

Contribution to the Flora of Indiana.

By Stanley Coulter.

(By title.)

Further Studies on Anomalous Dicotyledonous Plants.

By D. M. Mottier.

(Abstract.)

The studies referred to deal with the development of the embryo with special reference to the origin of the cotyledons in *Actea alba*, *Stylophorum diphyllum* and *Sanguinaria canadensis*. In the origin of the cotyledons all three species show, in varying degrees, the distinguishing characteristics of typical anomalous dicots. In each the embryo becomes pear-shaped before any indication of the cotyledonar primordium is apparent. The primordium of the cotyledons now appears as an almost complete, circular, ridge-like outgrowth from the margin of the broadly truncated end of the embryo. With the further growth of this ridge a bifurcation soon appears at a point exactly opposite the primary cleft of the primordium, so that the two young cotyledons, which may or may not be of the same size, seem to represent two separate and opposite lobes of the distal end of the embryo with one of the clefts a little deeper than the other. In some cases (Stylophorum) the two cotyledons seem to arise as separate and independent outgrowths, but a little later their common base grows faster on one side than on the other, and in this manner the two clefts or bifurcations become unequal in depth.

It is important to note, however, that in embryos of different individuals of the same species the anomalous character is much more strongly marked than in others.

On the Germination of Certain Native Weeds.

By Stanley Coulter.

(By title.)

Revised List of Indiana Plant Rusts.

By J. C. Arthur.

Five years ago a list of the plant rusts of Indiana was prepared, and printed in the Proceedings for 1898, to show not only how many and what species occur within the State, but the application of the revised nomenclature, to which great attention has been directed within the last decade. At that time the writer had made little study of the basis for the generic names, but accepted largely the conclusions announced by Kuntze in his *Revisio generum plantarum*. Since the presentation of the list, two other papers have been brought before the Academy by the writer, discussing the status of the genus names *Puccinia* and *Gymnosporangium*, the only considerable points in controversy touched by the Indiana list.

In order to embody the latest conclusions and reaffirm those remaining unchanged, as well as to correct a few errors and add the species brought to light since that list was issued, the writer presents herewith a revised list of the Indiana plant rusts. It is given in the latest nomenclature to familiarize the members of the Academy with this phase of scientific movement. It is not a nomenclature that can be generally used at present, for the reason that no standard works of reference are yet available employing the accepted names. But it does not materially detract from the usefulness of a local list, like the present one, and yet gives the reader a chance to see the direction in which the new movement is leading.

The present list, like the preceding one, does not include the unattached aecidia and uredo. Some thirteen of these that have been mentioned from time to time in the Proceedings of the Academy have been traced to their teleutosporic connections since the last revised list was published, and are here included as autonomous species. Besides these, eleven species of rusts have been added to the State flora, having never been reported in any form before. The hosts reported in this list for the first time are recorded by month, county and collector. The specimens, on which these data are based, are in the herbarium at Purdue University. The references after the other hosts are to the page and year of the Proceedings of the Academy, where additional information can be found. The nomenclature for hosts is that of Britton and Brown's "Illustrated Flora of the Northern States and Canada."

The present list contains 105 species of plant rusts under sixteen genera, being an increase of more than 33 per cent. over the previous list of 1898, which contained 80 species under ten genera.

COLEOSPORIACEÆ.

1. COLEOSPORIUM SONCHI-ARVENSIS (*Pers.*) *Wint.*
   On Hieracium scabrum Michx. Vigo Co., 5, 1893 (Underwood).
2. COLEOSPORIUM IPOMŒÆ (*Schw.*) *Bur.*
   On Ipomœa pandurata (L.) Mey. 1896:171, 218.
3. COLEOSPORIUM SOLIDAGINIS (*Schw.*) *Thuem.*
   On Aster azureus Lindl. 1893:50.
   On Aster cordifolius L. 1893:51.
   On Aster Novæ Angliæ L. 1893:51.
   On Aster paniculatus Lam. 1893:51.
   On Aster puniceus L. 1893:51.
   On Aster sagittifolius Willd. 1893:51.
   On Aster salicifolius Lam. 1893:51.
   On Aster Shortii Hook. 1893:51.
   On Aster Tradescanti L. 1893:51.
   On Solidago arguta Ait. 1893:51.
   On Solidago cæsia L. 1893:51.
   On Solidago Canadensis L. 1893:51.
   On Solidago flexicaulis L. (*S. latifolia* L.) 1893:51.
   On Solidago patula Muhl. 1893:51.
   On Solidago rugosa Mill. 1893:51.
   On Solidago serotina Ait. 1893:51.
4. COLEOSPORIUM VERNONIÆ *B. & C.*
   On Vernonia fasciculata Michx. 1893:51.
   On Vernonia Noveboracensis (L.) Willd. 1893:51.

MELAMPSORACEÆ.

5. CHRYSOMYXA ALBIDA *Kühn.* (*Coleosporium Rubi E. & H.*)
   On Rubus cuneifolius Pursh. 1893:50.
   On Rubus villosus Ait. 1893:50.

6. Pucciniastrum Agrimoniæ (*DC.*) *Diet.* (*Cæoma Agrimoniæ* Schw.)
   On Agrimonia hirsuta (Muhl.) Bick. (*A. Eupatoria* Am. Auct.) 1893:50. 1896:218.
   On Agrimonia parviflora Sol. 1893:50.
7. Thecopsora Hydrangeæ (*B. & C.*) *Magn.* (*Uredo Hydrangeæ* B. & C.)
   On Hydrangea arborescens L. 1893:56. 1896:218.
8. Hyalopsora Polypodii (*Pers.*) *Magn.* (*Uredo Polypodii* DC.)
   On Cystopus fragilis (L.) Bernh. 1893:56.
9. Melampsora Medusæ *Thuem.*
   On Populus balsamifera L. 1893:51.
   On Populus deltoides Marsh. (*P. monilifera* Ait.) 1893:51. 1896:218.
   On Populus grandidentata Michx. 1893:51.
   On Populus tremuloides Michx. 1893:51. 1898:188.
10. Melampsora farinosa (*Pers.*) *Schræt.*
    On Salix amygdaloides Anders. Steuben Co., 8, 1903 (*Kellerman*).
    On Salix cordata Muhl. 1893:51.
    On Salix discolor Muhl. 1893:51. 1896:218.
    On Salix fluviatilis Nutt. (*S. longifolia* Muhl.) 1893:52.
    On Salix interior Rowl. Steuben Co., 8, 1903 (*Kellerman*).
    On Salix nigra Marsh. 1893:51.
11. Melampsoridium betulinum (*Pers.*) *Kleb.*
    On Betula lutea Michx. Steuben Co., 8, 1903 (*Kellerman*).

PUCCINIACEÆ.

12. Aregma disciflora (*Tode*) *Arth.* (*Phragmidium subcorticium* Wint.)
    On Rosa Carolina L. 1893:52.
    On Rosa humilis Marsh. (*R. lucida* Am. Auct.) 1893:52.
    On Rosa setigera Michx. 1893:52.
13. Aregma Fragariæ (*DC.*) *Arth.*
    On Potentilla Canadensis L. 1893:52. 1896:218.
14. Aregma speciosa *Fr.* (*Phragmidium speciosum* Cke.)
    On Rosa Carolina L. 1896:219.
    On Rosa humilis Marsh. 1898:179.
15. Triphragmium Ulmariæ (*Schum.*) *Lk.*
    On Ulmaria rubra Hill. Tippecance Co., 6, 1899 (*Arthur*).

16. GYMNOCONIA INTERSTITIALIS (*Schl.*) *Lagh.* (*Puccinia Peckiana* Howe and *Æcidium nitens* Schw.)
On Rubus occidentalis L. 1893:54.
On Rubus villosus Ait. 1893:54. 1896:220. 1898:188.

17. CÆOMURUS ACUMINATUS (*Arth.*) *Kuntze.*
On Spartina cynosuroides Willd. Jasper Co., 5, 1903 (*Arthur*); Steuben Co., 8, 1903 (*Kellerman*).

18. CÆOMURUS CALADII (*Schw.*) *Kuntze.* (*Uromyces Caladii* Farl.)
On Arisæma triphyllum (L.) Torr. 1893:56. 1896:222. 1898:189.
On Arisæma Dracontium (L.) Schott. 1893:56. 1896:222.

19. CÆOMURUS CARYOPHYLLINUS (*Schr.*) *Kuntze.*
On Dianthus Caryophyllus L. 1893:56.

20. CÆOMURUS EUPHORBIÆ (*Schw.*) *Kuntze.*
On Euphorbia dentata Michx. 1893:57. 1896:222.
On Euphorbia nutans Lag. (*E. hypericifolia* Gr.) 1893:57. 1896:222.
On Euphorbia humistrata Engelm. Tippecanoe Co., 6, 1902 (*Arthur*).

21. CÆOMURUS SOLIDAGINI-CARICIS (*Arth.*) *nom. nov.*
On Carex lanuginosa Michx. Jasper Co., 3, 1903 (*Arthur*).
On Carex varia Muhl. Jasper Co., 3, 1903 (*Arthur*).

22. CÆOMURUS GRAMINICOLUS (*Burr.*) *Kuntze.*
On Panicum virgatum L. 1893:57.

23. CÆOMURUS HOWEI (*Pk.*) *Kuntze.*
On Asclepias incarnata L. 1893:57. 1896:222.
On Asclepias purpurascens L. 1893:57.
On Asclepias Syriaca L. (*A. Cornuti* Dec.) 1893:57. 1896:222. 1898:187.

24. CÆOMURUS HEDYSARI-PANICULATI (*Schw.*) *Arth.*
On Meibomia Canadensis (L.) Kuntze (*Desmodium C.*). 1896:222.
On Meibomia canescens (L.) Kuntze (*Desmodium c.*). 1893:57.
On Meibomia Dillenii (Darl.) Kuntze (*Desmodium D.*). 1893:57. 1896:222.
On Meibomia lævigata (Nutt.) Kuntze (*Desmodium l.*). 1893:57.
On Meibomia paniculata (L.) Kuntze (*Desmodium p.*). 1893:57.
On Meibomia viridiflora (L.) Kuntze (*Desmodium v.*). 1893:57.

25. Cæomurus Hyperici-frondosi (*Schw.*) *Arth.*
On Hypericum Canadense L. 1893:57.
On Hypericum mutilum L. 1893:57.
On Triadenum Virginicum (L.) Raf. (*Elodea campanulata* Marsh.) 1893:57.

26. Cæomurus Junci (*Schw.*) *Kuntze.*
On Juncus tenuis Willd. 1896:222. 1898:187.

27. Cæomurus Lespedezæ-procumbentis (*Schw.*) *Arth.*
On Lespedeza frutescens (L.) Brit. (*L. reticulata* Pers.) 1893:57.
On Lespedeza procumbens Michx. 1893:57.
On Lespedeza repens (L.) Bart. 1896:222.
On Lespedeza capitata Michx. Jasper Co., 3, 1903 (*Arthur*).
On Lespedeza hirta (L.) Ell. Marshall Co., 10, 1893 (*Underwood*).

28. Cæomurus Orobi (*Pers.*) *nom. nov.*
On Vicia Americana Muhl. 1896:222.

29. Cæomurus perigynius (*Halst.*) *Kuntze.*
On Carex virescens Muhl. 1893:57.

30. Cæomurus Phaseoli (*Pers.*) *Arth.*
On Strophostyles helvola (L) Brit. (*Phaseolus diversifolius* Pers.) 1893:56. 1896:172, 222.
On Vigna Sinensis (L.) Endl. Tippecanoe Co., 10, 1903 (*Arthur*).

31. Cæomurus plumbarius (*Pk.*) *Kuntze.* (*Uredo gaurina* (Pk.) DeT.)
On Gaura biennis L. 1896:222.

32. Cæomurus Polygoni (*Pers.*) *Kuntze.*
On Polygonum aviculare L. 1893:57. 1896:223.
On Polygonum erectum L. 1893:58.

33. Cæomurus Rudbeckiæ (*Arth. & Holw.*) *Kuntze.*
On Rudbeckia laciniata L. 1894:152. 1898:187.

34. Cæomurus Trifolii (*Hedw.*) *Gray.*
On Trifolium hybridum L. 1893:58.
On Trifolium medium L. 1893:58.
On Trifolium pratense L. 1893:58. 1896:223. 1898:187, 189.
On Trifolium repens L. 1893:58.

35. Cæomurus Rhyncosporæ (*E. & G.*) *Kuntze.*
On Rhyncospora alba Vahl. Tippecanoe Co., 10, 1894 (*King*).

36. Dicæoma albiperidium (*Arth.*) *nom. nov.*
On Carex pubescens Muhl. Tippecanoe Co., 4, 1901 (*Arthur*).

37. Dicæoma Aletridis (*B. & C.*) *Kuntze.*
On Aletris farinosa L. Lake Co., 7, 1884 (*Hill*).

38. Dicæoma ambigua (*A. & S.*) *Kuntze.*
On Galium Aparine L. 1896:172.

39. Dicæoma Andropogonis (*Schw.*) *Kuntze.* (*Puccinia Andropogi* Schw.)
On Andropogon furcatus Muhl. 1896:219.
On Andropogon scoparius Michx. 1896:219.
On Pentstemon hirsutus (L.) Willd. 1896:217.

40. Dicæoma Anemones-Virginianæ (*Schw.*) *Arth.* (*Puccinia solida* Schw.)
On Anemone cylindrica Gr. 1896:219.
On Anemone Virginiana L. Tippecanoe Co., 6, 1903 (*Arthur*); Steuben Co., 8, 1903 (*Kellerman*).

41. Dicæoma angustatum (*Pk.*) *Kuntze.*
On Eriophorum polystachyon L. Noble Co., 8, 1884 (*Van Gorder*).
On Eriophorum Virginicum L. Noble Co., 8, 1884 (*Van Gorder*).
On Scirpus atrovirens Muhl. 1893:52. 1896:219.
On Scirpus cyperinus (L.) Kunth. 1893:52.
On Lycopus Americanus Muhl. (*L. sinuatus* Ell.) 1898:189.

42. Dicæoma apocryptum (*E. & Tr.*) *Kuntze.*
On Hystrix Hystrix (L.) Millsp. 1893:52.

43. Dicæoma argentatum (*Schultz*) *Kuntze.*
On Impatiens biflora Walt. (*I. fulva* Nutt.) 1893:52. 1896:220.

44. Dicæoma Asparagi (*DC.*) *Kuntze.*
On Asparagus officinalis L. Lake Co., 10, 1899 (*Breyfogle*); Fountain Co., 9, 1900 (*Beatty*); Tippecanoe Co., 3, 1901 (*Arthur*); Steuben Co., 8, 1903 (*Kellerman*).

45. Dicæoma Asperifolii (*Pers.*) *Kuntze.* (*Puccinia Rubigo-vera* (DC.) Wint.)
On Avena sativa L. 1893:55.
On Secale cereale L. 1896:221.

46. Dicæoma asteris (*Duby*) *Kuntze.*
On Aster cordifolius L. 1893:52.
On Aster lateriflorus (L.) Brit. (*A. diffusus* Ait.) 1896:219.
On Aster paniculatus Lam. 1893:52.

47. Dicæoma canaliculata (*Schw.*) *Kuntze.* (*Puccinia nigrovelata* E. & T. and *P. indusiata* D. & H.)
On Cyperus strigosus L. 1893:53, 54. 1894:154, 157. 1896:219, 220.

48. Dicæoma Caricis-Asteris (*Arth.*) *nom. nov.*
On Aster cordifolius L. 1893:49.
On Aster Drummondii Lindl. Tippecanoe Co., 5, 1901 (*Arthur*).
On Aster paniculatus Lam. Tippecanoe Co., 5, 1901 (*Arthur*).
On Aster sagittifolius Willd. 1893:49.
On Carex cephalophora Muhl. Tippecanoe Co., 6, 1902 (*Arthur*).
On Carex fœnia Willd. Tippecanoe Co., 4, 1901 (*Arthur*).

49. Dicæoma Caricis-Erigerontis (*Arth.*) *nom. nov.*
On Erigeron annuus L. 1894:151.
On Erigeron ramosus (Walt.) B. S. P. Jasper Co., 6, 1903 (*Arthur*).
On Leptilon Canadense (L.) Britt. Jasper Co., 6, 1903 (*Arthur*).
On Carex festucacea Willd. Tippecanoe Co., 4, 1901 (*Arthur*).
On Carex straminea Willd. 1893:52.

50. Dicæoma Caricis-Solidaginis (*Arth.*) *nom. nov.*
On Solidago cæsia L. 1893:49.
On Solidago Canadensis L. 1893:49.
On Solidago flexicaulis L. (*S. latifolia* L.) 1893:49.
On Solidago patula Muhl. Tippecanoe Co., 6, 1902 (*Arthur*).
On Carex Jamesii Schw. Tippecanoe Co., 4, 1902 (*Arthur*).
On Carex tetanica Schk. Tippecanoe Co., 6, 1899 (*Arthur*).

51. Dicæoma Chrysanthemi (*Roze*) *nom. nov.*
On Chrysanthemum Indicum L. Tippecanoe Co., 10, 1899 (*Dorner*).

52. Dicæoma Circææ (*Pers.*) *Kuntze.*
On Circæa Lutetiana L. 1893:53. 1896:219.

53. Dicæoma Convolvuli (*Pers.*) *Kuntze.*
On Convolvulus sepium L. 1893:53. 1896:219.

54. Dicæoma Dayi (*Clint.*) *Kuntze.*
On Steironema ciliatum (L.) Raf. 1893:53.

55. Dicæoma Dulichii (*Syd.*) *nom. nov.*
On Dulichium arundinacea (L.) Brit. 1893:52.

56. Dicæoma Eatoniæ (*Arth.*) *nom. nov.*

On Eatonia Pennsylvanica (DC.) Gray. Tippecanoe Co., 5, 1903 (*Arthur*).

On Ranunculus abortivus L. 1893:50.

57. Dicæoma Eleocharidis (*Arth.*) *Kuntze.*

On Eleocharis palustris (L.) R. & S. 1893:53. 1896:219.

58. Dicæoma Ellisianum (*Thuem.*) *Kuntze.*

On Andropogon scoparius Michx. Tippecanoe Co., 11, 1898 (Stuart).

59. Dicæoma emaculatum (*Schw.*) *Kuntze.*

On Panicum capillare L. 1893:53. 1896:220.

60. Dicæoma epiphyllum (*L.*) *Kuntze.* (*Puccinia Poarum* Niels.)

On Poa pratensis L. 1893:57. 1898:189.

61. Dicæoma fuscum (*Pers.*) *Kuntze.*

On Anemone quinquefolia L. (*A. nemorosa* Mx.) 1894:151.

62. Dicæoma Helianthi (*Schw.*) *Kuntze.*

On Helianthus annuus L. 1893:55.

On Helianthus divaricatus L. 1893:55.

On Helianthus giganteus L. Steuben Co., 8, 1903 (*Kellerman*).

On Helianthus grosse-serratus Mart. 1893:55. 1896:221.

On Helianthus mollis Lam. Jasper Co., 3, 1903 (*Arthur*).

On Helianthus strumosus L. 1893:55.

On Helianthus tracheliifolius Mill. 1893:55.

63. Dicæoma Heliopsidis (*Schw.*) *Kuntze.*

On Heliopsis scabra Dunal. 1893:54.

64. Dicæoma Muhlenbergiæ (*A. & H.*) *nom. nov.*

65. Dicæoma Windsoriæ (*Schw.*) *Kuntze.*

On Sieglingia seslerioides (Mx.) Scrib. (*Triodia cuprea* Jacq.) 1894:154. 1896:221.

On Ptelea trifoliata L. 1893:50. 1896:217.

On Muhlenbergia diffusa Schreb. 1893:53, 55.

On Muhlenbergia sylvatica Torr. 1896:221.

66. Dicæoma Impatientis (*Schw.*) *nom. nov.*

On Elymus Virginicus L. 1893:55. 1896:221.

On Impatiens biflora Walt. (*I. fulva* Nutt.) 1893:50.

On Impatiens aurea Muhl. 1896:217.

67. DICÆOMA KUHNIÆ (*Schw.*) *Kuntze*.
On Kuhnia eupatorioides L. 1893:54. 1896:220.

68. DICÆOMA LATERIPES (*B. & R.*) *Kuntze*.
On Ruellia strepens L. 1893:54. 1896:218.

69. DICÆOMA LOBELIÆ (*Ger.*) *nom. nov.*
On Lobelia syphilitica L. 1893:54. 1896:220.

70. DICÆOMA LUDIBUNDUM (*E. & E.*) *Kuntze*.
On Carex sparganioides Muhl. 1896:220.

71. DICÆOMA MAJANTHÆ (*Schum.*) *nom. nov.*
On Phalaris arundinacea L. Tippecanoe Co., 10, 1889 (*Stuart*).

72. DICÆOMA MELICÆ (*Syd.*) *nom. nov.*
On Melica diffusa Pursh. Tippecanoe Co., 10, 1899 (*Stuart*).

73. DICÆOMA MENTHÆ (*Pers.*) *Gray*.
On Blephilia hirsuta (Pursh.) Torr. 1893:54. 1896:220.
On Cunila origanoides (L.) Brit. 1893:54.
On Mentha Canadensis L. 1893:54.
On Monarda fistulosa L. 1893:54. 1896:220.
On Koellia pilosa (Nutt.) Brit. 1893:54.
On Koellia Virginiana (L.) MacM. 1893:54. 1896:220.

74. DICÆOMA OBTECTUM (*Pk.*) *Kuntze*.
On Scirpus lacustris L. 1894:151.

75. DICÆOMA PAMMELII (*Trel.*) *nom. nov.* (*Puccinia Panici* Diet. and *Æcidium Pammelii* Trel.)
On Panicum virgatum L. 1901:283.
On Euphorbia corollata L. 1893:49. 1901:284.

76 DICÆOMA PECKII (*De T.*) *nom. nov.*
On Carex cephalophora Muhl. Tippecanoe Co., 6, 1902 (*Arthur*).
On Carex stipata Muhl. Tippecanoe Co., 6, 1902 (*Arthur*).
On Carex trichocarpa Muhl. Tippecanoe Co., 11, 1901 (*Arthur*).
On Onagra biennis (L.) Scop. 1893:50. 1896:217.

77. DICÆOMA PHYSOSTEGIÆ (*P. & C.*) *Kuntze*.
On Physostegia Virginiana (L.) Benth. 1894:151. 1896:220.

78. DICÆOMA POCULIFORME (*Jacq.*) *Kuntze.* (*Puccinia graminis* Pers. and *Æcidium Berberidis* Pers.)

On Agrostis alba L. Steuben Co., 8, 1903 (*Kellerman*).

On Avena sativa L. 1893:53. 1896:220.

On Berberis vulgaris L. 1893:49.

On Cinna arundinacea L. Tippecanoe Co., 4, 1901 (*Arthur*).

On Dactylis glomerata L. 1896:220, 223.

On Hordeum jubatum L. 1896:220, 224.

On Poa compressa L. 1893:53.

On Poa pratensis L. 1893:53.

On Triticum vulgare L. 1893:54. 1898:188.

79. DICÆOMA PODOPHYLLI (*Schw.*) *Kuntze.*

On Podophyllum peltatum L. 1893:54. 1896:221. 1898:189.

80. DICÆOMA POLYGONI-AMPHIBII (*Pers.*) *Arth.*

On Geranium maculatum L. 1893:49. 1896:217. 1898:188.

On Polygonum emersum (Mx.) Brit. (*P. Muhlenbergii* Wats.) 1893:55.

On Polygonum hydropiperoides Michx. 1898:184. 1898:189.

On Polygonum lapathifolium L. 1898:184.

On Polygonum Pennsylvanicum L. 1898:184.

On Polygonum punctatum Ell. (*P. acre* H. B. K.) 1893:55, 57.

81. DICÆOMA POLYGONI-CONVOLVULI (*Hedw.*) *Arth.*

On Polygonum Convolvulus L. 1898:184.

On Polygonum scandens L. 1896:223.

On Polygonum Hartwrightii Gray. Steuben Co., 8, 1903 (*Kellerman*).

82. DICÆOMA PRENANTHIS. (*Pers.*) *Kuntze.*

On Nabalus albus (L.) Hook. 1893:55. 1896:221.

83. DICÆOMA PUNCTATUM (*Str.*) *nom. nov.*

On Galium asprellum Michx. 1893:53.

On Galium concinnum T. & G. 1893:53.

On Galium triflorum Michx. 1893:53.

84. DICÆOMA PUSTULATUM (*Curt.*) *nom. nov.*

On Andropogon furcatus Muhl. Jasper Co., 6, 1903 (*Arthur*).

On Andropogon scoparius Michx. Jasper Co., 3, 1903 (*Arthur*).

On Comandra umbellata (L.) Nutt. 1893:50.

85. Dicæoma Ranunculi (*Seym.*) *Kuntze.*
On Ranunculus septentrionalis Poir. 1893:55.

86. Dicæoma Rhamni (*Gmel.*) *Kuntze.* (*Puccinia coronata* Cda. and *Æcidium Rhamni* Gmel.)
On Avena sativa L. 1896:219. 1898:189.
On Calamagrostis Canadensis (Mx.) Beauv. 1893:53.
On Rhamnus lanceolata Pursh. 1898:184.

87. Dicæoma Sambuci (*Schw.*) *nom. nov.* (*Puccinia Bolleyana* Sacc.)
On Carex lurida Wahl. 1893:52.
On Carex Frankii Kunth. 1893:55. 1898:187.
On Carex trichocarpa Muhl. 1893:52. 1896:219.
On Sambucus Canadensis L. 1893:50.

88. Dicæoma Saniculæ (*Grev.*) *Kuntze.*
On Sanicula Canadensis L. 1893:55.

89. Dicæoma Silphii (*Schw.*) *Kuntze.*
On Silphium sp. 1893:55.
On Silphium integrifolium Michx. Tippecanoe Co., 8, 1901 (*Dorner*.

90. Dicæoma Sorghi (*Schw.*) *Kuntze.*
On Zea Mays L. 1893:54. 1898:188.

91. Dicæoma Taraxaci (*Plowr.*) *Kuntze.*
On Taraxacum Taraxacum (L.) Karst. 1893:53. 1896:219. 1898:188.

92. Dicæoma tenue (*Burr.*) *Kuntze.*
On Eupatorium ageratoides L. 1893:55. 1896:221.

93. Dicæoma Thalictri (*Chev.*) *Kuntze.*
On Thalictrum dioicum L. 1893:55.

94. Dicæoma Urticæ (*Schum.*) *Kuntze.* (*Puccinia Caricis* Reb. and *Æcidium Urticæ* Schum.)
On Carex riparia Curt. Steuben Co., 8, 1903 (*Kellerman*).
On Carex stricta Lam. Tippecanoe Co., 4, 1901 (*Arthur*); Steuben Co., 8, 1903 (*Kellerman*).
On Urtica gracilis Ait. 1898:185.

95. Dicæoma verbenicola (*E. & K.*) *nom. nov.* (*Puccinia Vilfæ* A. & H.)
On Sporobolus longifolius (Torr.) Wood. 1896:221.
On Verbena stricta Vent. 1896:218.

96. DICÆOMA VERNONIÆ (*Schw.*) *Kuntze.*
On Vernonia fasciculata Michx. 1893:55.

97. DICÆOMA VEXANS (*Farl.*) *Kuntze.*
On Bouteloua curtipendula (Michx.) Torr. 1901:283

98. DICÆOMA VIOLÆ (*Schum.*) *Kuntze.*
On Viola obliqua Hill (*V. cucullata* Ait.). 1893:56.
On Viola striata Ait. 1893:56.
On Viola pubescens Ait. Decatur Co., 5, 1889 (*Arthur*); Tippecanoe Co., 4, 1898 (*Arthur*).

99. DICÆOMA VULPINOIDIS (*D. & H.*) *Kuntze.*
On Carex vulpinoidea Michx. 1893:56. 1896:221.

100. DICÆOMA XANTHII (*Schw.*) *Kuntze.*
On Ambrosia trifida L. 1893:56. 1896:222.
On Xanthium Canadense Mill. 1893:56. 1896:222.
On Xanthium strumarium L. 1893:56.

101. GYMNOSPORANGIUM GLOBOSUM *Farl.* (*Rœstelia lacerata* Fr.)
On Cratægus coccinia L. 1893:56.
On Cratægus Crus-Galli L. 1894:153.
On Cratægus mollis (T. & G.) Scheele. (*C. subvillosa* T. & G.) 1898:186. 1898:188.
On Cratægus punctata Jacq. 1893:56.
On Juniperus Virginiana L. 1893:51.

102. GYMNOSPORANGIUM JUNIPERI-VIRGINIANÆ *Schw.* (*Rœstelia pyrata* Thax.)
On Malus coronaria (L.) Mill. (*Pyrus coronaria* L.) 1893:56. 1896:218.
On Malus Malus (L.) Brit. (*Pyrus Malus* L.) 1898:186. 1901:255.
On Pyrus communis L. 1893:56.
On Juniperus Virginiana L. 1893:51. 1896:218. 1901:255.

103. JACKYA CNICI (*Mart.*) *nom. nov.* (*Puccinia Cirsii-lanceolati* Schroet.)
On Carduus lanceolatus L. 1893:53.

104. PILEOLARIA BREVIPES *B. & Br.*
On Rhus radicans L. (*R. Toxicodendron* Am. Auct.) 1893:58 1896:223.

105. UROPYXIS AMORPHÆ (*Curt.*) *Schroet.*
On Amorpha canescens Pursh. 1893:58.

Additions to the List of Gall-Producing Insecta Common to Indiana.

By Mel T. Cook.

One year ago the writer presented a list of gall-producing insects, with a list of host plants, for the State of Indiana. This list is no doubt very incomplete, since the writer has collected specimens in Illinois and Ohio which have not been reported from Indiana. Furthermore, this collection of galls which I have received from other parts of the United States and Canada lead me to believe that galls have a very wide distribution; it is probable that the galls are distributed over as wide an area as the host species and, in some cases, are as widely distributed as the host genera. However, the insects may in some cases be restricted to smaller areas, due to other environments. Our knowledge of American galls is at present so limited that it is impossible to draw any definite conclusion on this subject.

Within the yast year I have collected a large number of galls in Illinois, Indiana, and Ohio, but, of course, many of these duplicate those reported in the list of one year ago. I have also received collections from various parts of the United States and Canada, and wish especially to thank Mr. F. L. Sims, of Laporte, Indiana, Mr. C. C. Deam, of Bluffton, Indiana, and Prof. W. A. Kellerman, of Columbus, Ohio, for interesting collections of Indiana galls.

The additional list which I now present gives an increase of two genera and eleven species of insecta.

Hemiptera:

41. Pemphigus populis-caulis, Riley, on Populus deltoides Marsh.
42. Pemphigus populis-transversus, Riley, on Populus deltoides Marsh.

Diptera:

43. Sciara ocellaris, O. S., on Acer saccharium L.
44. Cecidomyia holotricha, O. S., on Hicoria alba L. (Britton.)
45. Cecidomyia tubicola, O. S., on Hicoria alba L. (Britton.)

Hymenoptera:

46. Amphibolips sculpta Bass. on Quercus rubra L.

47. Andricus femoratus Ashm. on Quercus rubra L.

48. Andricus lana Fitch. on Quercus rubra L.

49. Diastrophus nebulosus O. S. on Rubus villosus Ait.

50. Diastrophus cuscutæformis O. S. on Rubus nigrobaccus Bailey.

51. Rhodites dichlocerus Harris, on Rosa sp ——.

Nos. 41 and 42 were collected in Wells County, Indiana, by C. C. Deam; Nos. 46 and 47 were collected near Laporte, Indiana, by F. L. Sims; No. 50 was collected in Steuben County, Indiana, by Prof. W. A. Kellerman, of the Ohio State University. All others were collected by me near Greencastle, Indiana.

No. 12. Trypeta solidaginis of the last report should have been placed under the order Diptera.

I should very much appreciate collections of galls from various parts of Indiana.

Nerve-End Organs in the Pancreas.

By E. O. Little.

The following is an abstract of work done to determine the number, position, and distribution of the Pacinian corpuscles in the pancreas of the cat. Mr. F. C. Jackson sectioned the material and counted the corpuscles.

	Cubic Centimeters of Pancreas.	Number of Pacinian Corpuscles in Pancreas	Number of Pacinian Corpuscles per c. c.
Pancreas, No. I...	10 5	72	6.85
" No. II..	12	43	3.58
" No. III	5 5	25	4.54
" No. IV	5	22	4 4
" No. V	7	85	12 14

Average number of corpuscles in pancreas 49.4, average number of corpuscles in per cubic centimeter of pancreas 6.17.

Ninety-five per cent. of the corpuscles are near the surface of the gland and may be stripped off with the mesentary; 5% are deep in the gland tissue. Of the 95% found near the surface, 28% were near dorsal, 72% near the ventral surface. Only occasionally was a corpuscle found in contact with the intestine.

A Crow Roost Near Richmond, Indiana.

By D. W. Dennis and Wm. E. Lawrence.

What is said in this paper about crows and their roosting is based upon observations taken by Professor Dennis and myself of one particular roost found about three miles south of Richmond, Indiana.

Through the latter part of January, 1903, crows were noticed flying in a direction about south by east in the evening and returning from the same direction in the morning. The evening flight was from 3 to 5:30; the crows were in flocks of from two or three or in a constant stream. The principal line of flight was about one-half mile west of Richmond. By actual count crows passed at the rate of one hundred or more in a minute for more than two hours. They were often so numerous it was impossible to count them. Judging from this there must have been at least 15,000 crows which roosted at this place. By 7 o'clock in the morning nearly every crow had returned from the roost on its way to cornfields, etc., in search of food.

Not far west of Richmond, in a small woodland, they stopped to rest or for some other reason. I have seen crows here by the thousand. It was here at this resting station that very evident exemplification was noted of their fear of man and their signaling to others following. I entered the woods and climbed a tree in order to watch better their maneuverings; however, they were not so kind and not one flew over the tree in which I was stationed. Repeatedly they flew at top speed in a line directly overhead but always, on discovering my presence, made a quick turn, uttered a peculiar call and passed around. This call evidently was a signal for those following to fly in like manner, because for the next few minutes the line passed to one side. Then some crow, not noting the signal, would appear coming directly towards me; but he never failed to make the sudden turn, utter the call and fly around.

This is more clearly brought out by "Driving the line." It was only necessary to walk in a railroad cut under a line of flying crows and it would bend around at a greater distance, the crows at the bend all the while signaling to those behind. In this manner on one occasion Professor Dennis drove them one-half mile to the west after which they passed on the east. On his return he in like manner drove them an equal distance to the east.

For some reason the crows never went directly to the roost. Whether it was done purposely to conceal the real roost can not be stated. However, they deceived us in this manner and caused us much trouble to find the roost. Three visits were made to the vicinity, two at night and one in the day time. The first visit, February 21st, they were found in a wood and an adjoining cornfield along a small stream of water. As we approached they preceded us. Approaching as quietly as possible, we stopped by a large tree and remained quiet, thinking we might be in the midst of the roost. Gradually all left; meanwhile scouts had been sent to watch us. They would fly directly overhead and then return to give information to the others. The roost was yet to be found. We went to the top of a neighboring hill and saw in the darkness several hundred feet beyond thousands of crows on the snow-covered ground. We could not approach without disturbing them. We did not remain till they went to the trees.

The next time was February 23d, from 6 to 6:30 p. m. We now found all the crows in the trees, most of them across the river from the place where we first saw them, in a large wood, the others in the sycamores along the river quite a distance from the main roost. They must have been doing picket duty, because they uttered no cries, while the others were constantly cawing; also when we purposely disturbed them some of them left silently to join the others.

The last visit, March 2d, was in the day time; the ground was carefully gone over; the boundaries were easily determined by the droppings, examination of which gave good evidence that they were eating a great deal of corn.

The main roost was located on the north side of a hill, 120 feet high, thickly wooded with beech, elm, and ash, and near the foot of this hill. Reference to the map will show that the roost was located in a gorge shut in by hills 90 feet high on the east, 50 feet high on the north and west, and, as before mentioned, 120 feet high on the south. A public road runs north and south to the east of the roost, and, as would be expected, the ground gave evidence of more crows roosting some distance from the road.

This particular hill was only used during the coldest weather; at other times the crows moved about from place to place for their roost. The hill

MAP OF VALLEY OF CROW ROOST.

⁂ Indicates roosting crows.
------ Indicates path of crows entering the valley.
Contour lines 10 ft. apart.

and the elevation of the surrounding land (as shown in the map) certainly furnished protection against the cold.

The crows began to arrive about 4 p. m., alighting in the neighboring trees and along the river bank, drinking water and picking pebbles. The main line seemed to arrive from the northeast and from no other direction. But, to our surprise, on our way home after leaving the valley, it was discovered that the crows from the northwest were flying southeast on a tangent with the valley and alighting in the trees and fields to the east; then turning at almost right angles they flew over the hill down into the valley where the roost was. Was this purposely done for protection?

In conclusion the main things to be noted are the bending of the line when men are seen; the signaling of danger to the oncoming line; that the crows never approached the roost directly and that they only roosted on the hillside during the coldest weather.

Some New Forms of Physiological Apparatus.

By J. F. Woolsey.

All branches of scientific work require special apparatus to fulfill their particular needs. The apparatus here shown was devised to meet certain requirements for adjustable apparatus, for use with the kymograph, in recording physiological experiments. It is apparently desirable in this work to have as many adjustments to the apparatus as possible, the solidity of the apparatus being unimpaired.

ADJUSTABLE STAND.

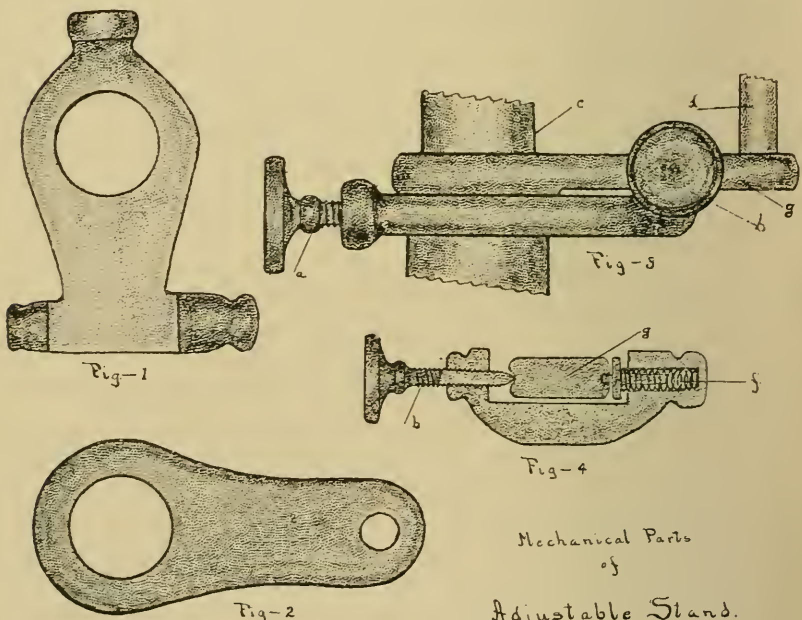
This stand consists of a base 5½"x8"x1"; a standard 18" high and 1" in diameter, to which is attached, by means of arms, the swinging rod upon which is supported, by means of universal clamps, the various forms of apparatus used in making the records upon the smoked drum of the kymograph. The entire stand weighs 15 pounds.

The swinging portion of the apparatus deserves special notice. Figure 2 of the mechanical parts serves as the top arm, and the upper plate of the lower arm. It is 3½" long and 1⅝" wide at the broadest part. Figure 1 is the lower plate of the lower arm, and is proportional in size to the upper plate. Figures 3 and 4 show the entire mechanism. In Figure 3, (a) is the coarse adjustment, and by releasing the set-screw the swinging rod (d) can be revolved about the standard (c); the desired pressure of the stylus against the drum of the kymograph is obtained by the manipulation of the more finely-threaded screw (b). In Figure 4, (b) represents the fine adjusting screw, and (f) the strong coiled spring, which operates the swinging rod attached to (g), as shown in Figure 3. The swinging rod is 14" long.

The University of Pennsylvania uses adjustable stands, devised and made by themselves, but the entire movement of the swinging rod is obtained from the bottom, and the mechanism is entirely different from the above. Credit is due Mr. R. P. Hobbs for his assistance in devising the mechanical parts.

FROG TABLES.

These tables are modifications of those used in the University of Pennsylvania, and meet certain requirements better. They consist, Figure 6, of a brass plate 4½"x8", to which is glued a single piece of cork ½" thick, and the adjustable arm or support. The adjustable part consists of a brass block (c) which slides upon the square rod (e), the set-screw (b), and has a horizontal play of 4½". The set-screw (a) allows of a further circular movement of the plate, and the square supporting arm is held to the stand by a universal clamp.



Mechanical Parts of Adjustable Stand.

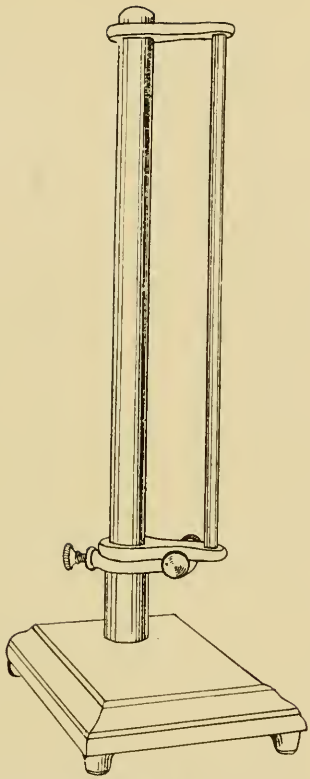


Fig. 5. Adjustable Stand.

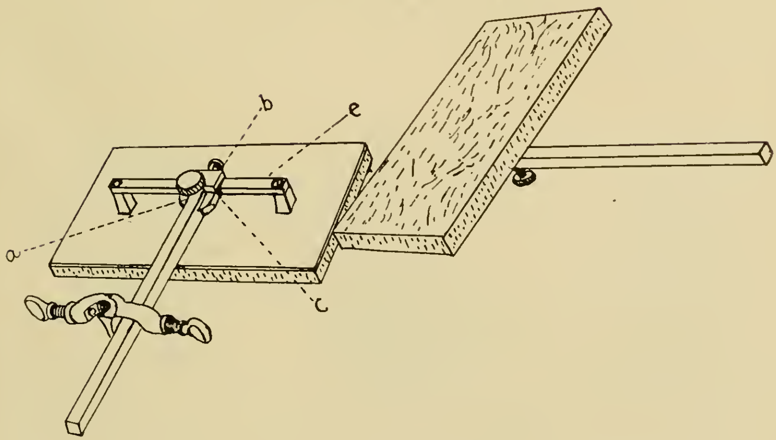


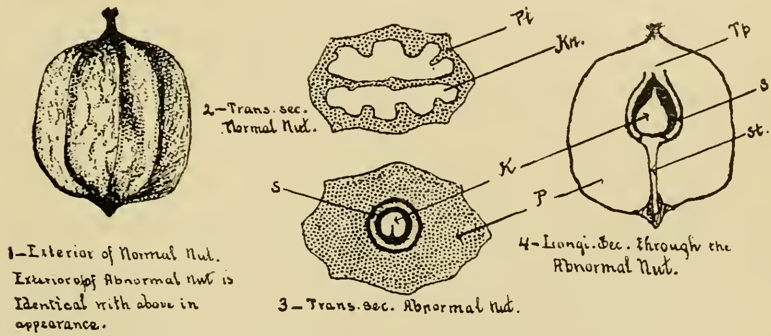
Fig. 6. Frog Tables.

An Abnormality in the Nut of Hicoria Ovata (Mill) Britton.

By John S. Wright.

The abnormal hickory nut figured and described here was one of a lot purchased in the market. In all outward appearances it was normal, the peculiarities were noted in cracking it. Fig. 2, a transverse section of a normal nut, shows the relative proportion of shell and seed. Fig. 3, transverse section of the abnormal fruit, shows the cavity one-celled and greatly reduced by the thickened walls (P). Figs. 3 and 4 show the interior filled with a nut somewhat like that of the hazel; (s) the walls hard and shell-like, and (K) the kernel, folded as indicated by the convolution on one side. The kernel had a bland, oily taste, faintly resembling that of the hazel nut. At the apex the tissues of the shell of this smaller nut appear to be continuous with those of the outer shell (Tp). The inner nut had a pedicel, indicated (st) in the figure. In cracking, this pedicel separated from the body of the small nut along a definite line. The shaft of this pedicel reached through the thick outer shell and readily separated from the surrounding tissues.

In view of the fact that the hickory nut is not extensively cultivated and apparently has not been observed hybridizing to any extent, or otherwise modified by breeding, the occurrence of this deviation from the type is deemed worthy of notice.



Bird Nests of an Old Apple Orchard Near Indiana University Campus.*

By Gertrude Hitze.

As part of my work in Nature Study during the Spring of 1902 I was assigned an old orchard east and north of Indiana University Campus. My work was to locate and report on all of the birds' nests of this orchard.

As a preliminary a plot was made of the orchard. The rows of trees were numbered serially from 1 to 22, and the individual trees in each row were also numbered. The orchard was thoroughly searched for nests between the latter part of April and the early part of June. The exact location of the nests is omitted in this report.

From an ethical and sentimental standpoint the work was very discouraging. Two-thirds of the nests were not completed or were destroyed in different ways. In all, 24 nests were found, and 18 of these came to grief in one way or another, as the report will show.

The report will be of interest as showing the vicissitudes of birds near a town, and the expense at which birds become and remain adapted to their environment.

TURTLE DOVE.

May 21st I found a nest loosely made of twigs, lined with hay and feathers, and containing two pure white eggs. May 23d this nest was robbed and destroyed. The old birds were flying about the orchard. On June 2d I saw no doves in the orchard.

CHIPPING SPARROW.

May 21st I found a little nest under a grapevine. It was built of dry grasses and lined with horsehair. The nest was built in a little hole in the ground. It contained one white egg with many brown

*Contributions from the Zoölogical Laboratory of Indiana University. No. 61.

spots. May 23d this nest had been robbed like so many others. The nest was not destroyed but the birds never returned.

May 23d I found a nest under another grapevine. The nest had four eggs in it. Two of the eggs were pipped. June 2d four little birds were in the nest, one of them with a lady beetle in its mouth. June 4th, birds almost feathered. They seemed not to be afraid of me as I drew near them. The mother did not go far from the nest as long as I was near. June 8th, the birds have flown. There were *six* little birds hopping about in a tree near the deserted nest.

SONG SPARROW.

May 23d, along the north fence I found a nest in a grapevine, nicely hidden among the leaves. The nest was made of twigs lined with dry grass. There was one white egg, spotted with heavy brown spots. June 2d, two eggs were in the nest. No bird was near at this time. June 4th, the nest had been robbed but not destroyed. No birds were near.

WHITE-THROATED SPARROW.

On April 30th I found a White-throated Sparrow building a nest in a brush heap. The bottom of the nest was finished and made of twigs. Every time the Sparrow carried any material to the nest a Catbird would fly down and take it away. The Catbird fought and chased the Sparrows until they left the nest unfinished.

HOUSE WREN.

May 21st, in the southeast corner of a shed I found a nest in the old woodwork. The nest was made of dry roots lined with chicken and turkey feathers. There were seven young almost feathered and nearly ready to fly. May 23d, the birds have flown.

CRESTED FLYCATCHER.

May 7th I saw two Crested Flycatchers flying around an old tree. They were building a nest, for one carried a feather, while the other flew at me whenever I came near them. I was unable to find their nest. May 9th I looked again for the nest but was unable to find it. May 21st I found the nest in a hole in the old tree. It was in a dead limb at a depth of about twelve inches from the opening. It was lined with feathers. There were five light eggs with heavy brown markings, especially at the large end. May 23d, no change in the nest. The birds were near. June 2d, five little birds were in the nest. June 9th, birds are just ready to leave the nest. June 11th, birds have flown.

BROWN THRASHERS.

I found a nest in a brush pile on April 23d. The nest was made of twigs lined with dry grass. There were three eggs with brown specks, more spots at the large end. On April 30th the nest had been robbed and no birds were near.

On April 30th I found another nest in another brush heap. There were two eggs in it. The mother remained hiding in the brush. On May 5th I found the brush pile was burned and the birds gone.

On May 7th I found an unfinished nest in still another brush pile. May 9th, the nest was finished but no bird was near. May 14th, four eggs in the nest with the Brown Thrasher on the nest. She was not a bit shy, and allowed me to come quite close to her. She then hopped off the nest and from twig to twig, and out upon the ground, and then flew away. The male sat off at the other side of the orchard and sang very merrily. May 16th, the female was still upon the nest, the male was very happy as he sat up in the tree and sang. May 21st, the nest had not been destroyed. The bird was quite friendly, as she would sit and allow me to talk to her. On the 23d I found that some boys had been in the orchard. They had robbed and destroyed all the nests. This one was not spared. The birds have disappeared.

On May 7th I found the foundation of a nest in a tree, nicely hidden by leaves. It was built of large twigs and lined with a few dry grasses. The nest seemed deserted. On May 9th no birds were near and no work had been done on the nest. June 1st, the birds had been working on the nest. It had been entirely relined. June 5th, one egg, blue, flaked with brown, was in the nest. June 9th, there were three eggs in the nest. The mother bird was quite nervous when I was near the nest. No further observations were made on this nest.

CATBIRD.

On May 2d I saw two Catbirds weaving straws into a nest. May 5th, the nest was gone. Catbirds not near. I believe they are hard to please. for they begin a nest and then desert it, sometimes leaving the foundation and other times entirely destroying every trace of it.

On May 7th I found a nest made of twigs and dry grass with Catbirds near it. On May 9th this nest was partially destroyed. The birds were gone.

On May 7th I found a nest in a tree. I chased the birds off from the nest to find two greenish eggs in it. The eggs were smaller than the Robin's eggs. The old birds fought me. May 9th, no change in the nest. Birds fought even harder than the last time. May 14th, one egg was pipped. May 16th, I climbed the tree. No birds flew at me, and I soon found that, like so many other nests, this one had been robbed. The eggs were gone. No shells nor birds were near.

On May 7th I found an unfinished nest. It was nicely hidden by leaves. It was built of twigs and a few dry grasses; no birds were near. This nest was deserted, as no more work had been done and no eggs were found in it on later visits.

On May 9th I found the fifth Catbird's nest. It contained one egg. No bird was near to fight. On May 14th two eggs were in the nest, and on May 16th the eggs had been broken and the nest torn up. No birds were near.

The sixth nest was found on May 9th. It contained one egg, but no bird was near to fight. On the 14th the nest had two eggs in it, but they were broken and the nest was destroyed.

On May 14th I found a nest quite high in the tree. There was one egg in it. May 21st, the egg was gone; it looked as though it had been broken. The inside of the nest was torn out.

On May 21st I found a newly built nest. The Catbirds were in the tree and seemed very interested in the nest. On May 23d the nest was destroyed and no birds were near.

ROBIN.

On April 21st, 1902, a Robin's nest was found on the rail of a fence, about four feet from the ground. The nest was made of roots, dry twigs, dry grass, plastered together and to the fence with clay. Softer grass was used in the center. Two blue-green eggs were in the nest, their small ends toward the center of the nest. On the 23d the bird was on the nest when I made my round, but she flew off. There were four eggs in the nest, and just as soon as I left she flew back. On the 30th the nest was found to have been torn from the fence and thrown upon the ground. The eggs were broken. No birds were noticed near this place again.

On April 14th I found an unfinished nest in a tree. It was being constructed like the one above described. Birds working hard. April 17th the nest was completed, but the birds were not near. April 21st I found one blue-green egg in the nest. April 23d I found that three eggs had been laid but had been broken, and the shells were on the ground near and far. The nest was wet with the white of the egg, and the inside of the nest destroyed. I was unable to find the cause of the nest being destroyed. Nothing further was done on this nest by the birds up to the end of the observations.

On April 17th I found a nest in a tree which had been completed. The Blue Jays and the Robins were fighting, the latter being driven away. On April 23d I found a Robin on the nest sitting on one egg. April 30th I found the bird sitting on three eggs. The Robin seemed quite friendly, for she allowed me to come very near to her. Then she flew only after I made a motion as though to touch her. May 2d I found the bird sitting on four eggs. May 5th the Robin was still on the nest. She allowed me to come quite near. May 7th, two little Robins in the nest; the other two eggs were pipped. May 9th, four little birds. They seemed all mouths and eyes. The mother flew as soon as I came near the nest, but did not go more than five feet. The male followed me a long distance. This was the first time he had shown fight. On March 14th, the birds have grown very much. They would not take anything from me. Both the old birds tried to fight, and as I left the nest the male followed. May 16th the birds were nearly feathered; very shy. May 17th, all the birds have flown. In just one month from the time I found the nest all trace of the birds was gone. It was twenty-four days from the time the first egg was laid in the nest until the nest was empty.

On May 4th I found a Robin's nest up high in the tree. Made like those above described. May 7th I found four blue-green eggs in the nest with the female on the nest. On May 14th two of the eggs were pipped. The mother was very nervous. On May 16th four little birds were in the nest. On May 21st the little birds were nearly feathered, and on the 23d the birds nad flown.

BLUEBIRD.

May 21st I found a nest with one blue egg in an old and partially hollow tree. It was in a cavity on the east side about ten inches from the opening. The nest was lined with fine feathers, but in pulling off the bark much of the loose, decayed stuff fell into the nest. May 23, the nest has been robbed and the lining pulled out.

List of Mammals, Reptiles and Batrachians of Monroe County.

By Waldo L. McAtee.

(By title.)

Ecological Notes on the Mussels of Winona Lake.*

By T. J. Headlee and James Simonton.

In the summer of 1903 the writers, under the direction of C. H. Eigenmann, made observations on the mussel distribution of Winona Lake with a view to determining the reason for the same. We examined the shore line from 4 inches to 4 feet by wading, from 4 to 7 with a clam rake, from 7 to 86 feet with an iron dredge.

The species found were determined by comparison with shells that had been named by Call, Simpson and Baker. The nomenclature is that used by Call in his report on Indiana Mollusca, Geological Report, 1899. They were: Unio luteolus, Unio subrostratus, Unio glans, Unio fabalis, Unio rubiginosus, Anodonta grandis, Anodonta edentula Margaritana marginata.

This is a deep kettle-hole lake. In general the beaches are composed of sand and gravel, which shade off with varying rapidity into marly sand, then into sandy marl, then into coarse white marl, and finally into the fine dark marl that covers the bottom in all the deeper parts of the lake and which is the accumulation of plankton tests. The bottom steadily grows softer as the proportion of dark marl increases. So soft does it become that a small sounding lead sinks into it of its own weight from 6 to 12 inches. In some places, especially the southwest side and in the little lake the shallow part of the beach is formed of muck which shades off into marl without the presence of any sand or gravel.

In general it may be said that the mussel zone extends from the shore line to where the bottom changes to very soft marl. This region will average from 4 inches to 9 feet of water, although in some places the mud comes to within a few feet of the water's edge, while in others the sandy and gravelly bottom runs out into 22 feet of water.

A. grandis is usually found just on the outer edge of the sand and gravel bank, while A. edentula appears most numerously a little farther out. A few specimens of both species were taken closer in shore,

*Contributions from the Zoölogical Laboratory of Indiana University, No. 62.

grandis being sometimes found on sandy bottom, edentula, however, invariably upon a soft bottom. Neither (healthy forms) was ever taken on hard sand or gravel.

U. glans has been taken upon sandy and gravelly bottoms, in from 4 feet out. U. fabalis appeared in about the same region except that it goes out on the soft bottom even farther than edentula.

U. subrostratus appears on the outer edge of the sand and gravel banks in about four feet of water and extends out as far as the light form of U. luteolus.

U. luteolus is the most variable, the most widely distributed and the most abundant species in the lake. It varies from a moderately thin, light straw-colored shell, marked by radiating greenish lines, to an extremely heavy, almost black form. The gradations of form, color, and size are shown in the plate and are very nearly perfect. The straw-colored variety is found in from 4 inches to 22 feet of water; it is, however, dominant inshore, in weed patches (Potomogeton and Ceratophyllum), and on chara-covered bottoms. The dark variety occupies the same region but is dominant upon sand and gravel bottoms in from three and one-half to twenty-two feet of water. The intergrading forms cover the same territory as the straw-colored and dark varieties but can not be said to be dominant anywhere.

U. rubiginosus occupies about the habitat dominated by the dark form of U. luteolus, except that it was not found in deeper water than ten feet.

M. marginata was found so infrequently (only six times) that the writers could tell little of its distribution. The specimens found were taken on sand and gravel, and white marl bottoms in from four to twenty-two feet.

There are a number of conditions in the environment which suggested themselves to us as possible explanations for this distribution —age, sex, light, heat, food supply and oxygen, pressure, wave action, character of the bottom, and enemies. Sex can not be important, for males and females are found together throughout the habitat; light can have but little to do with it, for mussels are absent in places in three feet of water and are abundant in others in fifteen feet, the difference in light being considerable. Further, the light over some of the immense beds in White River is no greater and perhaps even less than in twelve feet of lake water. That heat has little effect, during the summer at least, is shown by the fact that heavy beds were found in different temperatures, and by the fact that temperature variation in the mussel zone did not amount to more than two degrees; oxygen is not important, for the supply of oxygen throughout the mussel zone varies very little; pressure can have but little to do with it, for we found specimens on a sandy bottom in twenty-two feet of water, while on dark marl bottoms in ten feet none were taken in any case. Food supply can not be effective, for it is about equally abundant throughout the zone. The food consists principally of diatoms; secondarily of low algæ forms, and one-celled animals.

It seems to us that there are three causes which control the distribution of mussels as it appeared in Winona Lake—wave action, character of the bottom and enemies.

The first cause applies only in water less than three feet deep. As U. luteolus and A. grandis appear in this region they are subjected to this agency. Specimens of both A. grandis and the dark form of U. luteolus have been found washed ashore after a storm, and scores of these shells appear along the shore line. Under similar conditions we have seen the light form of U. luteolus moving from the water's edge out into deeper parts; these facts point to the conclusion that the two first mentioned forms are prevented from occupying shallow water by wave action, but that the light form of U. luteolus, being very active and having a thick shell, can well occupy this region. Not only is washing ashore fatal to A. grandis, but wave action quickly action quickly wears away the shell and leaves the animal open to attack. Unio glans, fabalis, edentula, and subrostratus are very light and slow moving; U. rubiginosus is heavy and clumsy, like the dark form of luteolus; the first three, if washed ashore, would be unable to get back, and their shells would be unable to resist the wearing action of the waves, while the last mentioned form could resist wave wearing but would be unable to get back if washed ashore.

The character of the bottom applies throughout the mussel zone. The bottom in the weed patches differs from that in the deeper parts of the lake in being slightly less soft. The sandy and gravelly bottom affords firm foothold and allows the mussel to assume that position which enables it to get the best supply of food and oxygen, while the pure marl allows it to sink so far as to be smothered. Even if the animal does not sink entirely under, the overlying sediment is sufficient to smother it. That there is an overlying sediment is shown by the following experiment: We pumped water from twelve and six inches above the sandy and gravelly bottom in seven, ten, fifteen, twenty-five feet of water; the specimens revealed no sediment that would not settle on standing. Specimens were taken in thirty and thirty-six feet of water over a marl bottom and the twelve-inch samples yielded a small amount of such sediment, while the six-inch samples showed a decided amount. That matter in suspension is fatal to the mussel is shown by the fact that we found in the west side and south end of the lake what were evidently once thriving mussel beds, buried under a thin layer of coarse marl, which had been stirred up by the action of the steam dredge two years before. These mussels were found in the normal position undisturbed in any way. That the mussels were alive five years ago is shown by Dr. Moenkhaus' statement that he and his classes collected an abundance for study in those same regions at that time.

In order to test the ability of the mussel to stand these bottom conditions we made three wire clam baskets, lowered one in twenty-five feet of water, another in thirty-five feet, another in eighty-five feet. We got the following results:

August 5, a basket containing thirteen U. luteolus and one A. grandis was placed in 25 feet of water on a dark marl bottom. On the 10th two examples of U. luteolus were dead; on the 15th one U. luteolus was dead; on the 17th two U. luteolus were dead and four were missing.

August 9, a basket containing five U. luteolus of the light variety and one of the dark, and one A. edentula was lowered in 35 feet of water on a sandy gray marl bottom. On the 15th, one A. grandis and one U. rubiginosus were added. On the 20th one U. luteolus of dark variety was dead; on the 24th five U. luteolus and one U. rubiginosus were found to have the gills badly choked with sediment, while the anodontas were missing.

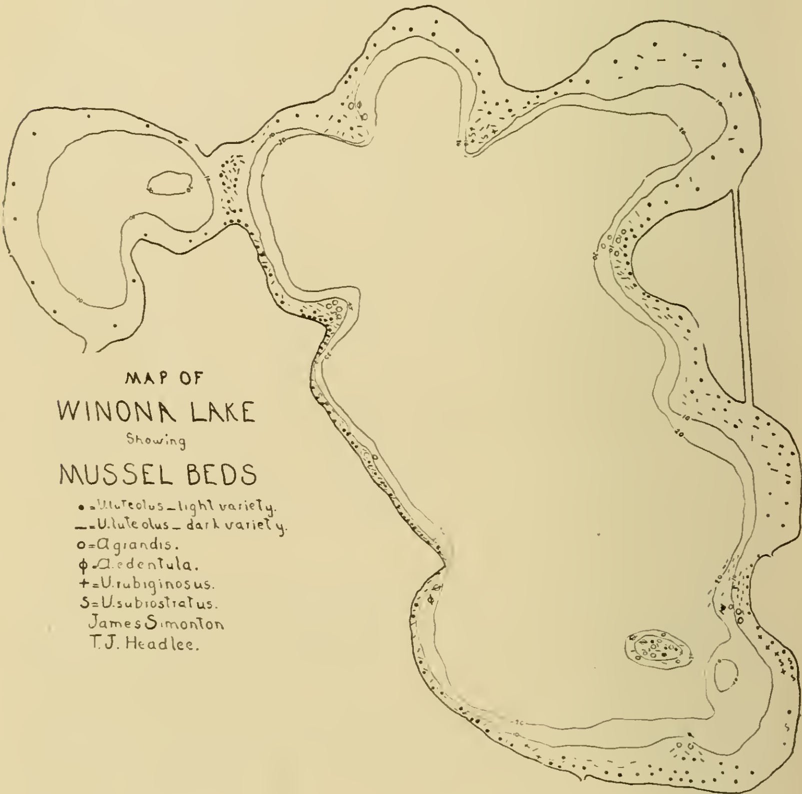
August 15, a basket containing seven U. luteolus of light and one of dark variety, two A. edentula, and one A. grandis was lowered in 85 feet on a pure dark marl bottom. On the 21st one U. luteolus of dark variety was dead; on the 24th seven U. luteolus and one A. grandis showed gills badly choked with sediment, while the two edentula were in better condition, showing very few patches of marl in gills.

To sum up: In the basket in twenty-five feet, lowered on dark marl, in nineteen days five were found dead and four missing; in the basket in thirty-five feet, lowered near Sandy Point on a sandy gray marl bottom, in fifteen days one was dead, all showed gills partly filled with sediment; in the basket in eighty-five feet, lowered on pure dark marl, in nine days two were found dead and the gills of all but A. edentula badly choked with sediment. U. fabalis, U. glans and U. subrostratus were not included in this experiment because the first two would have slipped out through the meshes and the third could not be obtained at the time. However, it seems reasonable to suppose that they would have proven not unlike the others. It seems, therefore, that those forms possessing light weight in proportion to surface exposed and close-fitting valves are best able to resist the soft marl and the overlying sediment.

A. grandis and edentula, having light and close-fitting valves, are found accordingly on the outer edge of the sandy marl bank; the edentula, being better fitted to withstand the bottom conditions, is found out in the edge of the dark marl. U. glans and fabalis, owing to lightness and close-fitting valves, occupy about the same situation, the fabalis having much the lighter shell, being found out as far or farther than the edentula. They are also found inshore, where not subjected to wave action. U. subrostratus, having medium weight valves, which are also close-fitting, is confined to the gravel and sand banks, weed patches and chara-covered beds. U. rubiginosis, having very heavy and rather loose-fitting valves, is confined to clear sand and gravel banks. The dark form of luteolus, having extremely heavy and rather loose-fitting valves, is confined to hard sand and gravel banks. The straw-colored form by its medium weight and tight-fitting valves is able to live on sand, gravel, in mud patches and on chara-covered bottoms. Owing to the fact that so few specimens of M. marginata were found we were unable to draw any conclusions as to its ecology.

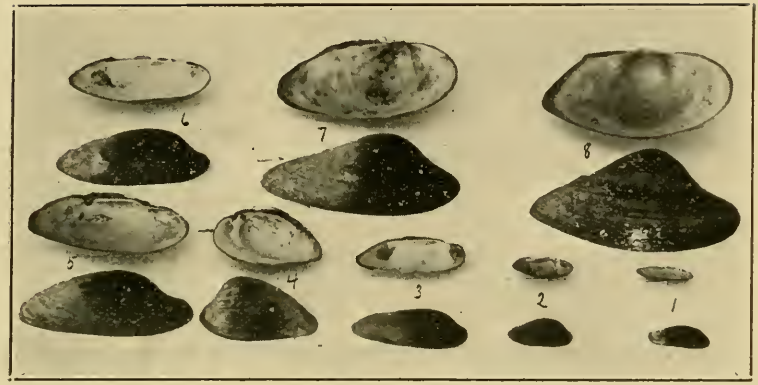
The muskrat is the principal enemy of the mussels; around his house many mussel shells are found, but no live mussels. Shells of all the species in the lake except the smaller ones are found, the Anodonta shells being in much greater evidence than is proportionate to their total number. They do not appear so on first examination, for they are broken up by the animal and worn by the waves. The conditions on the sand banks beyond reach of wave action are very favorable for Anodonta life, except for the presence of the muskrat. Anodontas are absolutely absent from water some distance from his home, where we found Unios rather abundantly. This points to the fact that the muskrat confines the Anodonta to the deeper waters at the edge of the sandy and gravelly banks.

It seems to us that the foregoing facts give basis for the following conclusions: First, that the mussel zone lies mainly upon sandy and gravelly banks, and on the outer edge of the same; second, that wave action and the muskrat determine the limit of the distribution shoreward, and that the character of the bottom is the principal factor determining the outer boundary of the zone.



EXPLANATION OF PLATES.

PLATE I.



1—Unio fabalis; 2—Unio glans; 3—Unio subrostratus; 4—Unio rubiginosus; 5—Margaritana marginata; 6—Unio luteolus; 7—Anodonta grandis; 8—Anodonta edentulus.

PLATE II.

1, 2, 3, and 4 are pairs of U. luteolus, which exhibit gradations of form, color and size from the light straw-colored forms to the almost black variety.

a, b, c, d, e, f, g, and h exhibit the gradations of color and markings found, from white to dark varieties, without regard to sex.

Conditions Effecting the Distribution of Birds in Indiana.*

By Amos W. Butler.

GENERAL CONDITIONS.

The regular annual movements of birds, their migrations, are among the most striking of the manifestations of Nature. With the revivifying breath of spring, the absent birds return. Last fall, when the summer's work was done, they went to warmer climes. Now, they seek anew their breeding grounds. Some make their homes with us; others go farther north to rear their young. The semi-annual ebb and flow of these tides of bird-life, the breeding range and the food supply are general factors that enter into the distribution of birds everywhere. Our ancestors noted them as signs of the seasons. They exist today, though we do not see them so readily because of our changed conditions.

ZOÖLOGICAL AREAS.

Indiana is a meeting-ground of various birds. Into it range typical forms of different zoölogical regions. From the west, are prairie birds; slightly tinging the north, are northern forms; while the dominating influence of the lower part of the State is southern. Indiana lies within the eastern (Atlantic) faunal province. According to Mr. Allen, it is distinctively Carolinian (Bull. Mus. Comp. Zoöl. II, No. 3, pp. 393-395), yet the southwestern part is within the range of many birds characteristic of the Louisianian Fauna (Austroriparian Province of Prof. Cope, Bull. U. S. Nat. Mus. No. 1, 1875, pp. 67-71). Dr. Merriam would include the bulk of the State in the Upper Austral Zone, the Lower Austral Zone reaching into southwestern Indiana and the Transition Zone influencing the northern part (Bull. No. 10 Biol. Surv. U. S. Dept. Agr. 1898).

*Contributions from the Zoölogical Laboratory of Indiana University, No. 37.

DISPERSAL BY STORMS.

Following heavy storms, of wide extent, at sea, it sometimes happens that birds are blown or driven far inland. This, in part, accounts for the unusual occurrence, at times, of numbers of certain birds. One of the most notable instances of this was the wide dispersal of Brünnich's Murres (Uria lomvia) by a north-Atlantic storm, in December, 1896. They were driven as far south as South Carolina and over the eastern United States, at least to Indiana and Michigan. A number of specimens were taken in Indiana (Butler, The Auk, XIX. 1897, April, 197-200).

CHANGES IN CONDITIONS.

The birds about us are not those that were familiar to our fathers. Many kinds that were common to them have disappeared. Others that they did not know have come to take their places. In the early days of our history, dense forests stretched unbroken, save by water courses, from the Ohio River northward almost to Lake Michigan. Through these, threaded the runways of wild animals and the trails of wild men. Within the gloom of these continuous woodlands dwelt birds peculiar to such surroundings. With the clearing of our land, there disappeared from that area many forest-inhabiting birds. The range of others became restricted to the remaining timber districts. Meadows and pastures replaced the forests. Birds loving such surroundings, prairie forms, there made their homes.

The beautiful little Carolina Paroquet (Conurus carolinensis), which once ranged in countless numbers throughout the eastern United States, as far north as the Great Lakes, has not only disappeared from our limits, but also from almost every part of its range. From but a few almost inaccessible localities in the Southern States has it been recently reported, and it is now on the verge of extinction. It was last reported in Indiana from Knox County in 1859 (Hasbrouck, The Auk, VIII, Oct. 1891, pp. 369-379; Butler, Ibid, IX, Jan., 1892, pp. 49-56).

The Ivory-billed Woodpecker (Campephilus principalis), the largest representative of its family, was found in the early part of this century in suitable localities in southern Indiana, notably in Franklin and Monroe counties and in the lower Wabash Valley. Their shy, retiring ways led them to leave when men appeared bearing the evidences of civilization.

They have almost entirely disappeared from earth. A few individuals linger among the almost inaccessible regions of the Southern States (Hasbrouck. The Auk, VIII. 1891, pp. 174-176).

The Pileated Woodpecker (Ceophlœus pileatus), known to the early settlers as Logcock and Black Woodcock, was familiar to the eyes and ears of the early colonists. They were averse to sharing their haunts with the white man. Less and less their numbers grew. They disappeared from one locality after another, until now but few are left in the more sparsely settled districts of the State (Butler. Birds of Ind., 1897, p. 838).

The croak of the Raven (Corvus corax sinuatus) was a familiar sound to the early pioneers. They saw its numbers lessen from year to year, until their children, now, never see its form and do not know its voice. From one locality after another, the few remaining birds have disappeared, until at this time it is probable that none are to be found within the State. Until within the last five or six years, they have been known to nest in Martin and Dubois counties, but I can learn of none having done so since (Proc. Ind. Acad. of Sci., 1897, p. 202).

The Wild Turkey (Meleagris gallopavo), our most noble game bird, has been generally extirpated, although it is still reported from Knox, Gibson and other counties of the lower Wabash Valley. It, probably, is also to be found, in rare instances, in some of the wilder regions, elsewhere, in southern Indiana. It formerly was numerous throughout the State.

The Swallow-tailed Kite (Elanoides forficatus) is known but to few. In 1812, Alexander Wilson reported these graceful, giant, swallow-shaped birds as abundant upon the prairies of Ohio and Indiana Territories (Amer. Orn., VI, 1812. p. 70). For seventy years after that but one was reported from Indiana (Haymond. Proc. Phil. Acad. N. S., Nov., 1856. p. 287). Since then they have been seen at irregular intervals in the southern two-thirds of the State.

Wild Pigeons (Ectopistes migratorius) were formerly found in such countless numbers that no estimate could be made of their abundance. During the season of their flight, flocks of enormous size successively passed, obscuring the sun and sometimes hiding the sky. At night, they gathered in roosts in favorite localities. These roosts were often of great extent. They alighted upon the underbrush, crushing it to the ground, and so weighted the trees that limbs of large size were broken off by the burden put upon them. After the first third of the century, their numbers began noticeably to diminish; but few large flights were seen in our State after 1870. Ten years later, they had almost disappeared. Now, they are nearly extinct. A few individuals are to be found in certain localities in the rougher portions of southern Indiana (Proc. I. A. S., 1899).

In the extreme northern part of the State, prairies and swamps, lakes and woodland alternate. The marshes and lowlands of northwestern Indiana form attractive spots to many swamp birds and waterfowl. Different kinds of ducks collect there and a number of species breed in the more retired places. Formerly, they were much more numerous. There, also, the Whooping (Grus americana) and Sandhill Cranes (Grus mexicana) bred in numbers. Snipe and Plover were found abundantly. Phalaopes and Black Terns (Hydrochelidon nigra surinamensis) frequented the lakes and ponds. Gallinules, Coots and Grebes still rear their young. Rails of four species make their homes among the reeds. Marsh Wrens and both the American (Botaurus lentiginosus) and Least Bitterns (Ardetta exilis) frequent the sedges; while the stems of these plants are drawn together to form nesting places for the Red-winged (Agelaius phœniceus) and Yellow-headed Blackbirds (Xanthocephalus xanthocephalus), and their tops are woven into the globular nests of the two species of Marsh Wrens. The dryer marshes are the breeding grounds of such rare forms as Henslow's (Ammodramus henslowii) and Nelson's Sparrows (Ammodramus candacutus nelsoni). The swampy woodland is the home of other water-loving species. Among the tops of the tallest trees are still to be found the small remnants of large colonies of Great Blue Herons (Ardea herodias) and Black-crowned Night Herons (Nycticorax nycticorax nævius). Here, too, we have recently learned that the beautiful White American Egrets (Ardea egretta) commonly made their homes, nesting in colonies or heronies. By this fact, its known breeding range is extended northward a distance about equal to the length of this State (Proc. I. A. S., 1897, pp. 198-201). Among the tree-tops, too, were to be found the nests of the Osprey (Pandion haliætus carolinensis) and Bald Eagle (Haliæetus leucocephalus). In the larger cavities in the tree trunks, the Wood Ducks (Aix sponsa) still rear their broods, and the deserted Woodpecker holes in the old snags are occupied by White-bellied Swallows (Tachycineta bicolor) and Prothonotary Warblers (Protonotaria citrea).

All this has greatly changed. Some of these characteristic forms have almost disappeared, while the draining of the swamps and the reclaiming of the land have lessened the area favorable for the homes of others. Few, indeed, are the numbers of most of these birds in this region compared with the innumerable company that occupied it a half century or more ago.

Field Sparrows (Spizella pusilla), Vesper Sparrows (Poocaetes gramineus), Dickcissels (Spiza americana), Grasshopper Sparrows (Ammodramus savannarum passerinus) and Meadowlarks (Sturnella magna) are representatives of those that sought the fields with which man replaced the native woods. Others, such as the Bobolink (Dolichonyx oxyzivorus) and Prairie Horned Lark (Otocoris alpestris praticola), also extended their range as favorable localities were found. At the time of the settling of our State, the breeding-grounds of the Bobolink within our present limits were probably about the southern end of Lake Michigan, extending southward over the prairies of the Kankakee Basin and eastward as far as the site of Rochester. Possibly some bred in the smaller prairies in the northeastern part of the State. From these points they have gradually spread southward, extending their breeding range as far south as the counties of Union, Decatur, Marion and Vigo. They are not numerous there; but under favorable conditions, a few may be found at nesting time, enlivening the scenes of rural life with their charming songs, as far south as has been indicated (Butler, Proc. I. A. S., 1895). The Prairie Horned Larks, too, from practically the same districts, have gradually been found to nest farther south until they have been reported as breeding in Franklin, Decatur, Johnson, Monroe and Knox counties. Following their extension southward, their numbers have gradually increased until now they are familiar birds in many places where they were unknown a few years ago (Butler, Birds of Ind., 1897, pp. 874-6).

As tillable land is neglected and begins to grow up in bushes and briers, other birds press in to occupy such congenial haunts. The most notable of these, perhaps, are Bachman's Sparrow (Peucaea aestivalis bachmanii), the Lark Sparrow (Chondestes grammacus), the Cardinal or common Redbird (Cardinalis cardinalis) and the Yellow-breasted Chat (Icteria virens). All these have been observed to be extending their range, where conditions are favorable; but the extension, perhaps, is the most striking in the case of the two sparrows first mentioned.

From the south other forms are ranging into our limits. The Black Vulture (Catharista atrata) was found by Audubon in southern Indiana. From 1834 to 1879, it was not reported from the Ohio Valley. It was next noted in Indiana in 1879 (Quick. J. C. S. N. H. 1881. p. 341). It is now recognized as a resident in some numbers in the lower Wabash and Whitewater valleys, and is found in regularly increasing numbers in the southern third of the State. Bewick's Wren (Thryothorus bewickii) is slowly spreading over the same district (Trans. Ind. Hort. Soc. 189., p. 99). It soon becomes acquainted with man and takes up its abode about his home. In that region, it becomes the House Wren, replacing the larger Carolina Wren (Thryothorus ludovicianus) which has, latterly, to a great extent, left the vicinity of man's structures and inhabits the thickets and the underbrush of the more open woods. These are not to be confused with the smaller Short-tailed Wren, the true House Wren (Troglodytes ædon), that breeds in central and northern Indiana. Other birds, also, have changed their habits. The Purple Martin (Progne subis), Barn Swallow (Chelidon erythrogaster) and Phœbe (Sayornis phœbe) have generally sought after other breeding sites than the cliffs and bluffs where the white men first found their nests. The Chimney Swift (Chætura pelagica) now prefers an unused chimney to a hollow tree. We have become so accustomed to these sociable birds that it is hard to realize that they have not always been dwellers with man about his home. Some of them, most notably the Eave Swallow (Petrochelidon lunifrons) and the Purple Martin, have been the birds most persecuted by the European House Sparrow (Passer domesticus), generally called "English Sparrow." They have made use of the nests of the former; have occupied the sites of the latter. The result is that comparatively few of either of these birds are left with us.

INFLUENCE OF RIVERS.

The rivers of Indiana penetrate the State from different directions, and each has its influence, be it greater or less, upon the distribution of life. The most prominent streams are the Wabash and its tributaries, and the Whitewater and Kankakee. Lake Michigan touches our limits; and its effect is likewise felt. The extension southward into the upland meadows, between the water courses, of the birds of the open prairies, and the range of southern forms up the valleys of our streams is as though the great spread fingers of two mighty hands were interlocked, the one representing the extension of life southward and the other the projection of southern birds northward.

The region of the Lower Wabash, with its bottoms, cypress swamps and ponds, was the home of many southern birds which found there the northern limit of their range. Among these congenial surroundings were noted such southern forms as the White Ibis (Guara alba), Wood Ibis (Tantalus loculator), Yellow-crowned Night Heron (Nycticorax violaceus), Little Blue Heron (Ardea cærulea), Snowy Heron (Ardea candidiesima), American Egret (Ardea egretta) and Florida Cormorant (Phalacrocorax dilophus floridanus). Some of these there made their homes and reared their young. Other birds ranged farther up the stream and it, and other water-courses, are now known to be routes along which certain species move to breeding grounds farther north.

The extreme effect of a river on the distribution of a bird is illustrated in the case of the Prothonotary Wårbler. Prior to 1875, it was regarded as solely a bird of the Southern States, yet its actual range was then, without doubt, practically the same as we now know it. In that year Mr. E. W. Nelson observed it to be common in the Lower Wabash Valley in Illinois (Bull. Essex Inst. Vol. IX, 1877. p. 34). In 1878, Mr. William Brewster found it abundant in Knox and Gibson counties, Indiana (Bull. Nutt. Orn. Club, Vol. III, 1878. p. 155). The natural haunts of these birds are the swampy woods and the thickets along water-courses or about ponds or lakes. As one suitable locality after another was discovered farther northward, it was found to be occupied by these birds. They were reported from Vigo, Clinton and Carroll counties and from just over the State line near Danville, Illinois. They extended up the Mississippi River, sending off numbers of migrants up the different river courses. Some ascended the Kaskaskia and others the Illinois (Loucks Bull. Ill. Lab. N. H., Vol. IV, 1894). The Kankakee, a tributary of the latter stream, comes into northwest Indiana from the west and becomes quite a factor in its influence upon bird life. At Momence, Illinois, its course is blocked by an outcrop of stone. Above this, it is a sluggish stream, at times widening into lakes. Much of its course is bordered by woods. Marshes and swamps alternate with thickets and sloughs along its valley. Amid such attractive surroundings, Prothonotary Warblers find summer quarters and are characteristic birds. They likely reach this valley by way of the Illinois River, though possibly some may come from the Wabash Valley. The divide between the Kankakee Basin and the Lake Michigan Basin is but a slight barrier. Occasionally, these birds are found near the Lake Shore in Lake and Laporte counties, and at places along the St. Joseph River and its tributaries, both in Michigan and Indiana (Cook. Birds of Mich. 1893. p. 110). In St. Joseph County, Michigan, and the counties of Elkhart, Lagrange, Steuben, and in the adjoining county of Dekalb, in this State, they have been found, at some places, breeding commonly. The Prothonotary Warbler has never been reported along the Ohio River above the mouth of the Wabash.

The Sycamore Warbler (Dendroica dominica albilora) is another bird that prefers the vicinity of streams and in its migration follows their courses. It is found not only along the Wabash River, but also along the Ohio and Whitewater. It is common up the Wabash River to Carroll County and has been noted from Lafayette and Ft. Wayne. There is nothing to show that it is found in the Kankakee Valley or reaches the basin of Lake Michigan. It is common up the White River Valley, as far as Indianapolis, and up the Whitewater River to Brookville, ranging to Connersville and Richmond. By one of these routes, it pushes on to southeastern Michigan. There, is has been found in some numbers in the valley of the Raisin River, Monroe County, in Kalamazoo County, and has been reported as not uncommon near Detroit.

The Cerulean Warbler (Dendroica rara) is not a bird living solely along the streams, but appears to prefer the wooded sides of the valleys. It extends its range up the Wabash River to Carroll, Tippecanoe and Wabash counties. It has been found at English Lake near Kouts in the Kankakee Valley. It ranges up the Whitewater River to its upper waters; is found about Muncie; is tolerably common in Dekalb County; and is one of the most common woodland birds in Monroe, Wayne and Ingham counties, Michigan. These localities are probably reached by way of the Whitewater or Miami river. It, like both the Warblers previously referred to, breeds in suitable places throughout its range. Each of these three species frequents different kinds of localities; the Prothonotary Warbler, as noted, prefers the wooded swamps; the Sycamore Warbler seeks the tall timber along the streams, preferably, as its name indicates, the sycamore trees; the Cerulean Warbler occupies the woods of the river valleys, but appears to prefer the wooded hillsides that border them. Each is notably affected in distribution by the water-courses.

EFFECT OF LAKE MICHIGAN.

The effect of a large interior body of water is well illustrated by Lake Michigan. There, on the open water, many kinds of water fowl, that would otherwise go south, remain through the winter. To it, come different forms of sea birds in spring, winter and fall. Among these are Jægers, the rarer Gulls and some Sea Ducks.

It also attracts such cosmopolitan birds as the Knot (Tringa canutus), Turnstone (Arenaria interpres) and Sanderling (Calidris arenaria). The latter and the Semi-palmated Plover (Ægialitis semipalmata) are found along its shores in considerable numbers in late summer. The Belted Piping Plover (Ægialitis meloda circumcincta), a bird supposed to breed much farther northward, has been found breeding along the pebbly lake beach. The effect of the lake upon the local climate has been observed by farmers. The result is noticeable in the fruiting of plants. Fringing the southern shores of Lake Michigan are sandhills or dunes of varying sizes, some reaching an altitude of more than 150 feet. Upon and near these, grow northern pines and other characteristic vegetation. As would be expected, birds that love homes among the pines are to be found. While comparatively little study has been given to this region, it is known that the Pine Warbler (Dendroica vigorsii) breeds there (Brayton. Proc. Ind. Hort. Soc. 1879. p. 108). Other northern forms have been reported, and it is likely careful investigation will show other interesting facts concerning this district. Where-ever pines grow, the American Crossbills (Loxia curvirostra minor) seem to be more or less regularly found. This is not only true among the sand-dunes near Lake Michigan, but about Lafayette, Bloomington and Brookville. At each of the two first named places, they have been reported as breeding. While this would not be surprising the reports have not been verified. The pines in other restricted areas, notably Pine Hills, Montgomery County, and the Knobs in southern Indiana, are interesting fields for the study of these points.

The most notable influence in the bird-life of our State is the changes that have been wrought through man's influence. The general conditions of migration, breeding and food supply are those common to all regions. They operated in the days of the aborigines as they do this year, differing only in some of their manifestations. The unusual conditions, such as storms, effecting the dispersal of birds, work now as hitherto. There are special conditions manifested in favorable surroundings, attractive bird-homes, and in topographical encouragement, leading them to extend their range. These are strongly illustrated in this State. To him who carefully studies the birds of any locality, these powerful influences are apparent. They are emphasized by their details and their repetition. By grouping the results of local observations, is told the story of the influences acting in the distribution of the birds of the State.

Discoid Pith in Woody Plants.

By F. W. Foxworthy.

The occurrence of a discoid pith, i. e., one which is interrupted at frequent intervals by cross partitions variously known as disks, diaphragms, plates or lamellæ, has been noted by numerous observers in certain of the woody plants.

The first mention of it seems to have been by the Anatomist Grew (Anat. Plantarum, 1682. Pl. 19. f. 4), who described and figured it in *Juglans*.

Ch. Morren, in the Ann. Nat. Hist., Vol. 4, No. 22, 1839, gave a good historical sketch of the observed cases of discoid pith, and described in detail and figured certain forms.

W. C. Williamson (Proc. Man. Lit. and Phil. Soc. for 1851) in a paper "On the Structure and affinities of the plants hitherto known as Sternbergiæ"—described the casts of this kind of pith which had been considered entire fossil plants—with the group name *Sternbergiæ*, and showed their true nature and affinities—as members of the genus *Dadoxylon Brongn.* He also mentioned the occurrence of discoid pith in a number of recent plants.

M. Gris, in his very painstaking work "Sur la moelle les plantes ligneuses" (Ann. des Sci. Nat. ser. 5. No. 14. 1872), described two structurally distinct forms of discoid pith. The first, which he terms *Heterogenous Continuous Diaphragmatic*, has the pith continuous between the disks, e. g. *Liriodendron*.

The second he terms *Heterogenous Discontinuous Diaphragmatic* and, in this, the pith is not continuous between the disks, the interspaces being empty or filled with air, e. g. *Juglans*.

Pith of the first type occurs in *Liriodendron* and *Magnolia species*, in *Asimina* and some other representatives of the *Anonaceæ*, in *Nyssa*, and, according to Solereder (Anatomie der Dicotyledonen, Stuttgart, 1899), in many of the *Ternstroemiaceæ*, as well as in *Brachynema* (*Ebenaceæ*) and in certain of the *Convolvulaceæ*.

The cells making up these disks are large, irregular in outline, very thick-walled, lignified, and contain starch in winter. The cells filling the interspaces are small, regular, very thin-walled, unlignified and empty.

The formation of the disks takes place at a very early stage in the growth of the twig; they may be seen just back of the growing point in Fig. 1, which is a longitudinal section through a young twig of *Liriodendron*.

The genus *Magnolia* presents some interesting modifications of this type. The genus has been described as always having these partitions in the pith; but, several have pointed out that this statement is incorrect. In the examination of the American and some of the Asiatic species, I have found only two, *M. Virginiana* and *M. fœtida*, in which the fully developed disks occurred. In all the other species examined, cells of the sort described as making up the disks occurred scattered singly or in small groups throughout the pith. Baillon, in his Natural History of Plants, says of this: "In the rapidly developed shoots of some Magnolias we have seen these septa reduced to a single cell, nearly central, on which all the surrounding cells of the ordinary parenchyma abut by one end, bent, or drawn out in a quite peculiar fashion."

In Fig. 2, which is a longitudinal section of a twig of *M. tripetala*, these scattered groups of cells are shown; and, Fig. 3 shows the same kind of cells in a cross-section of a twig of the same species.

In *Asimina* the disks seem to be made up of more regular and thicker-walled cells than are found in *Magnolia* and *Liriodendron*.

In the slender woody twigs of *Nyssa*, very strongly developed disks were found, stronger in fact than in any other case examined.

Function of pith of this type:—

No satisfactory explanation of the function of this type of pith has been offered. From superficial examination, the suggestion that its function was one of mechanical support would seem reasonable; but, the fact that the most strongly developed diaphragms were found in the strong and slender twigs of *Nyssa*, while the thick *Magnolia* twigs with their relatively large pith showed the weakest development of this type, seems to indicate that the suggestion of mechanical support is not a sufficient explanation of their function.

The second type of pith has often been mentioned and figured in species of *Juglans*. I have also studied it in *Pterocarya*, *Celtis*, *Mohrodendron* (*Halesia*), *Forsythia viridissima*, *Jasminum species*, *Paulownia*, and

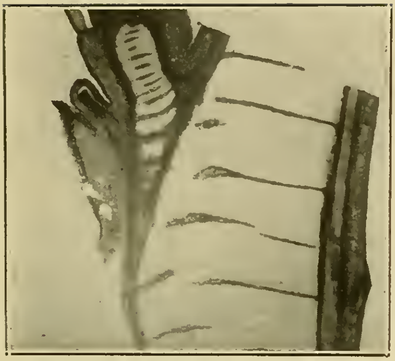


Fig. 1.

Fig. 2.

Fig. 3.

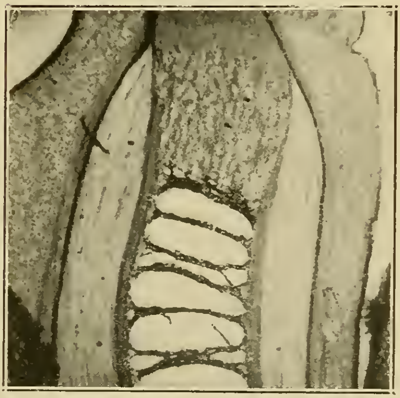


Fig. 4

Actinidia. Besides these, Solereder found it in *Wormia* (*Dilleniaceæ*). *Diplotaxis* (*Cruciferæ*)-*Fouqiera* (*Tamarisc*), *Princepia Chrysobalanaceæ*), *Aucuba* (*Cornaceæ*, only in herbarium material), *Pedalium* (*Pedaliaceæ*), *Daphnyphyllum* (*Daphnyphyllaceæ*): Williamson also found it in the fossil plants known as *Sternbergiæ* and mentions it as occurring in certain living species of *Pinus*. In some genera, as e. g. *Forsythia* and *Jasminum*, it occurs in some species but not in others.

The cells making up the partitions are thin-walled, empty and often shrunken and the space between the partitions is irregular in outline and extent. Fig. 4, from a twig of *Juglans cinerea*, shows this type.

Function and manner of formation:—

Morren and Williamson both considered that the pith served as a mamilla for the bud and, as the nourishment is exhausted from the pith it separates into disks—beginning first in the immediate vicinity of the bud. The cells in the center of the pith become shrunken and the pith separates into layers. This takes place quite early in the growing season. Morren gives good figures of this process in *Juglans regia*. The fact that twigs of *Celtis* often have the pith very plainly discoid in the region of the nodes but solid in the central part of the long internodes lends support to this view.

Taxonomic value of the occurrence of discoid pith:—

Juglans and *Pterocarya* are definitely separated off from the rest of the *Juglandaceæ* (A. Engler in Engler & Prantl-Nat. Pflanz. Fam. 111. I. p. 21) by the possession of discoid pith. In *Liriodendron*, *Asimina*, *Nyssa* *Celtis*, *Mohrodendron*, *Actinidia*, and several others, the presence of discoid pith seems a good generic distinction; but, in certain cases, as. *Forsythia* and *Jasminum*, it is of only specific value.

The New Science Laboratory at Moores Hill College.

By A. J. Bigney.

At the last meeting of the Board of Trustees of Moores Hill College, in June, 1904, they made additional provision for the Science Department by purchasing a large three-story brick building in the town which had been used as a business house. This building is very well adapted to its new purposes. Most of the internal changes have been made and the building occupied except the third story. It is forty-five feet front and seventy feet deep, and three stories high, with a full basement. The basement is used as a furnace room, shop, store-room, and photographic room.

The first floor contains a scientific library, a private room for the instructor, a combined biological laboratory and recitation room, a combined museum and geological laboratory, and one room occupied by the Y. M. C. A. and Y. W. C. A.

The second floor is occupied by the Philoneikean Society as chapter rooms. When the college needs these rooms the Society will vacate them.

The third floor will be occupied by the chemical and physical departments.

The scientific departments now have plenty of room for increasing their efficiency. The museum is growing very rapidly and this building will make it much more serviceable. No movement has been started in recent years that will prove as helpful not only for the college but also for the scientific interests of southeastern Indiana.

The Apache Stick Game.

By Albert B. Reagan.

(Abstract.)

(Original in possession of the Bureau of American Ethnology. Illustrations used by permission of Bureau.)

The Apache stick game is played only by the women. It is played in the winter when there is no farm work to be done; also at any other time when the women are not employed in the daily toil. At this game the women are experts. It is a gambling game, and the women often bet and lose all they have on it, even the clothes on their backs. Most usually, however, only beads and such-like trinkets are staked. Below is a description of the game and the requisites: The game-field, including its rock-circle, the counting sticks, and the three "Setdilth" sticks used in playing the game.

The Game Field.—This field is a level, circular spot, six or seven feet in diameter. This circular area is inclosed in a circle of cobblestones, forty in number. These rocks are arranged in groups of ten each, that is, ten to each quadrant of the circle. The rocks are the tallies; an entire circle of forty tallies constitutes a game. Besides the rocks in the circle, a large flat rock occupies the center of the field. On this rock are hurled the setdilth sticks on their mission of chance, as we shall see later.

The Counting Sticks.—These are small sticks used in marking the tallies gained. One of these is placed between the last rock tally and the next rock in the circle in the direction the player is moving it.

The Setdilth Sticks.—These are three in number. Each is a foot in length and is the half of a green limb or a willow shrub of about an inch in diameter. The bark is left on the round face; its split face is marked by a broad diagonal charcoal mark across the center. These sticks are all held in the hand in a vertical position at the same time; and are hurled endwise upon the center rock to fall with whichever face up chance may direct. Counting the points then begins.

Counting the Points.—The points in the game are decided by the faces of the setdilth sticks that are up after the sticks have fallen. If one split face is up it counts two points; if two split faces, three points; if all three split faces, five points; and if the three rounded faces are up ten points and the player has the privilege of playing again before passing the sticks to the next player.

Marking the Points Gained.—Usually four persons play this game. The opposite players are partners. One set of players move the counting

The Setdilth Game—Sticks falling after having bounced on the center rock.

sticks round the stone-circle in one direction (Each player has her own counting sticks whether a partner of another man or not); and their opponents move in the opposite direction. For the points gained in hurling the sticks an equal number of rocks in the circle are counted and the counting stick is moved forward to the position between the last rock tally and the next cobble-stone in the direction the counting stick is being moved. In moving the counting stick, should it chance to be placed in the space between two rocks that an opponent's counting stick is occupying, the opponent's counting stick, that is, the first stick occupying the space is taken up and its owner must begin the game again. Two skilled players will often throw each other back in this manner time after time. This makes the game quite interesting. When a counting stick has completed the entire circle, that is, when it has marked forty successive tallies its owner has the game. A transfer of the staked property follows. Then the betting begins for a new game.

A Note on the Radio-Activity of Strontium Salicylate.

By J. F. Woolsey.

(By title.)

Cuban Notes.

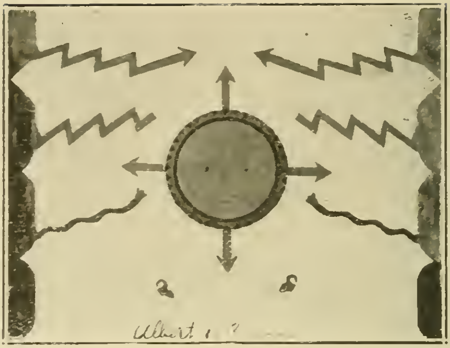
By C. H. Eigenmann.

(By title.)

Some Paintings from One of the Estufas in the Indian Village of Jemez, N. M.

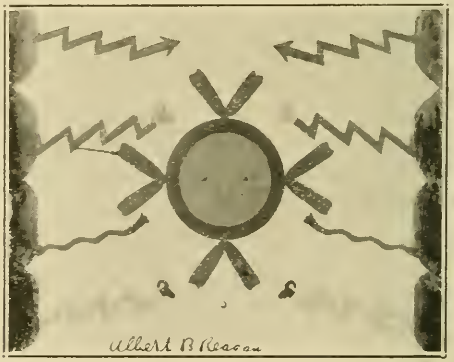
Albert B. Reagan.

Soon after I became U. S. Indian Farmer at Jamez, N. M., the Jamez Indians had a masked dance, and as this dance occurred on mail day they stopped the mail carrier and would not allow him to proceed on his journey. This they did in accordance with their custom not to allow a white man to enter or to pass through the village while they were thus occupied. The stopping of the mail led to the arrest of the Indian Governor, Jose Romero, who, as a result of the preliminary examination, was bound over to the United States grand jury which was to meet the next March, six months after the crime was committed. Taking pity on the Indian, I bailed him out, and took him back to the village. From that time on throughout the winter months the Jamez were very friendly to me and allowed me to visit their performances at will, though they did not send me special invitations to do so. At the trial in March the governor was found guilty and fined the full extent of the law for interfering with the carrying of the mail. As soon as the sentence was handed down, I went to the judge, and after a great deal of argument, persuaded him to suspend the sentence upon the promise of good behavior. So I returned to the village with the governor a second time. In the evening after our return the "Principals" of the place met, and as the greatest favor they could bestow upon me they invited me in the name of their tribe to visit any and all of their ceremonies, both open and secret, stating further that they would let me know whenever they had any special ceremony. This, with but one exception, they carried out to the letter. Acting upon this invitation I visited each of the Estufas at will, often being with the Indians in them sometimes as high as six nights in a week. I also examined the "blind closets" and secret rooms in the dwellings. Thus was I enabled to see many things of interest. Among these are the masks worn by the clown dancers in the masked dance, and the paintings on the inside walls of the Estufas and of the secret rooms. Some of these are here given.



I. Sun-God Section in One of the Estufas at Jemez, N. M.

1. Clouds, the Steps to Heaven. (Dark marginal figures.)
2. The Bolt Lightning that does not strike the earth. (Upper figures.)
3. The Bolt Lightning that strikes the earth. It is the Red Snake or Indian Devil, called Savah by them. (Second figure from the top on each side.)
4. The Flash Lightning, the God of Flowers. (Third figure from top.)
5. The Good Snake, the Blue Snake, the God of Rain. (Lower figures.)
6. The Sun, the father of the universe and the God of all things. By the Indians he is called Patahgatzah or Pay.



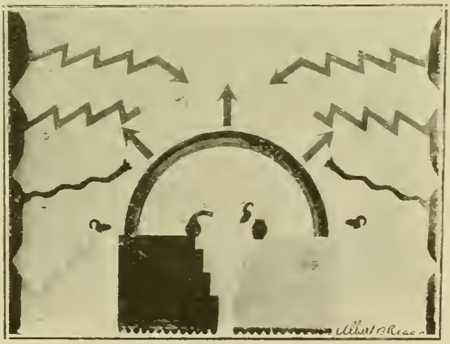
II. The Moon-God Section in one of the Estufas at Jemez, N. M.

1. Clouds.
2. Bolt Lightning that does not strike the earth.
3. The Red Snake or Indian Devil.
4. The Flash Lightning, the God of Flowers.
5. The Blue Snake, the God of Rain.
6. The Moon, the Mother God of the Universe, called by the Indians Ahtahwahtzah, or Pah.

IV. THE EVENING STAR SECTION IN ONE OF THE ESTUFAS AT JEMEZ, N. M.

1. Clouds.
2. Bolt Lightning that does not strike the ground.
3. The Red Snake or Indian Devil.
4. The Flash Lightning or God of Flowers.
5. The Blue Snake, the God of Rain.
6. The Evening Star, the God of the Evening. Jointly with its brother, the Morning Star, it possesses the attributes of Truth and Filial Love. Its Indian name is Homa Wangho.

NOTE.—The photographer having spoiled the negative of the Morning Star Section, I cannot show a photograph of it here.

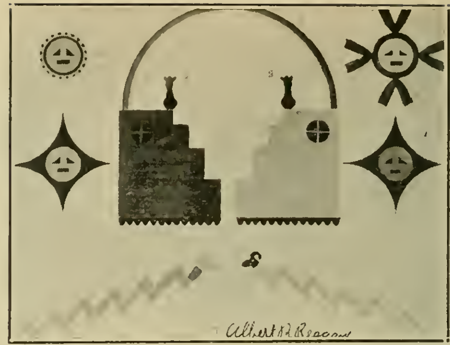


VI. A RAINBOW SECTION IN ONE OF THE ESTUFAS AT JEMEZ, N. M.

1. Clouds.
2. The Bolt Lightning that does not strike the ground.
3. The Bolt Lightning that strikes the earth. It is the Red Snake or Indian Devil.
4. The Flash Lightning, believed by the Indians to be the producer of bloom, hence the God of Flowers.
5. The Blue Snake, the God of Rain.
6. The Rainbow in the East. (a) Water receptacles of the universe; (b) Clouds, the Steps to Heaven; (c) raindrops; (d) the rainbow arch; (e) dart-heads thrust out by the rainbow as a means of protection.

NOTE.—This is the rainbow in the east. Beneath the arch the representatives of good and evil, the rain snake and the red snake, are in combat. The rain snake, being defeated, is retreating eastward and is taking the clouds with him, hence the rain is over.*

*The Rainbow Section just opposite this section represents the rainbow in the west. It differs from the rainbow section given here in that it has the God of Flowers projecting from the water jars beneath the arch.



VII. A Wall Painting in a Secret Dark Room in One of the Indian Houses at Jemez, N. M.

1. Sun. (In left-hand upper corner.)
2. Moon. (In right-hand upper corner.)
3. Morning Star.
4. Evening Star.
5. Rainbow in the West.
6. The Red Snake.
7. The Blue Snake, the God of Rain.
8. The Flash Lightning, the God of Flowers. It is projecting from the water receptacles of the universe. The step-like figures below the water-jars are clouds from which raindrops, represented by black points, are dropping.

VIII. A Miscellaneous Group.

1. The Sun as carved on a bowlder on the trail between Zia and Jemez, N. M.; also on a rock near White River, Ariz.
2. A Sun drawing in an Estufa at Santa Anna, N. M.
3. A Getlu, probably a representation of a comet. It was used as a handpiece in the masked dance of March 17, 1900. (Used here by permission of the Bureau of American Ethnology.)
4. A Head Ornament worn by a male column dancer in the masked dances at Jemez, N. M.
5. A Sun Mask worn by a sun clown in the masked dances at Jemez.
6. A Moon Mask worn by a moon clown in the masked dances at Jemez.
7. A Morning Star Mask worn by a morning star clown in the masked dances at Jemez.
8. An Evening Star Mask worn by an evening star clown in the masked dances at Jemez.
9. The Bolt Lightning drawn on the beam at the entrance of an Estufa at Santa Anna, N. M.
10. The White Snakes drawn on the center beam in the south Estufa at Jemez, N. M.

BEAN BLOSSOM
WASHINGTON
MARION
BENTON
BLOOMINGTON
RECENT
Alluvium
GLACIAL
Drift
Clay
MISSISSIPPIAN
Harrodsburg
Knobstone
BLOOMINGTON

Geology of Monroe County, Indiana, North of the Latitude of Bloomington.

By Albert B. Reagan.

This work was undertaken as independent research work in stratigraphic geology in Indiana University, in the summer of 1903, at the suggestion of Dr. J. W. Beede.

In 1880 Mr. G. K. Green published a paper entitled "Geology of Monroe County,"* in which he discusses the stratigraphy of the county, giving several sections and lists of fossils and a very generalized geological map of the county. Mr. C. E. Siebenthal has given a lengthy description of a considerable part of the the region here under consideration in his report on the "Bedford Oölitic Limestone."** Prof. V. F. Marsters describes the geography of Bean Blossom Creek in an article entitled "Topography and Geography of Bean Blossom Valley, Monroe County, Indiana."*** These papers will be discussed when the subjects with which they deal are taken up.

GENERAL REMARKS.

The rocks of this region, with the exception of the Glacial and post-glacial, are Mississippian in age. At the close of the Mississippian period or in the later Carboniferous time the region was raised above the sea. With the exception of a few cases due to local warping its strata dip gently to the southwest. After the area was elevated, the erosive agencies thoroughly dissected the region. The master stream, Bean Blossom Creek, and its numerous tributaries incised for themselves canyon-like valleys. Then on reaching grade, they widened their inner valley floors. On these floors the streams meandered, until a glacier, which crossed the northern part of the county, dammed the lower Bean Blossom and laked the region. Since the retreat of the glacier, side tributaries have, for the most part, recut their channels through the glacial debris to their former level; and

*2d Ann. Rep. Bureau Statistics and Geology, Indiana, pp. 427-449, 1880.
**21st Ann. Rep. Geol. Nat. Res. Ind. pp. 293.
***Proc. Ind. Acad. Sci. 1902 (for 1901), pp. 222-237.

Bean Blossom is now aggrading its channel. The region thus dissected by stream-cutting presents an intricate mass of small, deep canyon-like valleys separated by sharp ridges.

STRUCTURE.

The Mississippian rocks of northern Monroe County are divided into the following formations beginning at the top; Mitchell limestone, Salem (Bedford) limestone, Harrodsburg limestone and the Knobstone (the latter including the Riverside sandstone and the New Providence shales). These formations are exposed in the order named as one passes across the county from west to east. The dip is to the south of west.

SECTIONS.*

Section 1.—From Stout's Creek east to the top of the divide on the half section line of Section 8, Bloomington Township:

	Feet.
Harrodsburg limestone—	
1. Unseen	20
2. Thin-bedded limestone	15
3. Very thin-bedded, gray limestone (crinoid stems abundant).	5
4. Thin-bedded limestone	10
5. Massive limestone forming base of cliff	20
Knobstone—	
6. Massive sandstone	20
7. Shaly sandstone and sandy shale	32
8. Unseen	25
Total	147

Section 2—On small creek near northwest corner of northeast ¼ Section 7, Bloomington Township:

	Feet.
Oölitic—	
1. Unexposed	70
Harrodsburg limestone—	
2. Thin-bedded limestone (Spirifer)	2
3. Unseen	12

*The strata of the sections are numbered from the top downward.

	Feet.
4. Dark, irregular, non-fossiliferous limestone weathering rough. (There are rusty particles in this stone which forms the falls in the stream.)	10
5. Limestone	4
6. Rather massive, dark, iron-gray limestone forming second fall	2
Knobstone—	
7. Very hard, thin-bedded, light-colored sandstone	4
8. Massive, hard sandstone	4
9. Thin-bedded limestone grading into massive sandstone. Forms third fall	25
10. Unseen. Sandstone?	5
11. Sandstone	5
12. Massive, thin-bedded, soft, light-colored sandstone	20
13. Light-colored sandstone weathering to yellow and brown	10
14. Shaly sandstone and sandy shale	20
15. Unseen	20
Total	213

Section 3—On the west line of Section 5, Bloomington Township, near southwest corner:

Knobstone—

	Feet.	Inches.
1. Massive sandstone with reddish-brown bands	4	0
2. Laminated white sandstone with reddish-brown bands	5	0
3. Massive light-colored sandstone	2	0
4. Laminated soft, brown sandstone with reddish-brown bands	0	8
5. Shaly sandstone	9	4
6. Massive, rather soft, light-colored sandstone. Weathered surface dirty brown, rough, pitted	10	0
Total	31	0

Section 4—Near the northwest corner of the southeast ¼ of the north-east ¼ of Section 25, Bloomington Township:

Harrodsburg limestone—

	Feet.	Inches.
1. Light to dark gray limestone	5	0
2. Very thin-bedded, rough, non-fossiliferous limestone	12	0
3. Unseen. Limestone?	10	0
4. Dark gray limestone weathering rough and pitted. Very fossiliferous	0	2
5. Thin-bedded limestone, gray in color and weathering a pitted surface	5	0
6. Laminated, thin-bedded, fine-grained, gray limestone	0	6
7. Unseen	5	0
8. Thin-bedded, course, iron-gray limestone weathering rough. Forms an escarpment	10	0
Knobstone—		
9. Sandstone	40	0
Total	87	8

Section 5—Just east of Andrew Stine's residence, one and one-half miles east of Stinesville.

Glacial—

	Feet.	Inches.
1. Unseen	2	0
2. Cross-bedded brown sand, indurated at the top	12	0
3. Unseen	5	0
4. Very finely laminated, yellow sand, banded with brown	0	4
5. Closely compacted gravel composed mostly of angular fragments, many of which are foreign to the region	1	0
6. Irregularly stratified sand (moulding)	5	0
7. Uncemented, light-brown sand	25	0
8. Reddish-brown sandy clay	5	0
Harrodsburg limestone—		
9. Limestone forming precipice in ravine	0	4
10. Very hard, thin-bedded, dark-gray sandstone	5	0
11. Very hard, bluish-gray sandstone	15	0

		Feet	Inches.
12.	Thinly-bedded gray sandstone, banded with streaks of white	0	4
13.	Thin-bedded, light-colored sandstone	10	0
14.	Sandstone	35	0
15.	Unseen	20	0
	Total	140	8

The sand represented in the upper part of this section was deposited at the foot of the glacier. The mouth of the little stream was closed by the ice and its basin laked, allowing the deposit of the stratified material. The stream has since cut a gorge through the center of the deposit. The lateral extent of the deposit is not great because the little lake was small and narrow.

Section 6—In railroad cut 1 mile north of Stinesville:

Thicknesses, in part, estimated.

Harrodsburg limestone—

		Feet.	Inches.
1.	Massive to thin-bedded limestone	40	0

Knobstone—

		Feet.	Inches.
2	Very hard, rough-feeling, granular, calcareous sandstone weathering to a rusty brown	0	3
3.	Bluish-gray, massive sandstone	3	0
4.	Bluish-gray sandstone filled with chert and geodes	0	8
5.	Soft, blue sandstone	0	3
6.	Calcareous, fossiliferous, somewhat cherty sandstone	0	6
7.	Bluish-gray, very soft shale	0	8
8.	Thin-bedded, soft, very light-brown sandstone	2	0
9.	Stratum of chert concretions	0	4
10.	Massive, brown sandstone weathering dark and pitted	6	0
	Total	53	8

Section 7.—On the road an eighth of a mile west of Bowman Schoolhouse, Bean Blossom Township:

Glacial

	Feet.	Inches.
1. Yellowish, jointy clay with small rock fragments and occasional bands of brown moulding sand one to six inches thick	12	0
2. Very light-brown sand, when wet (white when dry), and extremely fine	40	0

Section 8.—On the road west of the Able Schoolhouse, just east of Mr. Maple's residence, Bean Blossom Township:

	Feet.
Glacial material—	
1. Yellow clay grading into moulding sand	15
2. Light-colored clayey sand	10
3. Yellow sand	10
4. Light-colored sand with occasional bands of gravel and a few bowlders	55
5. Yellow clayey sand	4
6. Gravel	3
Knobstone—	
7. Sandstone	2
Total	99

Section 9.—Township line, ¾-mile north of Lemon P. O.
A section in delta deposit. Glacial—

	Feet.
1. Yellow clay	3
2. Thinly-bedded, finely-stratified, yellow to light-brown clay breaking down to a hard yellowish-brown clayey earth	3
3. Yellow, laminated, extremely fine moulding sand, banded with bands of yellow, brown and white indurated material	10
Total	16

Section 10.—North and south section line, 420 yards west of Lemon P. O., on the south side of the ridge.

Harrodsburg limestone—

	Feet.	Inches
1. Thin bedded, bluish-yellow limestone	5	0
2. Thin-bedded, gray to brown limestone, poor in fossils and weathering pitted	20	0
3. Brown to gray, rather hard limestone, composed of crinoid stems and Bryozoa	5	0
4. Yellow, non-fossiliferous limestone with rusty particles	0	6
5. Blue-gray limestone weathering yellow and brown	5	0
6. Very hard, speckled limestone	0	6
7. Very hard, rough, gray limestone, composed largely of crinoid stems	2	0
8. Yellowish-blue limestone	1	0
9. Massive, hard, fossiliferous limestone	4	0
10. Limestone	10	0
11. Thin-bedded, very hard, fossiliferous limestone (crinoids and Bryozoa)	1	0
Knobstone—		
12. Sandstone	45	0
13. Unseen	30	0
Total	129	0

Section 11.—Near Mr. C. C. Fulford's home on Indian Creek, half a mile west of Canada Gap:

Knobstone. Thickness estimated—

	Feet.
1. Sandstone grading into coarse shales	100
2. Bluish-gray, very soft shale	25
Total	125

Section 12.—Up ravine near the northeast corner of northwest ¼ of Section 3, Bean Blossom Township, near Mr. Samuel Kid's residence:

Harrodsburg limestone—

		Feet.
1.	Massive, white to gray, hard limestone with many geodes..	15
2.	Thin-bedded, very fossiliferous, iron-gray limestone........ (Bellerophon, Productus and Spirifer.)	4

Knobstone—

3.	Thin-bedded, rusty sandstone with geodes...............	4
4.	Massive, bluish sandstone..............................	3
5.	Thin-bedded, blue sandstone............................	3
6.	Massive, bluish-gray sandstone.........................	5
7.	Very thin-bedded, shaly sandstone, weathering to white sandy clay	20
8.	Thin-bedded sandstone	35
9.	Massive sandstone	10
	Total	99

Section 13.—Ellet's Hill, ¾ mile west of Lemon Schoolhouse, south of the west side of Ellet's graveyard.

Oölite—

		Feet.
1.	Fine-grained, whitish-gray, oölite, like that quarried at Stinesville and Bedford..................................	25
2.	Massive, coarse-grained, dark-gray oölite................	10

Harrodsburg limestone—

3.	Limestone	65

Knobstone—

4.	Sandstone and sandy shale..............................	100
	Total	200

Section 14.—In ravine north of Mrs. W. E. Wood's house near the center of the north line of the south east ¼ Section 32, Washington Township:

Harrodsburg limestone—

1. Mostly thin-bedded, very hard, steel-gray limestone with crinoid stems 10

Knobstone—

	Feet.
2. Soft, brown, massive sandstone	10
3. Thin-bedded, bluish-gray, soft sandstone shaling on weathering	45
4. Shale	20
5. Unexposed	10
6. Yellowish-brown sandstone	5
7. Not exposed	10
8. Thin-bedded, yellowish-brown sandstone	2
9. Covered	15
Total	127

Section 15.—45 rods west of township line on Hindostan road near Mr. T. J. Farr's house:

Harrodsburg limestone—

	Feet.
1. Hard, rough, dark-gray limestone containing fossils	15
2. Covered slope	5
3. Hard, gray limestone weathering rough, dark, and pitted	5
4. Thin-bedded, hard, cherty, fossiliferous limestone	10
Knobstone—	
5. Sandstone	4
Total	39

Section 16.—Ravine west of road, one-half mile south of Bean Blossom Church, north of Unionville:

	Feet.
1. Oölitic limestone	
2. Very hard, thin-bedded, light-gray limestone, weathering rough and pitted. Contains fossils	20
Knobstone—	
3. Sandstone, varying from shaly to massive, very soft, blue, weathering yellow and brown	90
4. Covered slope	10

Stobo lmiestone. Iens—

		Feet.
5.	Hard, rough, gray, crinoidal limestone....................	1
6.	Hard, gray limestone, few fossils........................	15
7.	Hard, gray limestone with rusty particles and crinoid stems	5
8.	Soft, blue, sandy shale..................................	10+
	Total	151

STRATIGRAPHY.

The Knobstone is the surface rock over the greater part of the region here considered. It extends from Brown County west to the Harrodsburg limestone contact which extends in a general northwest and southeast direction, crossing the country east of Bloomington. Northeast of this line, however, there are several detached patches of limestone resting on the Knobstone. The entire thickness of the Knobstone is not exposed in this area; but according to Mr. Siebenthal it is about 600 feet. The formation, as far as examined, is composed of a series of alternating, friable, arenaceous shales and sandstones. On the whole the formation is non-fossiliferous. At intervals, however, as at Stobo Post Office, there are intercalated, lenticular beds of limestone and calcareous septaria with rich faunas. This formation, on account of its incoherent, loosely-cemented, easily-eroded condition, has been cut up into a confused tangle of crooked ridges and deep hollows which trend in all directions. Commercially the Knobstone is of little value on account of its friable condition, but the arenaceous shales may be of value in the making of brick and cement.

The Harrodsburg limestone lies on the Knobstone and below the Salem (Bedford) limestone. In the main, it forms a belt from three to five miles in width along the eastern outcrop of the Salem limestone or oölite, and is bordered on the east by the broken hills of the Knobstone. This limestone once covered the entire region east of the oölitic contact, as is attested by its patchy remains in various parts of the county. The triangle between Bean Blossom Creek and White River from Mt. Tabor east to within one mile of Canada Gap is capped with it. A large, irregular, much lobed area of it occurs as the surface rock in the vicinity of the Farr schoolhouse east of Hindostan, and another just west of Hubbard's Gap. East of the railroad, about two miles southeast of Gosport, a small area of this formation is half submerged in glacial sand. Another small triangular area, with strata dipping to the east, lies on the east side of a ridge a mile south of the Bean Blossom Church. Besides the patches mentioned, there are several other small ones of this formation in the area. In addition to these, main lobes extend to the east from the limestone belt for several miles. One of these lobes extends in a linear strip to Unionville. From there it turns back toward the northwest for three miles. This strip is the watershed of the region through which it extends. On the limestone lobes are located most of the roads in the Knobstone region. The Harrodsburg limestone as exposed on Ellet's hill is 65 feet thick. Its lower portions are limestones containing a great number of geodes, or "mutton heads," which range in size from a pea to a bowlder two feet in diameter. Above the geode layers the stone contains pyrite, is somewhat crystalline, and is tinted with blue, gray, or green.

This limestone is thin-bedded. The bedding planes separating the strata are, in many instances, lenticular, intercalated masses of chert. The strata were found to be more massive toward the top of the formation. Also as the top of the formation is approached the limestone gives up its molluscan fauna and takes on a Byrozoan fauna.

"The contact of the Harrodsburg and oölitic limestones is almost always marked by a 'crowfoot' (stylolite), with which are associated masses of silicified oölitic fossils and black siliceous masses."*

To the present time the Harrodsburg limestone has proved of commercial value only for macadamizing purposes.

The Salem limestone lies above the Harrodsburg limestone and beneath the Mitchell limestone. It forms a belt about three miles in width. It begins near Gosport and extends beyond Bloomington, embracing the quarry districts of Big Creek, Stinesville, Elletsville and Bloomington. Beside the belt strip there are several detached areas. One caps Ellet's hill, near Lemon Post Office. This latter patch covers an area of about ten acres. The oölite of this patch is of average thickness and is of fair quality. It is massive, free from lamination and bedding planes.

---

*Siebenthal, loc. cit. p. 298.

Analyses of Salem limestone:

Sample 1 from Adams quarry—

	Feet.
Residue insoluble in acid	.41
Lime (CaO)	52.76
Magnesia (MgO)	1.04
Carbon dioxide (CO_2)	43.80
Alumina and ferric oxide (Al_2O_3, Fe_2O_3)	1.57
SO_3	.06
Total	99.67

Sample 2. Johnson quarry, Bloomington—

	Feet.
Residue insoluble in acid	.77
Lime (CaO)	54.67
Magnesia (MgO)	.60
Carbon dioxide (CO_2)	43.04
Alumina and ferric oxide (Al_2O_3, Fe_2O_3)	.42
Phosphorus peroxide (P_2O_5)	.19
SO_3	.19
Total	99.88

For exhaustive treatment of the Salem (Bedford) limestone the reader is referred to Siebenthal's article already mentioned.

THE GLACIAL DEPOSITS.

The glacial deposits, so far as the writer's observations extend are: Glacial till, outwash and eolian deposits, bench or terrace deposits and delta deposits.

GLACIAL TILL.

The drift deposit was first observed on Jack's Defeat Creek in the neighborhood of the old Dutch church. From there it continues in a northeasterly direction, crossing Bean Blossom Creek near the mouth of Camden Branch. According to Siebenthal's description* it then bends south of Lost Ridge, near the mouth of Indian Creek, and follows the course

*21st Geol. Rep. Ind. p. 300.

of the latter creek to Canada Gap, continuing in the same direction and, passing a half mile south of Godsey Post Office, it crosses into Morgan County three-quarters of a mile east of Godsey. Swinging southeastward it re-enters Monroe County where Hacker's Creek leaves it, extending up that creek to the neighborhood of Hacker's schoolhouse. From here eastward the drift limit becomes harder to trace. The ice-sheet must have been very thin, since the topography shows little, if any, modification. Scattered erratics are found all over the ridge dividing the waters of Roberts' Creek from the headwaters of Honey and Hacker's creeks. It seems probable that the foot of the ice-sheet rested on this hill, and that the drift found in the head waters of Honey Creek was carried there by the water resulting from the melting of the glacier. Many large granite bowlders from one to three feet in diameter are found along the small stream leading north from Hubbard's Gap, in Sec. 11 (10 N., 1 E.), and along the other tributaries of Roberts' Creek. In section two of the same township heavy deposits of sand, gravel and till lie against the hillsides. In the neighborhood of Godsey Post Office the same phenomena may be seen. Heavy beds of gravel and till lie against the hillsides bordering their slopes on the south. In Canada Gap, section 9 (10 N., 1 W.), the evidences of ice occupation are plain though the quantity of drift material is very limited. The territory between Indian Creek and Bean Blossom Creek and White River displays evidence of ice occupation in many places in modified topography and deposits of till, sand and gravel. Till, sand and gravel occur in the valleys leading south from Hubbard's Gap in the vicinity of Fleener Post Office, and patches of these same materials are occasionally met with south of the divide east of that gap. On the whole the drift is thick in the valleys and thin on the hills. This light drift on the hills indicates that the ice-sheet which crossed them was comparatively thin.

OUT-WASH AND EOLIAN DEPOSITS.

North of Mount Tabor and between there and Gosport, as well as the south slope of the hills between Mount Tabor and Ellet's hill are covered with a heavy deposit of sand. A sand apparently identical with the above caps several hills and fills several preglacial ravines on the south side of Bean Brossom Creek near Andrew Stine's residence about two miles east of Stinesville. The sand near Andrew Stine's residence was evidently deposited in water. That it was of glacial origin is attested by the fact that it is banded with erratic gravel. The sand here is cross-bedded, stratified and, in several instances, finely laminated. The lamination and stratification, however, are not constant. Towards the top of this sand the stratification ceases. This top seems to have been of eolian origin. This sand was deposited as an out-wash in front of the advancing glacier after it had filled the channel of Bean Blossom. That it was deposited in front of the advancing ice-sheet is clearly shown by evidence that after its deposition the glacier passed over it, crushing it under its weight until now the sand is almost as compact as the Knobstone formation beneath it. Still further evidence that the sand was deposited just in front of the ice-sheet is the fact that the Bean Blossom was filled at that point with ice. Had it been filled with sand instead of ice to the level of the present deposits some remnants of the sand would still remain on the south side of the inner valley of Bean Blossom Creek, which is not the case. The sand in the vicinity of Mt. Tabor and Gosport is very fine and flour-like. It usually forms a loose or slightly compact, massive bed twenty or more feet in thickness. Occasionally it shows indications of stratification, but at no place is the stratification constant. In speaking of this sand Mr. Siebenthal says that it seems to have been deposited from high water resulting from a melting ice sheet.* It is therefore outwash material. How it came to be deposited as it is, however, is quite a mystery. The deposit is V-shaped with the apex to the west. A limestone ridge separates its legs. On this ridge the sand is thin and suggests by its distribution that it might be eolian in origin. It seems clear, then, that the sand on the south side of the ridge must have come around the west end of the ridge instead of over it, and that the whole deposit was laid down in the slack water between Bean Blossom Creek and White River at the time of the high water that accompanied the melting of the ice-sheet. This opinion is strengthened by the fact that the sand plain gets lower and lower toward the east instead of higher as it would had the sand come over the ridge. This conclusion is further strengthened by the fact that this sand does not occur on the current, or south side of the Bean Blossom as it probably would had it not been deposited in slack water. The sand, on the whole, seems to have been an eddy deposit.

*Op. cit.

BENCH OR TERRACE DEPOSITS.

These deposits have been described both by Mr. Siebenthal and Professor Marsters. In speaking of them Mr. Siebenthal says: "Terraces occur in the valley of Bean Blossom Creek above the crossing of the drift limit. Drift deposits occur below that, but are irregular in height and have not the level top of terraces. The terraces range from mere knolls to benches a mile wide. The lower portions of these beds consist of sand and erratic gravel with sand and smaller gravel above, and over all sandy clay and loam. These terraces seem to have been deposited by high waters which must have resulted from the melting of the glacier which covered the head waters of the creek in Brown County, and the drainage of the glacier which crossed its lower course. The various tributaries of Bean Blossom Creek have similar deposits in a smaller way, the materials of which are, however, of local origin. The fact that the drift material of foreign origin is confined to the creek itself, argues that it was derived from the glacier occupying the upper course of the creek."

In speaking of the same terraces Professor V. F. Marsters says:*

"Rimming the valley slopes are to be found a number of benches of variable widths, with surfaces sometimes as flat as a floor or with an exceedingly gentle decline valleyward, with outer edges lobate in shape and descending with a marked angle to the level of the valley floor. These occur at various points within the limits of Monroe County, invariably situated on the north and east sides of the valley, and varying in elevation from twenty feet in the lower part of the stream to seventy or more feet in the upper part of the valley near the east line of Monroe County. In all the cases examined they were found to be composed of mixtures of clay and sand undoubtedly derived from the disintegrated rock formations constituting the surface of the uplands. No glacial debris of any sort was found either on the surface or in any of the sections or cuts in the benches noted within the limits of Monroe County."

It will be readily seen that the two authors quoted above differ from each other concerning the origin of the bench material. Mr. Siebenthal says in substance, that it is of glacial origin; and Professor Marsters gives a directly opposite view, stating that no glacial material of any

*Proc. Ind. Acad. Sci. for 1901, p. 225.

kind was found in any terrace within the limits of Monroe County. The difference of opinion may be explained in part, by the fact that Mr. Siebenthal has included the delta plains in his terraces and Professor Marsters has omitted them, as is found later in his paper.

To turn to the terraces themselves, the most of them are capped with ten or more feet of a mixture of clay and sand undoubtedly derived from the disintegrated rocks constituting the surface of the uplands. Some of the other benches are capped with glacial material; others with both glacial and residual material. Underneath the loose material are always to be found friable sandstone, or more frequently sandy shales many feet above the water in Bean Blossom Creek. The bench lying between Mt. Tabor and Ellet's hill is composed of shale and shaly sandstone except at the top. The sandstones and shales are exposed at several places along the road leading east from Mt. Tabor as well as in the ravines north of the road. The top is capped by a thin layer of sand or sandy clay. The bench on which Pleasant Valley Church is situated is all shale except the top part which is composed of a few feet of residual clay on which rest ten feet of erratic gravel and clay. The bench on the north side of Bean Blossom Creek, beginning almost one-half mile east of Bean Blossom Church and extending to the Brown County line is composed of blue shale resting upon which are ten to twelve feet of residual clays.

The benches seem to be due not to glacial agencies in the main, but to the bench-weathering of the arenaceous shales of the region, together with the formation of small side deltas which have become confluent. This opinion is strengthened by the following facts: (1) The terraces are higher above the creek bed at the east than at the west, when if they had resulted from a laking of the basin as Mr. Siebenthal supposes they were, they would have been higher at the west. (2) The material did not come from the foot of the glacier in Brown County, as this author supposes, because the finer material is along and just west of the Brown County line, the coarser, farther down the creek. (3) While the benches rise toward the east the deltas of the larger tributaries do not always do so, thus leaving gaps that would have been filled had the bench material come down the creek from the glacier which crossed its upper tributaries. (4) The benches rise toward the east with the rise of the shales.

In preglacial time Bean Blossom Creek, as we shall see later, cut its channel to base level. At that time all its tributaries likewise cut to grade. Both the creek and its tributaries began to meander and to etch back their valley sides. The thin Harrodsburg limestone being removed as well as the upper Knobstone, the shaly slopes, weathering flat, became, with the modifications mentioned above, the terraces of today.

This subject will be further investigated in the near future. At that time it is hoped that the origin of the terraces can be more definitely determined.

After the ponding of Bean Blossom Creek the tributaries silted up their channels which became miniature estuaries. They then began to form deltas in the lake and in the slack water regions. The western tributaries, for example, Buck Creek, built their deltas in a direct line toward the center of the lake. This demonstrates that the water in which the delta was built was free from strong currents. The deltas of the eastern tributaries swing westward, often forming an east and west bar, now a ridge, thus indicating that these tributaries entered a swollen, westerly-moving stream. The eastern deltas also attest that Bean Blossom Creek was not then ponded but was a slowly moving stream reaching from bluff to bluff. When the estuaries were all filled and the deltas had reached the level of the benches the tributaries spread their debris over the benches as well, so that today it is hard to tell, so far as topographical appearance goes, where the terraces leave off and the deltas begin. Two of the most conspicuous deltas are those of Buck and Wolf creeks. In writing about these Prof. Marsters says:*

"Besides the portion of each creek, wriggling across the valley bottom, there are rather long and narrow strips or delta-like accumulations similar in content to the benches already described, and extending from the valley slope to within a few yards of the Bean Blossom channel which hugs the south slope of its valley. The surface does not attain the characteristic flatness of the rimming benches, but is slightly irregular in relief and increasingly so towards the slope to which it is attached. This is especially true for the Buck Creek case, but not for the Wolf Creek. The increasing irregularity may be in part due to the nearly complete burial of a projecting spur, whose top is barely coated over with the delta deposits now spread almost across the entire width of Bean Blossom; but it must be said that no outcrops of limestone or sandstone, such as make the slopes of the valley, have been discovered within its limits. On the other hand, the irregularity of relief may have been produced by

*Loc. cit. p. 235.

the piling up of the great load of silt within Bean Blossom by the tributary, but did not succeed in building it up to the lake level; in other words, it is an incomplete delta, or bar.

The Wolf Creek case differs from the former only in having a moderately flat top, or at least the higher flats on it attain about the same level, thus suggested that it was built up nearer to water level, and hence more even and uniform in relief. These differ from the rimming benches only in that they *extend across the valley floor*, while the former, being made by smaller streams close to each other, have built a series of small benches or deltas which have become confluent, and hence continuous *along the valley side*."

The delta material is derived from the disintegrated rocks of the adjacent uplands or is of glacial origin or is of both glacial and residual debris according to the source of the tributary and the proximity of the foot of the ice-sheet. The ice-sheet entered both Canada and Hubbard's gaps and at several places between these two gaps its foot rested on top of the Bean Blossom Creek—White River divide. Consequently glacial material is to be found in the deltas of Indian and Honey creeks leading south from these respective gaps. Below are sections from some of the most conspicuous deltas of the area:

Sections taken on the Buck Creek delta:

Section 1.—Well on Dolan road one mile north of Dolan.

	Feet.
1. Yellow clay	18

Section 2.—Well on Dolan road, one-half mile north of Dolan.

	Feet.
1. Black soil	1
2. White sand	6
3. Yellow clay	15

Section 3.—On A. Oliver's place on the Dolan road one mile north of Dolan. A well was once dug here through yellow clay for 47 feet.

Section 4.—Solomon Laughlin's well about a mile south of Dolan.

	Feet.
1. Clay and sand	36
2. Solid rock	?

Section 5.—On the road on the half section line between sections 34 and 35. Washington township, one and three-fourths miles north of Dolan.

		Feet.
1.	Yellow clay breaking down to yellow earth	5
2.	Whitish-yellow clay	1
3.	Yellow clay	1
4.	Whitish, laminated clay becoming very hard on exposure	5
5.	Yellow jointed clay	5
6.	Yellow to brown jointed clay	5
7.	Shale	1+

No glacial material of any sort was found in this delta.

INDIAN CREEK DELTA.

Section 1.—Well at Lemon Post Office.

The section here was composed entirely of loose material. The bottom of the well was in loose erratic gravel at a depth of 20 feet.

Section 2.—Marion Coater's well, forty rods east of Lemon Post Office.

		Feet.	Inches.
1.	Black earth	2	0
2.	Yellow clay	8	0
3.	Yellow coarse sand	0	8
4.	Gumbo clay	14	0
5.	Fine quicksand	3+	

The Indian Creek delta is composed more or less of glacial material, as is shown by the sections. This, of course, was anticipated as the stream heads in Canada Gap.

Sections taken in the vicinity of the Honey Creek delta.

Section 1.—Well north of the road one-eighth of a mile east of Pleasant Valley Church.

		Feet.
1.	Clay	5
2.	Erratic gravel	7

Section 2.—Another section near the preceding one.

		Feet.
1.	Gravel	18
	Bowlder stratum	4

Like the Indian Creek delta this delta contains glacial material. The glacial material came through Hubbard's Gap.

A section taken on a delta at the mill south of Dolan gave the following:

		Feet.
1.	Bedded, jointed yellow clay banded with red, burns red...	20
2.	Bedded, laminated, jointed blue clay, hard when dry, soft when wet	5
3.	Very soft, massive, blue clay, burning white	20

POST GLACIAL DEPOSITS.

Under this head will be considered the alluvium and the alluvial fan deposits.

Alluvium.

At the close of glacial times Bean Blossom Creek and its tributaries recut their channels to an unknown depth. Then a process of meandering and slight aggrading set in, which has continued to the present time. As a result the creek and its tributaries have developed large alluvial plains. The alluvial plain of Bean Blossom will average a mile in width throughout Monroe County, while many of its branches have bottoms a quarter to a half mile wide in their lower courses. The depth of the alluvial deposits was not ascertained, but in lower Bean Blossom Valley they are probably quite thick. The best farms of the region are located on these plains.

Alluvial Fans.

A number of small V-shaped valleys with very steep channels were found traversing the steepest, southern slopes of Bean Blossom Valley. These on reaching the valley-floor spread out their debris in the form of alluvial fans, their channels disappearing altogether where the fan intercepts the valley floor. The fans project but a few yards beyond the mouths of the valleys. These are evidently fans as they do not possess the flat tops and steep outer margins of the deltas. That they are post-glacial is evident from the fact that some of the little valleys have cut their channels through glacial debris. The one just east of Andrew Stine's house will serve as an example. In addition to this the fans are built on the alluvial floor of the creek which has been made since glacial times.

PHYSIOGRAPHY.

Springs.

The springs of the area are to be found mostly in the limestone regions. They owe their origin to underground drainage. None are mineral springs so far as the writer knows. They furnish the water supply for the city of Bloomington and supply the water for domestic use throughout the region where they are found.

Abandoned Swamps.

About three-quarters of a mile north of the Lemon schoolhouse, on the top of the north bench of Ellet's hill, is a deposit of iron ore gravel. This limonite is scattered over a large area and is evidence of the existence of a large swamp which has now dwindled down to a pond. This swamp probably dates back to glacial times. It was most likely formed between the foot of the ice-sheet and the ridge that terminates Ellet's hill at the south.

Salt Licks.

Several salt licks are to be found in Indian Creek and Bean Blossom valleys. They seem to be evidence of saline shales beneath the valley floors.

Boulders not Glacial in Origin.

In a ravine just north of Ellet's hill, about a mile northwest of Lemon Post Office, are several large bowlders some of which will weigh several tons. These bowlders are not glacial in origin because they are neither scratched nor worn, but are large concretions weathered from the adjacent sandstones of the ravine. That this conclusion is correct is attested by the fact that a half-weatheredout concretion of large size is in situ projecting from the sandstone wall of the ravine near by. The concretions are largely composed of silica and are very hard.*

Lost Ridges.

Standing in line with a point between White River on the left and Bean Blossom Creek on the right in section 5, Bean Blossom Township, is a subcircular knob called Indian or Pasture Mound. This mound being

*In the vicinity of these bowlders were several granite bowlders of glacial origin.

in line with the mound to the north and being composed of the same kind of material suggests that the two were once continuous and are yet continuous beneath the valley floor.

South of Bean Blossom Creek, opposite the railroad cut in section 9 of the same township, there is another ridge standing in line with the projecting "mainland" east of Jack's Defeat Creek. It is almost a third of a mile in length, about 400 yards wide and some 80 feet above the valley floor. It seems to have been a ridge between Jack's Defeat and Bean Blossom creeks before the aggrading of the valley floor caused the former creek to change its channel to the east through a former wind gap in the ridge. This left the ridge isolated.

North of the Bean Blossom, in section 24 of this same township, there is another conspicuous ridge known as "Lost Ridge." It is in line with the "main land" to the north, from which it is separated by only about a hundred yards of flat floor, through which a small stream runs from the Bean Blossom Valley to join Indian Creek. In this case, as in the previous one, the trend of the slope and the trend of the adjacent valley slope, together with the fact that the composition of the rocks is identical, suggest attachment beneath the present valley floor. There are several other similar islands in the Bean Blossom Valley.

These bits of relief are "islands" surrounded by alluvial material. They strongly attest that the Bean Blossom Valley has been aggraded very considerably.

Half Submerged Points and Peninsulas.

Several tied-on, peninsula-like ridges, known as knobs and points, project from the valley walls into the valley of Bean Blossom Creek, with the connecting neck almost submerged beneath the alluvium of the valley. They also attest to the aggrading of the valley.

Abandoned Valleys.

In the glacial region on the south side of Bean Blossom Creek several of the short valleys that were filled with glacial debris still remain filled. The glacial filling of the other valleys have been removed wholly or in part. Those which remain filled have had no springs at their heads since glacial times. Since much of the drainage of that part of the county is underground drainage the little valleys have remained filled.

Young Valleys.

The steep-graded, V-shaped valleys of the south side of the Bean Blossom Valley have already been described in this article and shown to be postglacial. In writing of these valleys Prof. Marsters says:*

"Traversing the steepest slopes of Bean Blossom are to be found numerous V-shaped valleys, with remarkably steep channels, ending their lower course at the point of intersection of the valley floor with the adjacent slope. In all cases small alluvial fans are built on the valley floor with their apex projecting but a few feet or yards at most beyond the mouths of the young valleys. In none of the observed cases was it found that the level of the valley floor would extend into the mouth of the young valley. It is therefore believed that the greater part of the cutting of these young valleys may date subsequent to the preglacial filling. The fact that alluvial fans and not deltas with steep outer edges and flat tops occur at their mouths, suggest that they have been constructed since the laking of the valley, and hence are regarded postglacial."

Reversed Drainage Due to Aggrading.

In section 24, Bean Blossom Township, the little stream which flows through the little gap between the "mainland" and Lost Ridge normally should flow direct to Bean Blossom Creek instead of into Indian Creek. Its head waters are in Bean Blossom Valley proper, not in Indian Creek Valley. The reversal of drainage is due to the aggrading of Bean Blossom Creek, so that the fall is greater through the gap.

Change of Channel Due to Aggrading.

Jack's Defeat Creek, running northeast from Stinesville, from all appearances normally ran just east of the Monon Railroad track between the "mainland" and the lost ridge, previously described, to join the master stream. With the aggrading of Bean Blossom Creek this little creek likewise aggraded itself until, having dammed its lower course with debris, it turned east and joined Bean Blossom farther up stream.

Abandoned Channels.

There are two abandoned channels of considerable size in the region. The one, that of Jack's Defeat Creek, between the "main land" and the

*Loc. cit. p. 236.

lost ridge just east of the railroad, has already been mentioned. The other channel extends from the top of the divide just north of the Abel schoolhouse west to the limestone ridge that is half submerged beneath the sand just east of the railroad track in section 5, Bean Blossom Township. It is about a mile in width and extends from the Bean Blossom Valley north to the White River Valley. The bed of this channel, which is now filled with glacial sand, is at least twenty-five feet below the present surface, as is attested by the sections taken in the wells of the region. The origin of this channel is still undetermined. The data at hand seem to suggest that after the retreat of the ice-sheet from the immediate vicinity, an ice-gorge dammed White River and compelled it to cut a new channel. After the breaking of the ice dam the river, as the new channel was not as deep as the old, abandoned the new and resumed the old channel. As it was being abandoned the new channel became a slack water region in which was deposited the sand which now fills it.

Wind Gaps.

There are many wind gaps in the area. They are the result of the degrading action of small streams on opposite sides of a divide. The streams have etched back their respective channels until they have cut through the divide, thus forming a wind gap. Conspicuous among these are Canada and Hubbard's gaps. These two gaps are both on the divide between White River and Bean Blossom Creek. They were both in existence in glacial times as they have glacial material deposited in them. In each rested the foot of the ice-sheet, and through each was carried south into the Bean Blossom Valley large quantities of glacial debris as has been shown in the discussion of the deltas of Indian and Honey creeks; the latter creek heading in Hubbard's Gap and the former in Canada Gap. These gaps are in interest now as they furnish prospective routes for steam and electric railways.

Bean Blossom Creek.

Bean Blossom Creek enters Monroe County from the east a little south of the northeast corner of the county and flows a little south of west to the northwest corner of Bloomington Township.* Here it changes its direction to a northwest course. It continues in this direction until it

*The change in the course of this creek is due to its sheering off to the northwest on coming in contact with the harder Harrodsburg and Salem limestones. Its lower course follows the trend of these out-crops.

enters White River a mile below Gosport. Throughout the county it has a wide, flat-floored picturesque inner valley, averaging a mile in width, the sides of which range from 100 to 200 feet in height. In this valley the present diminutive creek persists in keeping to the southwest side. The slopes of the valley usually range somewhere between 25° and 40°; the steeper slopes being usually on the south side, the south slopes of Ellet's hill and Mt. Tabor north of the creek being the only examples to the contrary. Rimming the valley slopes are a number of benches of variable widths, as has been previously noted, while projecting above the alluvium of the valley are hummocks and ridges, "islands" whose content is precisely the same as the country rock on either side of the valley. Beside these, tongues, promontories and tied-on ridges project into the valley.

This stream has had a varied history as has been already roughly outlined. It will be discussed under three heads, Preglacial, Glacial, and Postglacial history.

Preglacial History of Bean Blossom Creek.

At the close of the Mississippian period, or later in preglacial time, Bean Blossom Creek incised its channel to a depth much below its present level. That the incision was made in preglacial time is indicated by the following facts: (1) The old valley is now half filled with debris some of which is glacial in origin. (2) Its tributaries to the north as well as the wind gaps due to preglacial drainage likewise have glacial debris in them. (3) The glacier which crossed the northwestern part of Monroe County passed over and filled the creek, as is evidenced by the sand and glacial drift left in its valley. That the channel was deeper in preglacial time than now is demonstrated by the following evidence: The creek now meanders on a flat floor a mile in width. The floor, which is composed of alluvium for the most part, is still being aggraded. (2) Wells dug in the valley floor north of the channel, show that the loose material has great thickness. Mr. James Hughes' well, at his home on the road one mile east of Mt. Tabor nearly in the center of the southeast quarter of section 10, is 65 feet deep, yet it does not penetrate the entire thickness of the valley filling at that place. (3) Many of the meander-cut slopes have been largely buried beneath the valley filling. (4) Many of the tributary valleys, such as Jack's Defeat Creek, are aggraded for some distance up stream.

After incising the valley and widening it by meander cutting, Bean Blossom Creek began to aggrade its channel and at the close of the preglacial time had filled it nearly to the level it is today. The evidence in favor of such a conclusion is as follows: (1) At all points where the creek was protected from the invasion of glacial debris by promontories, such as Mt. Tabor and Ellet's hill, it still flows on the north side of its valley. At all other places it was driven to the south side by glacial debris. (2) The greater part of the clay and silt occupying the valley floor is of precisely the same kind as that covering the unglaciated highlands and valley slopes. It is evident that this filling simply represents the wash and soil-creep from the slopes and uplands on either side of the valley. (3) At the mouth of the creek where the glacier crossed the country only a patchy film of sand associated with bowlders composed partly of crystalline rocks cover the underlying clays, silts, etc.

This conclusion agrees with the following statement of Prof. Marsters concerning the preglacial filling of the valley:

"Inasmuch as the greater part of the clay and silt occupying the valley floor is precisely the same in kind as that covering the unglaciated uplands and valley slopes, it is evident that this filling simply represents the wash and soil-creep from the slopes and uplands on either side. Moreover, the rate of filling was so far in excess of the ability of the stream to carry off its load that the preglacial valley became clogged with the waste to such a degree that the stream now occupying the valley floor is for much of its course quite unable to spread its meanders over the entire width; only at the narrowest sections does Bean Blossom succeed in occupying the entire valley from slope to slope.

"Inasmuch as the filling of Bean Blossom at its mouth and for some little distance up stream is covered over by a patchy film of glacial sand associated with bowlders, composed partly of crystalline rocks, the underlying clays, silts, etc., antedate the glacial coating. Moreover, the occurrence of benches (to be associated with the glacial history) resting upon the valley filling also point to the same conclusion, that the present filling of the valley, less the benches and the glacial sands, etc., near the mouth of the valley, is preglacial."

The valley fillings, less the glacial sand, are, therefore, mostly preglacial.

Glacial History of Bean Blossom Creek.

As has been previously stated Bean Blossom Creek was laked by the ice-sheet which crossed its lower course. At the time of its laking there were deposited in its valley the deltas together with the loose materials that now cover the benches on either side.*

Post-Glacial History of Bean Blossom Creek.

Since glacial time Bean Blossom has been a diminutive, meandering creek in a broad, flat-floored valley, and throughout all postglacial time it has persisted in keeping to the south or west side of its valley. Evidently it does not fit its present valley. This fact suggests that the creek has not been able, on account of its diminutive size and the lack of time, to do much constructive work since the ice retreated. It is now at grade for ten miles above its mouth and must be actually aggrading its channel.

We quote Prof. Marsters for a more detailed description of this topic.**

"Since the close of the laking stage Bean Blossom River has developed a meandering course on its broad floor. Only in the narrowest sections of the valley has it succeeded in spreading its meander belt across the entire floor. For the most part it keeps to the west or south side of the valley, and yet still assumes a meandering habit for considerable stretches. In other words, the stream does not fit the present dimensions of the broad valley, which, accordingly, must have been brought about by other conditions than that resulting from lateral cutting, by a mature stream. Cross sections of the valley at its broadest places reveal a slight curvature of surface in the center and occasional abandoned meandering channels. This slight variation from a plain surface suggests flood plain construction. Whether this constructive work antedates the glacial episode of Bean Blossom is not certain, but it would seem from the data at hand, that the present postglacial Bean Blossom has not had time or the ability to do much constructive work since pleistocene time."

Two more things of interest in connection with Bean Blossom Creek remain to be explained. They are: (1) The reason for the channel of the creek keeping to its south bank, and (2) the reason why the slopes on the south side of the valley are steeper than those on the north.

---

*See Marsters, loc. cit. for further discussion of this subject.

**Loc. cit. p. 236.

The explanation of the former seems to be that the branches from the north carried in much more material than those from the south. The tributaries from the north are more numerous and larger than those from the south and carried into the valley great quantities of glacial material from the foot of the ice-sheet or material from the slopes near its foot. This caused a greater accumulation of sediment on the north side of the valley, and the deltas thus formed drove the stream to the south side of the valley. The deltas of Buck and Wolf creeks, for example, extend nearly across the valley to the south side. Where Mt. Tabor, or Ellet's Hill, protected the valley from glacial or upland sediments from the north, the channel finds its way to the north bluff. To sum up, it seems from the foregoing statements that the creek keeps to its south bluff because of accumulated material from its tributaries in the north side of the valley.

The answer to the other question, Why are the valley slopes steeper south of Bean Blossom than north of it? seems to be as follows: It was observed that the variation in the slope had a direct relation to the minuteness of dissection, or the spacing of the streams crossing it, and that the closer the streams are to each other, the more subdued the slope. As a greater number of streams cross the valley slope on the north side of the valley we find the more subdued slopes on that side. In addition to this the stream occupying the south side of the valley has confined its side-cutting to that side which has tended to keep these bluffs steeper.

Mineral Resources.

The principal mineral resources are rock, sands and clays. The rocks having been mentioned as to use and value, the sands and clays remain to be discussed.

Sand.

The sand of the area is in the vicinity of Mt. Tabor, and between that point and Gosport. This sand is very fine and flour-like and, consequently, it is not a plastering sand. However, it is a good quality of moulding sand and may be used for paving purposes. For these purposes it has been satisfactorily tried, several car loads being used. There is, besides detached patches, a continuous sand area covering several square miles to a depth of 20 to 40 feet.

Clays.

The residual clay derived from the breaking down of the Harrodsburg limestone is very stiff and of a deep red color. The clay resulting from the decomposition of the Knobstone shales is usually blue except on weathered surfaces, where it is light yellow. All the other clays of the region, those of the deltas being good examples, are yellow.

The blue clay is derived from the blue stone and shale of the Knobstone. Only three patches of this clay were noticed, one north of Bean Blossom Creek near the Brown County line, one just across Honey Creek on the road east of Fleener, the other in the delta (bench) south of Muddy Flat Creek, about a half mile south of Dolan. There are probably several other patches of this clay in the area, but as my investigations did not have reference to clays, no particular search was made for them. The clay of the first two patches mentioned is residual, while that of the last is probably stream wash and about 25 feet deep. On being burned in a kiln it burns white. The foreman of the tile mill at Dolan states that it is a good potter's clay. In burning tile the blue clay is mixed with equal parts of the yellow clay. This mixture produces a tile of fair quality.

Both the delta and bench formations in the Bean Blossom Valley are yellow above and sometimes down to a depth of 20 feet. This clay is the same in appearance as the yellow clay at Dolan that is made into tile. It is the opinion of the writer that a large tile and brick industry could be built up in this valley.

Indiana University, December 31, 1903.

Geology of the Fort Apache Region, Arizona.

By Albert B. Reagan.

(By title.)

What is the Age of the Aubrey Limestone of the Rocky Mountains?

By Albert B. Reagan.

The Carboniferous rocks of the Rocky Mountains are divided lithologically and palaeontologically into two distinct groups: The Red Wall and the Aubrey groups. The Red Wall is divided on palaeontological grounds into the Upper and Lower Red Wall, and the Aubrey on stratigraphical and lithological grounds into the Upper and Lower Aubrey. The Upper Aubrey is usually called the Aubrey Sandstone, the Lower Aubrey the Aubrey Limestone. In this paper it is the writer's purpose to establish the age of the last named group.

This group of rocks rests conformably upon the Upper Red Wall and shows conclusively by its position that it is Palaeozoic. Then as the Upper Red Wall is Coal Measures in age (see paper on "The Fossils of the Upper Red Wall Compared with those of the Kansas Coal Measures"), the Aubrey Limestone must be either Upper Carboniferous or Permian. Its position immediately above the Red Wall suggests the former; that is, that it is Upper Carboniferous. This conclusion is attested by the fossils identified from the group. They are: *Seminula argentia*, *Productus punctatus*, *Productus semi-reticulatus*, *Productus costatus* (?), *a Productus closely allied to if not, P. portlockienus*, *Spirifer cameratus*, *Bellerophon*, *Spirifer lineatus*, *Euomphalus pernodosus*, *Aviculopecten occidentalis Aviculopecten*, *a Hemipronites* (Gilbert), *Mekella striata-costata*, *etc.*

These fossils were all obtained in the first 100 feet of the Aubrey Limestone. They are all Upper Carboniferous, not Permeo-Carboniferous, in age, and therefore establish the age of the rocks in which they are found to be Upper Carboniferous beyond a doubt.

Note.— A few shells (*Pleurophorus*, *Schizodus*, and *Bakevellia*) found by Mr. Gilbert (U. S. Geographical Surveys west of the 100th meridian, vol. 3, page 177) in the topmost layer of the Aubrey Limestone suggests the Permeo-Carboniferous of the Mississippi Valley. This would seem to imply that the Aubrey Sandstone which is conformably superimposed on the Aubrey Limestone is Permeo-Carboniferous in age.

Some Fossils from the Lower Aubrey and Upper Red Wall Limestones in the Vicinity of Fort Apache, Arizona.

By Albert B. Reagan.

The Fort Apache region, Arizona, is the home of the White Mountain Apache Indians. The region, as described in the November number of the American Geologist for 1903, is included between the parallels 33° 15′ and 34° 15′, and the meridians 109° 30′ and 111°. In this region, practically all the geological ages are represented from the Archæan to recent. The Carboniferous Age, to which the fossils belong, is represented by the Aubrey and Red Wall groups of rocks. Each of these groups is separated geologically and stratigraphically into two divisions; the Aubrey into the Upper and Lower Aubrey, and the Red Wall into the Upper and Lower Red Wall. The fossils were collected from the Upper Red Wall and Lower Aubrey divisions. Those from each division were collected separately, and their exact position will be given in the description.

FUSULINA FISCHER (1837).

FUSULINA SECALICA.

Plate, Figs. 1 a, b.

White's description (in part): Shell varying from terete to subglobose, assuming all intermediate fusiform shapes, generally somewhat obtusely pointed, usually having the appearance of being slightly twisted at the ends; septal furrows moderately distinct, extending in more or less direct lines longitudinally, but are a little deflected just at the ends; centrifugal apertures about twice as high as the thickness of the cell-wall covering them, more than twice as broad as high, and of nearly uniform size throughout the whole coil.

The locular or external aperture is seldom clearly shown upon the fossils. It was apparently linear the full length of the shell until closed by a new longitudinal septum at each side, leaving only a new centrifugal aperture at the middle, in line with the others. Volutions from five to eight; septa from twenty to thirty in outer volution; septa nearly straight at their outer or external edges, but laterally undulating at their inner edges, where they join the outer surface of the next volution within, as may be seen in specimens that have had a part of their outer volution removed by weathering.

Dimensions very variable.

Position and Locality.—Strata of the Upper Red Wall, north bank of White River, twelve miles southwest of Fort Apache, Arizona. A few specimens of this species were also seen at several other places in the Fort Apache region as follows: At the crossing of the government trail on Carrixo Creek, on west bank of Cibucu Creek, one mile north of U. S. Indian farmer's residence, and on the east edge of the bluff one half mile northwest of agent's residence at White River, Arizona.

CAMPHOPHYLLUM.

[Milne-Edwards and Haime, Brit. Foss. Corals, Pl. LXVIII (1850).]

CAMPHOPHYLLUM TORQUUM.

Plate, Figs. 2 a, b, c.

Simple, usually large, conical to subcylindrical corallum, which in the case of specimens under three inches in length is usually bent or geniculated, but in larger specimens is nearly straight. Epitheca thin, with small encircling wrinkles and strong undulations of growth. Calice not seen. Septa very numerous, strictly radial in arrangement, extending about two-thirds the distance from the exterior toward the center, stout and usually straight within the outer vesicular zone, but becoming attenuated and somewhat curved or a little flexuous in crossing the vesicular area, where they alternate with an equal number of very short, thin ones. Visceral chamber filled with numerous imperfectly developed tabulæ, which pass nearly horizontally across the cavity with a more or less upward arching. Vesicular dissepiments highly developed in the periferal portion, forming numerous obliquely ascending small vesicles. Entire length unknown.

Range and Distribution.—Red Wall Group, Fort Apache, White River, Salt River, Carrixo Creek at the crossing of the government trail, and on Cibicu Creek, one mile north of the U. S. Indian farmer's residence, Arizona.

ACERVULARIA Schweigg.

ACERVULARIA DAVIDSONI Milne—Edwards and Haime.

[Pal. Foss. des Terr. Pal. P. 418, Pl. 9, Figs. 4-4 b (18—).]*

Coral composite, astræiform and massive, composed of unequally sized, usually five or six-sided corallites, having both an outer and an interior, slightly undulated or zigzag wall. The outer wall is thin; the inner wall is rarely well defined; the surface sinks, at first gradually and then abruptly, to form the cup, the diameter of which is about one-fifth of an inch. The bottom of the true calice is flat to slightly elevated. The septæ are radially arranged, and are stout and finely denticulate, there being about seven denticulations in the space of one line. They are usually about forty-two in number, and for the most part, extend into the true calice. The tabulæ are abundant in the central area; the dissepiments abundant in the periferal zone. The diameter of the larger corallites is about one-half inch.

This species is most nearly allied to A. *Profunda* Hall, from which it is distinguished by the larger size of the corallites, the greater constancy in the size of the calices, the less number and less conspicuous denticulation of the septa, and in the zigzag undulations of the outer walls.

Range and Distribution.—Devonion formation, on the government trail, four miles east of Canyon Creek, Arizona; on the John Dazen trail, three-fourths mile southeast of the cliff houses, near Oak Creek, and along the rim of the Tonto basin, Arizona; at the falls of the Ohio and at Sandusky, Ohio, etc.

CERIOCRINUS?

Plate, Fig. 3.

The specimens referred to this genus are a few detached plates and are insufficient to fully identify even the genus.

Position and Locality.—Upper Red Wall, north bank of White River Canyon, twelve miles southwest of Fort Apache, Gila County, Arizona.

ARCHÆOCIDARIS McCoy.

ARCHÆOCIDARIS.

Plate, Fig. 7.

The specimens here called *Archæocidaris* are some fragments. They are too imperfect for identification of the species; but, though much worn, are sufficient to identify the genus.

* For a figure of the fossil here described the reader is referred to plate XXX of the November number of the American Geologist for 1903.

Position and Locality.—Upper Red Wall, north side of White River Canyon, twelve miles southwest of Fort Apache, Arizona.

FENESTELLA?

Plate, Fig. 4.

Bryozoa; reverse side, branches ridged, long and generally straight; dissepiments from one-fourth to one-half the size of the branches; surface covered with a porous calcareous covering.

Position and Locality.—Upper Red Wall, near Fort Apache, Arizona.

PUGNAX HALL (1893).

PUGNAX UTA.

Plate, Figs. 8 a, b.

Meek's description: Shell small, more or less variable in form, often subtrigonial, generally wider than long, more or less gibbous; front truncated, or sometimes sinuous in outline; anterior lateral margins rounded in outline; posterior lateral margins convex or nearly straight and converging toward the beak at an angle of from 90° to 120°. Dorsal valve more convex than the other, greatest convexity near the middle or between it and the front, which has a broad, rather deep, marginal sinus for the reception of the corresponding projection of the front of the other valve; mesial fold somewhat flattened, but slightly prominent, and rarely traceable back of the middle of the valve; generally composed of three but sometimes four—rarely more—plications; side rounding down rapidly on each side of the mesial fold, and each occupied by about three or four plications; beak curving strongly beneath that of the other valve; interior with a faint linear mesial ridge, on each side of which is a raised curved line enclosing an ovate space, occupied by the abductor muscular impressions. Ventral valve distinctly less convex than the other, with a broad, shallow, short sinus, occupied by about two or three plications; anterior lateral margins on each side of sinus, with from two to four plications; beak moderately prominent, and more or less arched, rather pointed; foramen small."

Position and Locality.—Upper Red Wall, north bank of White River, twelve miles southwest of Fort Apache, Arizona.

AMBROCŒLIA Hall (1860).

AMBROCŒLIA PLANOCONVEXA Shumard.

Plate, Figs. 9 a, b, c.

White's description*: "Shell very small; breadth varying from a little more to a little less than the length; hinge-line of considerable length, but always shorter than the full width of the shell in front of it; lateral and front borders regularly and continuously rounded.

The dorsal valve would be almost circular but for its truncation by the hinge-line; nearly flat, but slightly convex at the umbo, and sometimes slightly concave at the front; beak minute, not prominent; area very narrow.

Ventral valve capacious, especially its posterior portion, which extends much behind the hinge-line, and ends in a prominent strongly incurving pointed beak; area very narrow, high, concave, mesial sinus absent, but in its place there is usually a slight flattening at the front and sometimes an indistinctly impressed line is to be seen extending from beak to front.

Surface apparently smooth, but under a lens it is seen to be finely granular, the apparent granules being the bases of minute striæ; a few concentric lines of growth are observable upon both valves."

Position and Locality.—Strata of the Upper Red Wall, north bank of White River Canyon, twelve miles southwest of Fort Apache, Arizona.

RETICULARIA McCoy (1844).

RETICULARIA PERPLEXA.

Plate, Figs. 10 a, b.

Shell ordinary size, nearly circular in outline; breadth a little more and convexity a little less than the length; hinge-line shorter than the full width of the shell in front of it; lateral and front borders regularly and continuously rounded; cardinal area distinct, arched, and moderately high.

Ventral valve convex, extending much behind the hinge-line in a prominent, strongly incurved beak; area small; mesial sinus absent, but in its place there is a slight flattening at the front and three indistinctly impressed lines are to be seen extending from front to beak. This flattening gives to the shell a slight sinuosity.

*White, U. S. Geog. Surv. W. of the 100th meridian, Vol. IV, P. 135, Pl. 3, Figs. 10 a, b, c

Dorsal valve circular in outline except where truncated by the hinge-line; regularly convex; beak less prominent than that of the other valve, extending beyond the hinge-line; area very narrow.

Surface marked by very numerous almost indistinct radiating costæ and by somewhat strong concentric markings.

Position and Locality.—Upper Red Wall Group, north bank of White River Canyon, twelve miles southwest of Fort Apache, Arizona.

DIELUSMA King (1859).

DIELUSMA BOUVIDINES (Morton).

Pla'e, Fig. 11.

White's description (in part)*: Shell ovate or elongate-ovate in outline; sides behind the middle laterally compressed. Ventral valve strongly arcuate from front to beak, the curvature being greatest behind the middle, rather more capacious than the other valve; beak prominent, incurved; foramen moderately, not squarely, truncating the beak, but opening obliquely backward, mesial sinus broad, and more or less distinct at the anterior part of the valve, but becoming obsolete at or behind the middle. Dorsal valve generally almost straight along the median line from front margin to a little behind the middle, from which part it gently curves to the beak; gently and somewhat uniformly convex from side to side, without a mesial fold.

Surface nearly smooth; shell structure finely punctate.

Position and Locality.—Upper Red Wall Group, Fort Apache, Arizona.

SEMINULA McCoy (1844).

SEMINULA ARGENTIA Shepard.

Plate, Figs. 12 a, b, c, e.

Shell varying considerable in outline, generally subovate; seldom as wide as long, usually moderately gibbous, but sometimes old shells are much inflated. Ventral valve generally a little more capacious than the dorsal; beak rather prominent, incurved; mesial sinus usually not very deep, and becoming obsolete about the middle.

---

*U. S. Geog. Surv. W. of the 100th meridian, Vol. IV, P. 144, Pl. XI, Figs. 10 a, b, c.

Dorsal valve somewhat uniformly convex, but most prominently so near the umbo; beak small, slightly prominent, mesial fold entirely wanting as a rule. Surface marked by faint traces of radiating striæ and by occasional imbricating lines of growth.

Range and Distribution.—Upper Red Wall group and Lower Aubrey: Carrixo Creek, at the confluence of White and Black rivers, and on either side of White River in Maricopa County, and at Fort Apache and at Jemez, New Mexico, White River, Arizona, etc. Common throughout the upper carboniferous of America and in England and India in the sub-carboniferous also. Its range also extends into the Permian.

MYALINA de Konnick, 1844.

MYALINA?

Plate, Fig. 13.

The specimen here figured in outline is too badly crushed to warrant a description, but is obviously a member of the genus Myalina.

Position and Locality.—Upper strata of the Upper Red Wall, south side of White River Canyon, one mile west of Fort Apache, Arizona.

EUOMPHALUS Sowbery (1815).

EUOMPHALUS PERNODOSUS Meek and Worthen.

Plate, Figs. 14 a, b, c, e

White's description* (in part): "Shell rather above medium size when full grown, nearly discoidal, the spire being only very slightly elevated, and the inner portion of it being quite flat, or evenly depressed. Test thick, volutions five or six, the upper side flattened and sloping gently inward to the distinct suture, outer side flattened, convex, under side rounding; the angles formed by the upper and outer sides constitute a distinct carina which is rugose or corrugated upon the outer volution; upon the under side of the volutions there is a row of moderately large, rounded nodes, separated by spaces of about their own width, those of the last half of the outer volution being obsolete;" umbilicus not seen.

*U. S. Geog. Surv. W. of the 100th meridian, Vol. IV, P. 158, Pl. 12, Figs. 2 a, b, c.

PLATE EXPLANATION.

Fig. 1. Fusulina secalica..
- 1 a. A specimen showing the septal furrows and the centrifugal aperture.
- 1 b. Some weathered specimens.

Fig. 2. Camphophylum torquum....................................
- 2 a. Longitudinal view of a portion of a coral.
- 2 b. Cross section.
- 2 c. A longitudinal section showing tabulæ.

Fig. 3. Some crinoid plates..

Fig. 4. Fenestella ? ....

Fig. 5. ? Rhombopera ? ....

Fig. 6. Hemeitrypa ?..

Fig. 7. Archæocidaris spines......   ....

Fig. 8. Pugnax uta ....
- 8 a. Ventral valve.
- 8 b. Dorsal valve.

Fig. 9. Ambocælia planoconvexa ....
- 9 a. Dorsal view.
- 9 b. Ventral view.
- 9 c. Side view.

Fig. 10. Reticularia perplexa ....
- 10 a. Ventral valve.
- 10 b. Dorsal valve.

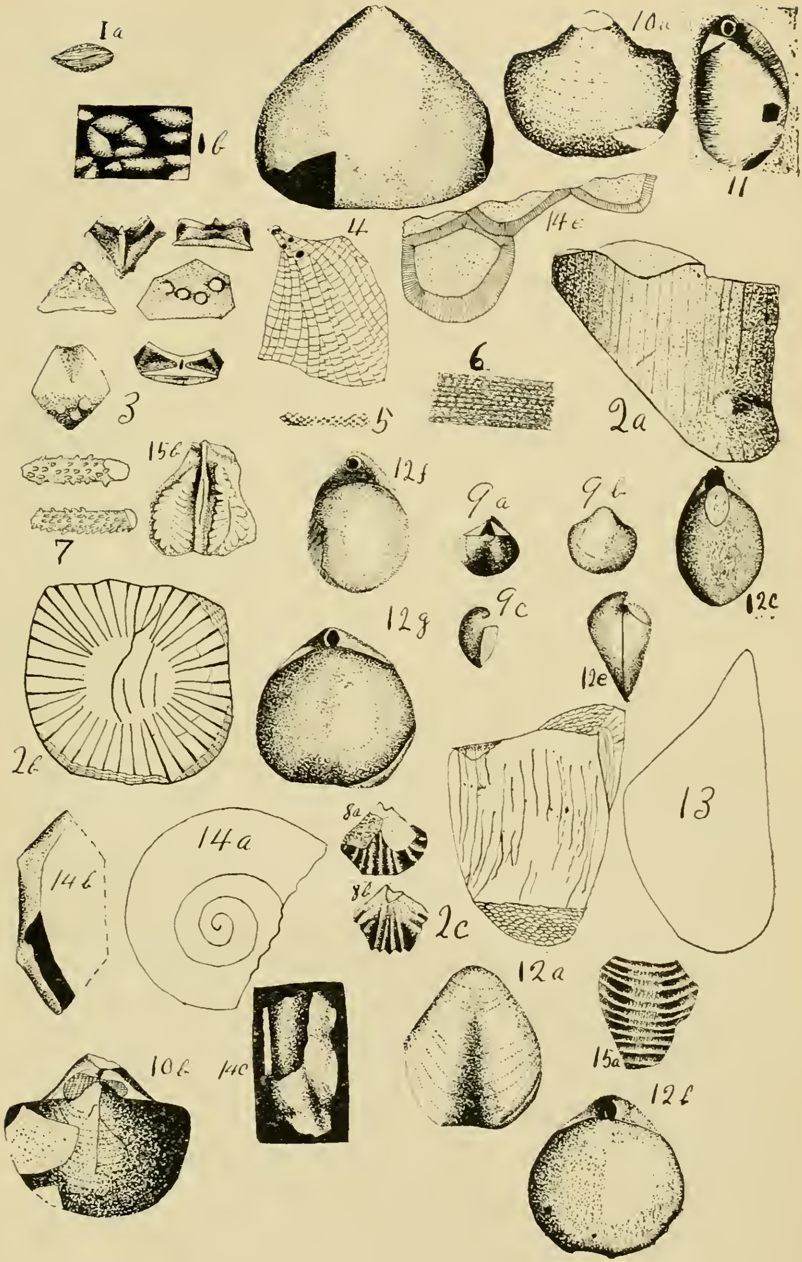
Fig. 11. Dielasma bovidines, dorsal view...........................

Fig. 12. Seminula argentia ....
- 12 a. Ventral valve showing sinus.
- 12 b, f and g. Dorsal views.
- 12 c. Dorsal view of a young specimen.
- 12 e. Side view.
- 12 m. An old specimen.

Fig. 13. Myalina ? Outline only....................................

Fig. 14 a, b, c, e. Fragments of an Euomphalus pernodosus...........

Fig. 15. Productus punctatus ....
- 15 a. A portion of the dorsal valve.
- 15 b. Inside of dorsal valve, showing muscular impressions.


1a
1b
4
10a
11
14e
2a
3
5
6
15b
7
12f
9a
9b
12c
9c
12g
12e
2b
13
8a
14a
14b
8b
2c
12a
15a
10b
14c
12b

Position and Locality.—In limestone strata at top of the lower Aubrey group, Aubrey Cliff, one mile northeast of White River, and at the crossing of the government trail on Carrixo Creek, Arizona.

CALAMARIÆ.

CALAMITES.

CALAMITES CANNÆFORMIS.

Long, slender, tapering reed-like stem, jointed and having a large pith. Its exterior surface is finely striated, but the striæ are not continuous, but are interrupted at the joints by a "break." The striæ on each side of said "joint break" correspond to each other. Each stria has a small pinhead-like projection on it near its upper extremity. The bark which was left in the cast is about 1-132 of an inch in thickness. It seemed to be fibrous. The striæ impressions and the grooves between the striæ which were filled with the bark tissue show very distinctly, the latter being ridges on the inside of the bark, the former depressions. The leaves were strap-like (?) the stem is flattened and in its longer diameter, three feet above the ground it exceeded five inches. At its lower end the joints grow rapidly smaller and shorter, so that this end is conical, but so curved as to represent a dog's tearing tooth. From these lower tapering joints came out the small roots which nourished this peculiar tree and which were still found imbedded in the clayey stratum by the writer. The top of the stem was not found but it most likely was cone-like.

Habitat.—West of Cibicu Creek and one mile north of the Phœnix-Fort Apache trail, Arizona. The specimen above described was found imbedded in a shaley white sandstone, underlaid with a thin stratum of clay, into which the lower part of the above-mentioned tree extended. The location is on the east side of the mesa to the west of the aforementioned Cibicu Creek, and about 42 feet below its summit.*

*The specimen here described was sent to the university at Albuquerque, N. M., and is now in the collection there.

The Sun or Gunelpiya Medicine Disk.

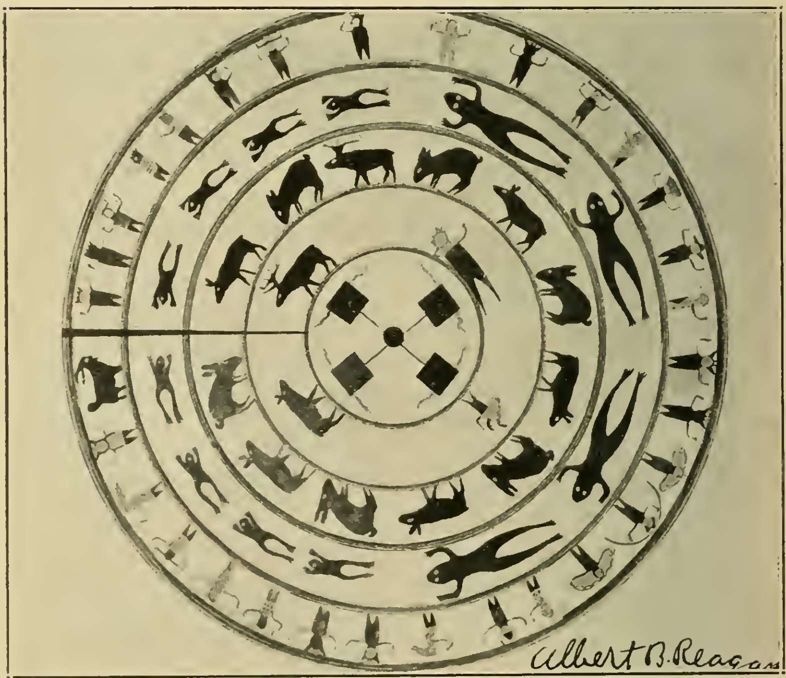
By Albert B. Reagan.

This disk is used as a last resort in the Apache medicine ceremonies. It is drawn on a leveled, sanded spot of ground some sixteen feet in diameter. The materials used in painting the figures are obtained as follows: The green is ground up leaves; the red, ground up sandstone; the yellow ground up limestone; the black, powdered charcoal. The rings separating the concentric spaces are rainbow circles. The central figure is the sun, and the squares associated with the sun are the medicine blocks. The first and second concentric spaces from the central area represent land; the space in which the frogs are swimming, water; and the outer concentric space, the abode of the gods.

This drawing is an Apache prayer in an elaborate form. In it they have all the gods of the universe represented, and on the mercy of these gods they throw the patient. As has been stated this is a last resort. The gods can either make the sick one well or take him to themselves, that is, to the Happy Hunting Ground.

When this drawing is completed, which is always at about four o'clock in the afternoon of the same day in which it was commenced, the patient is carried and placed on the central figure with face toward the evening sun. A medicine dancer wearing a ghost hat then enters the medicine circle, and, carrying a bowl partly filled with water in one hand, he takes a pinch of dust from each of the representative figures and puts it into the bowl. Having completed his dust-gathering, he proceeds to the sick one and daubs him all over with the muddied water. This being completed, he sends a hissing breath through his hands, thus expelling sick to the four quarters of the earth. He then leaves the medicine circle and gallops off into obscurity. When he has departed the chief medicine man, after sprinkling the patient with cattail flag pollen as he prays to the gods, takes up the bowl of muddied water left by the ghost dancer, and daubs the patient as the ghost dancer had daubed him before, while those present chant a medicine song to the gods. When he has completed his task, the oldest woman present takes the muddied bowl and continues the daubing process. Her act completes the ceremony. The sick one is then carried from the scene and all who wish, gather dust from the representatives of the gods and put it into some containing receptacle, usually a tobacco sack. The dust gathering being completed, the medicine disk is at once obliterated. It must be made, used, and destroyed in a day.

On the night following the Gunelpiya medicine disk performances, the ghost dance is given for the benefit of the sick one. The next day the patient usually dies.



The Sun or Gunelpiya Medicine Disk.

The Fossils of the Red Wall Compared with Those of the Kansas Coal Measures.

By Albert B. Reagan.

For the purpose of definitely determining the age of the upper half of the Red Wall limestone of the Rocky Mountains the writer has prepared the following tabulated comparison of the fossils of that series of rocks with those of the Kansas Coal Measures. The Kansas fossils were taken from Dr. J. W. Beede's Carboniferous Invertebrates of Kansas (Univ. Geol. Surv. of Kansas, vol. VI, pp. 1-187, plates 1-22). Some of the Upper Red Wall fossils were identified by Prof. Meek (see Gilbert's Report, U. S. Geog. Surv. w. of the 100th meridian, vol. III, p. 178); some by Prof. White (see White's Report in vol. IV, U. S. Geog. Surv. w. of the 100th meridian); the others by the writer, under the direction of Dr. Beede of the University of Indiana. The fossils identified by Meek are marked (1), those by White (2).

RED WALL FOSSILS.	KANSAS FOSSILS.
Fusulina secalica.	Fusulina secalica.
	Anolopra anna.
Camphophyllum torquum.	Camphophyllum torquum.
	Limopteria alata.
	Trachypora austini.
Archæocidaris ?	Archæocidaris agassiz.
Archæocidaris tudifer.[1]	Archæocidaris tudifer.
Derbya ?	Derbya bennetti.
Derbya crassa.	Derbya crassa.
	Derbya cymbula.
	Derbya biloba.
Derbya Kuokuk.	Derbya Kuokuk.
Derbya affinis.	
	Chonetes granulifer.
Chonetes mesolobus.[1]	Chonetes mesolobus.
	Chonetes glaber.
	Chonetes vernemlianus.
	Productus pertenius.
	Productus symmetricus

Productus nebrascensis.	Productus nebrascensis.
Porductus costatus.[1] [2]	Productus costatus.
	Productus longispinus.
Productus semi-reticulatus.[2]	Productus semi-reticulatus.
Productus prattenianus.[1]	Productus cora.
Productus. ?	Productus sp.*
Productus, like P. portlockienus.	
Reticularia perplexa.	Reticularia perplexa.
Ambocœlia planoconvexa.	Ambocœlia planoconvexa.
Spirifera kentuckensis.	Spiriferina kentuckyensis.*
Hemipronites crinistria.	
Hemipronites crassus.[2]	
Spirifer cameratus.	Spirifer cameratus.
	Enteletes hemiplicata.
Pugnax uta.	Pugnax uta.
	Pugnax rockymontana
Meekella striatacostata.	Meekella striatacostata.
	Aviculopecten hertzeri.
	Aviculopecten providencensis.
	Aviculopecten sculptilis.
Aviculopecten interlineatus.[1] [2]	Aviculopecten interlineatus.
Aviculopecten occidentalis.	Aviculopecten occidentalis.
	Aviculopecten carboniferus.
	Aviculopecten McCoyi.
	Aviculopecten germanus.
Aviculopecten ?	Aviculopecten sp.*
Monoteria mariam.[1]	Limopteria mariam.
Myalina sp.	Myalina sp.
Myalina (?) swallovi.[1]	Myalina swallovi.
Nuculana (?).	Nuculana bellistriata.
Schizodus (?)[1] sp.	Schizodus wheeleri.
	Schizodus hari.
Rhombopora sp.	Rhombopora lepidodendroides.
Fenestella shumardi.[1]	Fenestella shumardi.
Fenestella sp.	Fenestella sp.
Polypora stragulata.[1]	Polypora sp.
Glauconome nereides.	Pinnatopora tenuilineata.
Synocladia biseralis.	

Fistulipora nodulifera.	Fistuipora nodulifera.
Modiola (?) ?	Modiola sulbelliptica.
Murchisonia sp.	Murchisonia sp.
Platysomus[2] sp.	
Phillipsia[2] sp.	Phillipsia sp.*
Nautilus occidentalis.	Nautilus planovolvis.
Euomphalus (like E. nodosus).[2]	Euomphalus sp.*
Euomphalus pernodosus.	Euomphalus pernodosus.*
Macrocheilus[2] sp.	
Pleurotomeria[2] sp.	Pleurotomeria tabulata.
	Pleurotomeria sp.
Bellerophon crassus.	Bellerophon crassus.
Dielasma bovidines.	Dielisma bovidines.
Seminula argentia.	Seminula argentia.

Of the 36 genera of the Upper Red Wall tabulated above, 32 are represented in the fossils of the Kansas Coal Measures, and of the 32 species identified 26 are identical. The tabulated comparison, therefore, determines the age of the Upper Red Wall of Arizona to be practically the same as that of the Kansas Coal Measures.

NOTE.—The species and genera marked (*) were taken from Bulletin 211 of the U. S. Geological Survey. Some of the other Kansas species (not marked) were taken from Dr. Beede's Report, Kansas University Science Bulletin, Vol. I. No. 7. September, 1902.

NOTICE.

Owing to the limitations of the appropriation and the length of the paper, it was found necessary to defer until 1904 the publication of the paper described below:

ECOLOGICAL NOTES ON THE BIRDS OCCURRING WITHIN A RADIUS OF FIVE MILES OF THE INDIANA UNIVERSITY CAMPUS.

BY WALDO LEE MCATEE.

With Photographic Illustrations by CLARENCE GUY LITTELL.

INDEX.