

Overview of Animal Diversity - Invertebrates

Read: Text ch 32 & 33

Bullet Points:

- some properties of animals
- symmetry & cephalization
- body plans & body cavities
proto- & deuterostomes
- selected phyla:
 - Sponge Bob and friends
 - sponges
 - cnidaria – jellyfish
 - platyhelminthes – flat worms
 - rotifers
 - ectoprocts & brachiopods
 - mullusca - snails, squid etc.
 - annelida – fishing worms
 - nematoda – round worms
 - arthropoda – crabs, spiders, insects etc.
 - echinodermata – starfish (secondarily radial)
 - chordata – some of your best friends



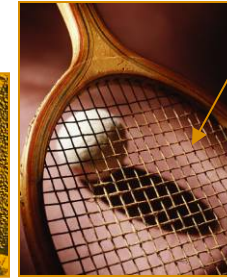
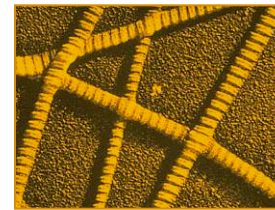
What is an Animal?

Animals (Metazoa). 1

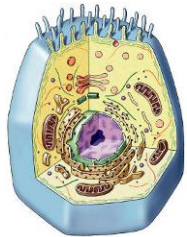


that ingest food

collagen ('gut') is most abundant protein in vert. body



2. Cells a) **lack cell walls** (ch 6)

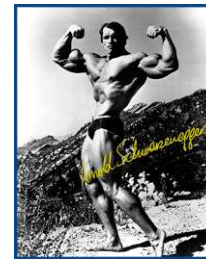


b) supported by **extracellular matrix**: (fig 6.30) proteoglycans, glycoproteins, integrin & **collagen**

c) (except Porifera)

3. Nervous tissue & muscle tissue

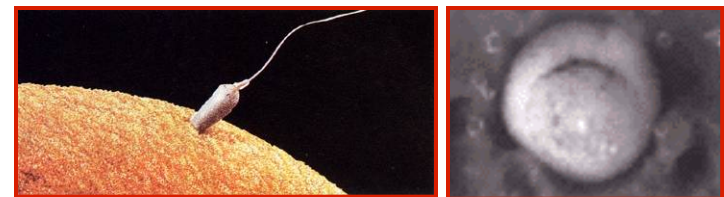
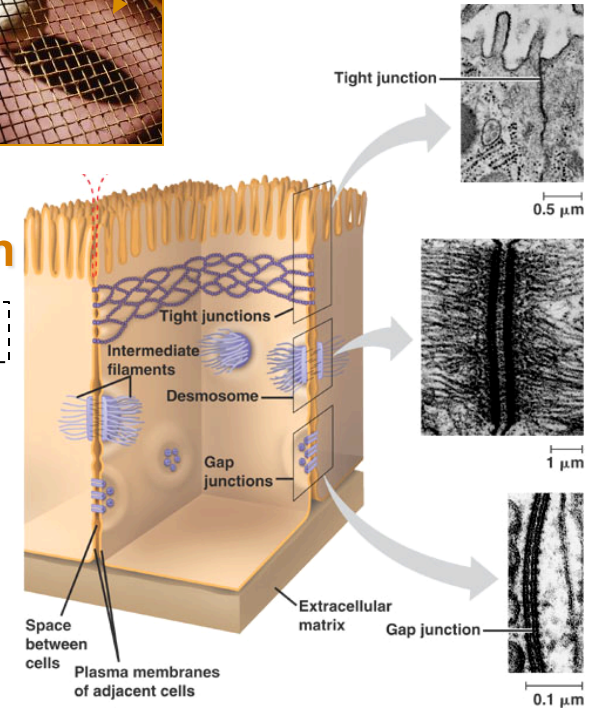
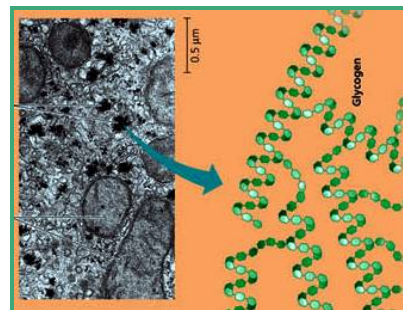
(except sponges)



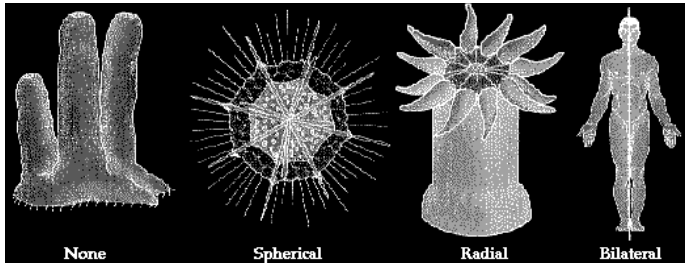
4. Life history (mostly):

sexual w/ small flagellated sperm & large immobile egg; cleavage, blastulation, **gastrulation** ... Fig 31.2:

+ **Glycogen**: carbohydrate store (like fungi) Fig. 5.6:



Body plans: Symmetry



Most animals that move actively are **bilateral**.

Bilateral symmetry is associated with



adult echinoderms lose juvenile bilateral symmetry

on the cephalic {head} end, that is usually first to encounter food, danger, and other stimuli.

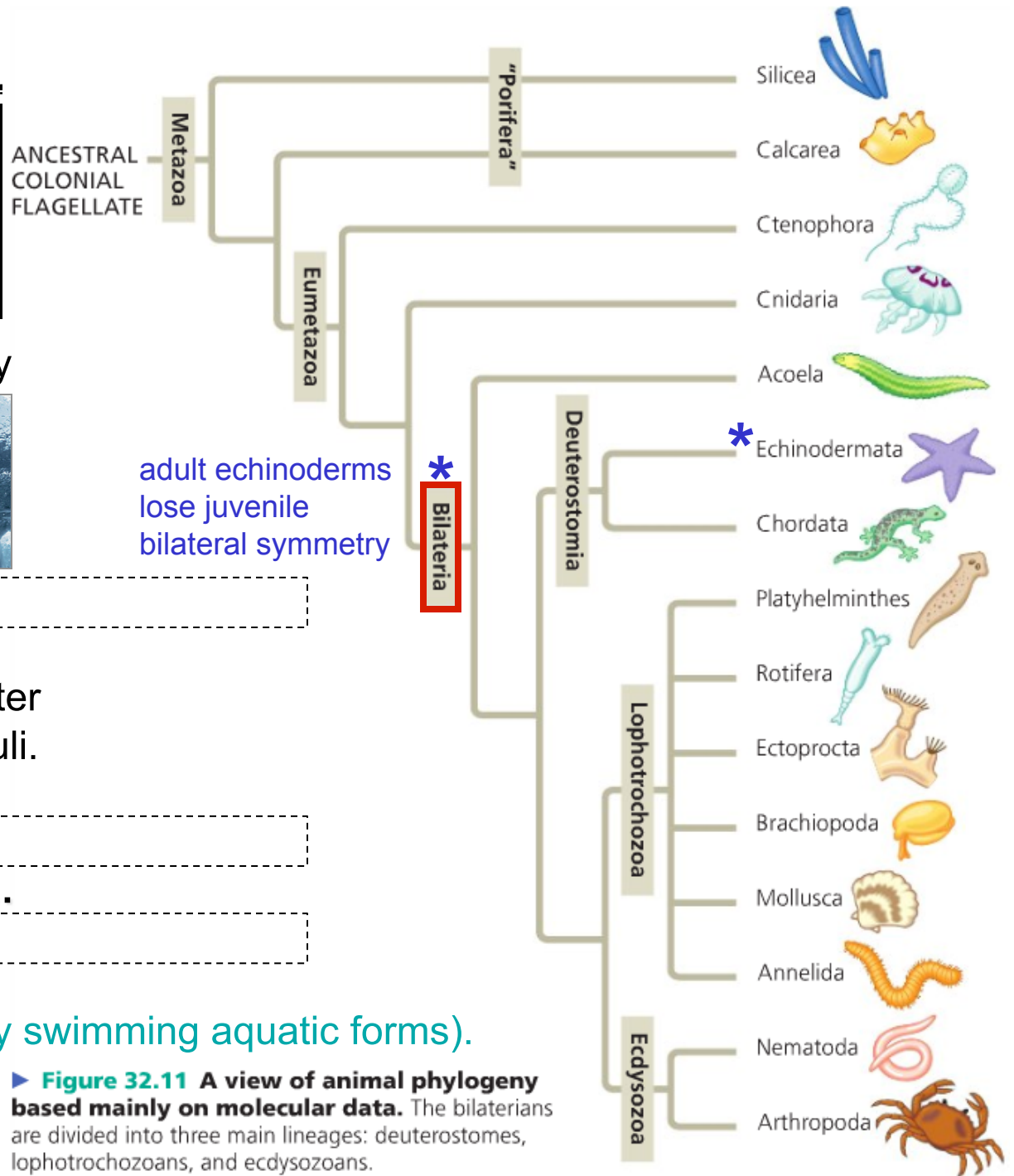
Cephalization also includes

concentrated in the head ...

(attached to a substratum)

or plankton (drifting or weakly swimming aquatic forms).

They meet the environment equally well from all sides.

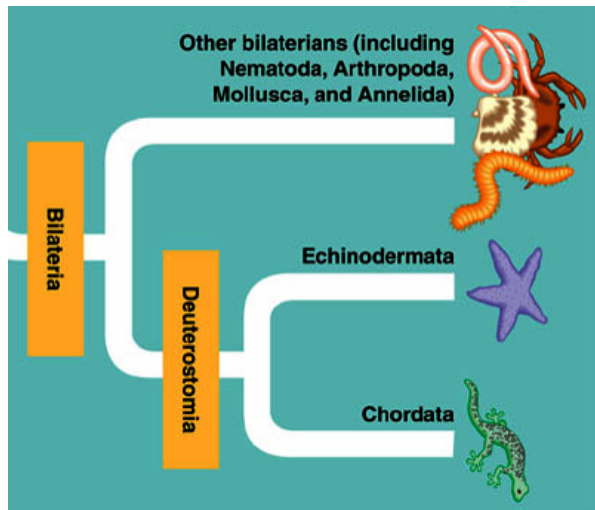


► **Figure 32.11 A view of animal phylogeny based mainly on molecular data.** The bilaterians are divided into three main lineages: deuterostomes, lophotrochozoans, and ecdysozoans.

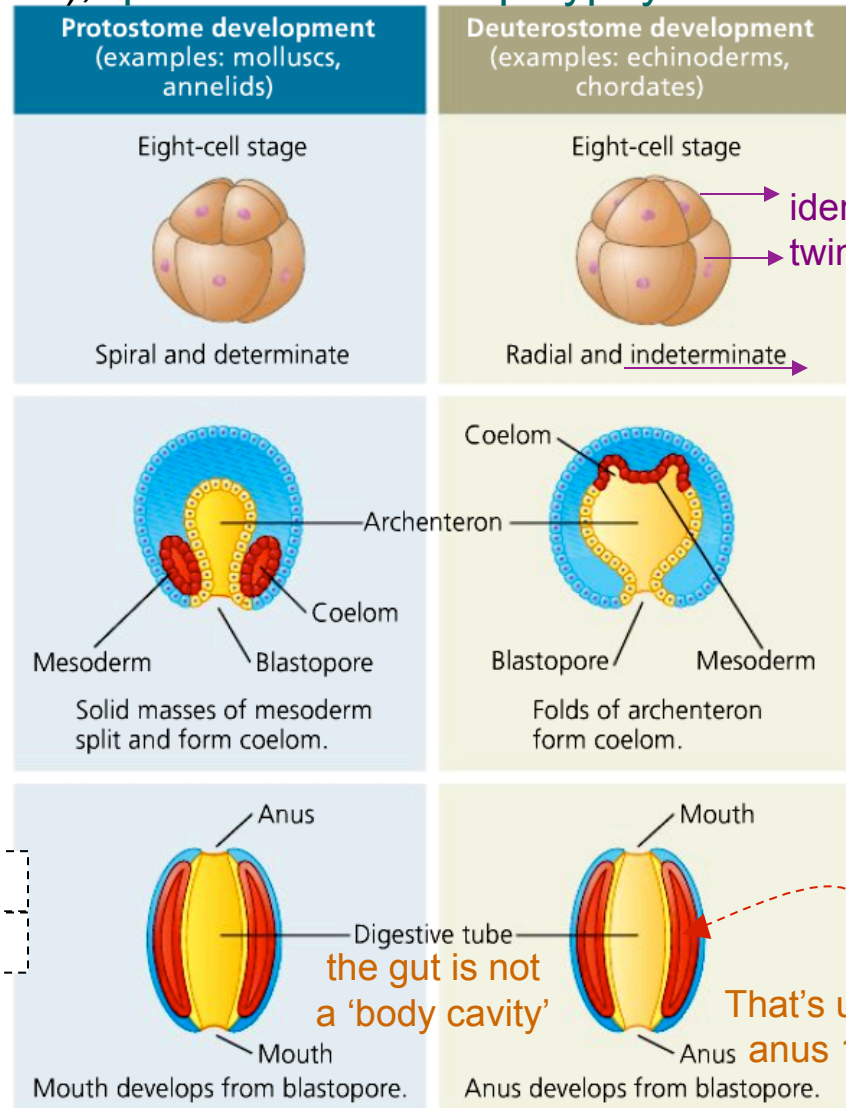
Patterns of development in bilateria: "Protostomes" vs Deuterostomes

in the modern molecular phylogeny (Fig 32.12), "protostomes" are polyphyletic

► **Figure 32.9 A comparison of protostome and deuterostome development.** These are useful general distinctions, though there are many variations and exceptions to these patterns.



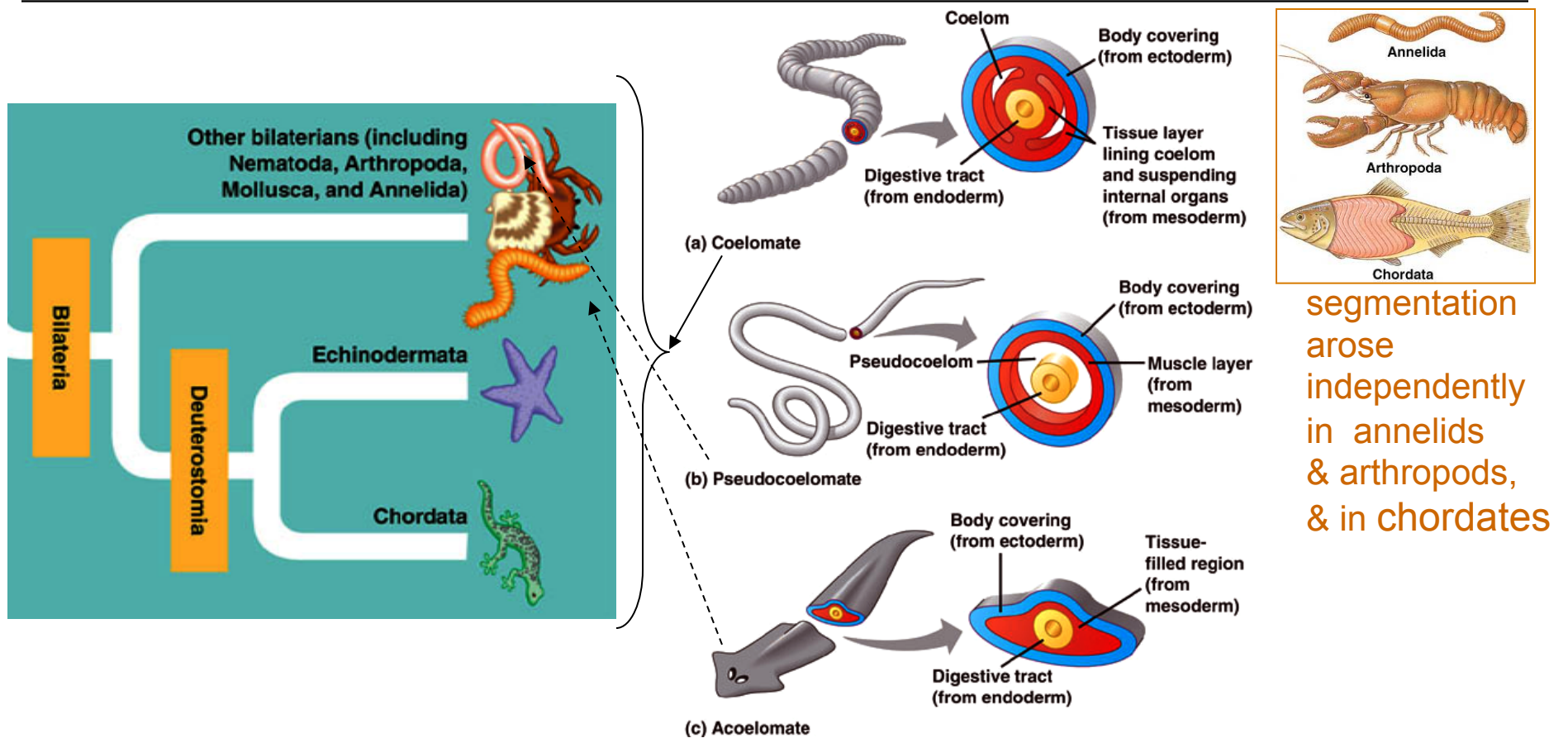
Key
 Blue: Ectoderm
 Red: Mesoderm
 Yellow: Endoderm



so you should understand deuterostome development & structure

That's us – anus 1st
 a coelom is

Patterns of development in bilateria: **Body Cavities**



The molecular-based phylogeny (Fig 32.11) suggests that

the bilateral animals are a












{coelom is shared derived trait in bilateria clade}

Bilaterians lacking coeloms (**acoelomates** - *flatworms*)

& those w/ **pseudocoeloms** (not completely lined by mesoderm - *roundworms*)

evolved secondarily from coelomates.

Selected Animal Phyla

Key Concept	Phylum	Description
Concept 33.1 Sponges are basal animals that lack true tissues (pp. 670–671)	Calcarea, Silicea (sponges)	 Lack true tissues; have choanocytes (collar cells—flagellated cells that ingest bacteria and tiny food particles)
Concept 33.2 Cnidarians are an ancient phylum of eumetazoans (pp. 671–673)	Cnidaria (hydras, jellies, sea anemones, corals)	 Unique stinging structures (nematocysts) housed in specialized cells (cnidocytes); diploblastic; radially symmetrical; gastrovascular cavity (digestive compartment with a single opening)
Concept 33.3 Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms (pp. 674–682)	Platyhelminthes (flatworms)	 Dorsoventrally flattened, unsegmented acoelomates; gastrovascular cavity or no digestive tract
	Rotifera (rotifers)	 Pseudocoelomates with alimentary canal (digestive tube with mouth and anus); jaws (trophi) in pharynx; head with ciliated crown
	Lophophorates: Ectoprocta, Brachiopoda	 Coelomates with lophophores (feeding structures bearing ciliated tentacles)
	Mollusca (clams, snails, squids)	 Coelomates with three main body parts (muscular foot, visceral mass, mantle); coelom reduced; most have hard shell made of calcium carbonate
	Annelida (segmented worms)	 Coelomates with segmented body wall and internal organs (except digestive tract, which is unsegmented)
Concept 33.4 Ecdysozoans are the most species-rich animal group (pp. 683–692) MEDIA Investigation How Are Insect Species Identified?	Nematoda (roundworms)	 Cylindrical, unsegmented pseudocoelomates with tapered ends; no circulatory system; undergo ecdysis
	Arthropoda (crustaceans, insects, spiders)	 Coelomates with segmented body, jointed appendages, and exoskeleton made of protein and chitin
Concept 33.5 Echinoderms and chordates are deuterostomes (pp. 693–695) MEDIA Activity Characteristics of Invertebrates	Echinodermata (sea stars, sea urchins)	 Coelomates with bilaterally symmetrical larvae and five-part body organization as adults; unique water vascular system; endoskeleton
	Chordata (lancelets, tunicates, vertebrates)	 Coelomates with notochord; dorsal, hollow nerve cord; pharyngeal slits; post-anal tail (see Chapter 34)

Metazoa

Eumetazoa

Bilateria

Lophotrochozoa

Ecdysozoa

Deuterostomia



Monophyletic origins of the metazoa:

an evolutionary link with fungi.

Wainright et al. *Science* 1993 Apr 16;260(5106):340-2

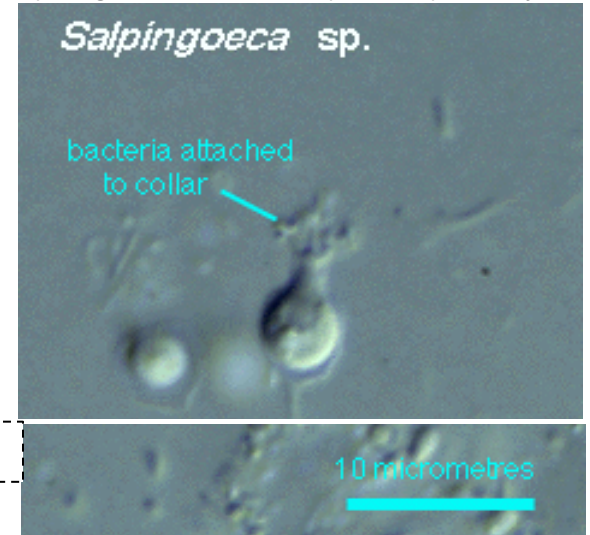
... comparisons of small subunit ribosomal RNA sequences describes the evolutionary origin and early branching patterns of the kingdom Animalia.

From these data, it was inferred that

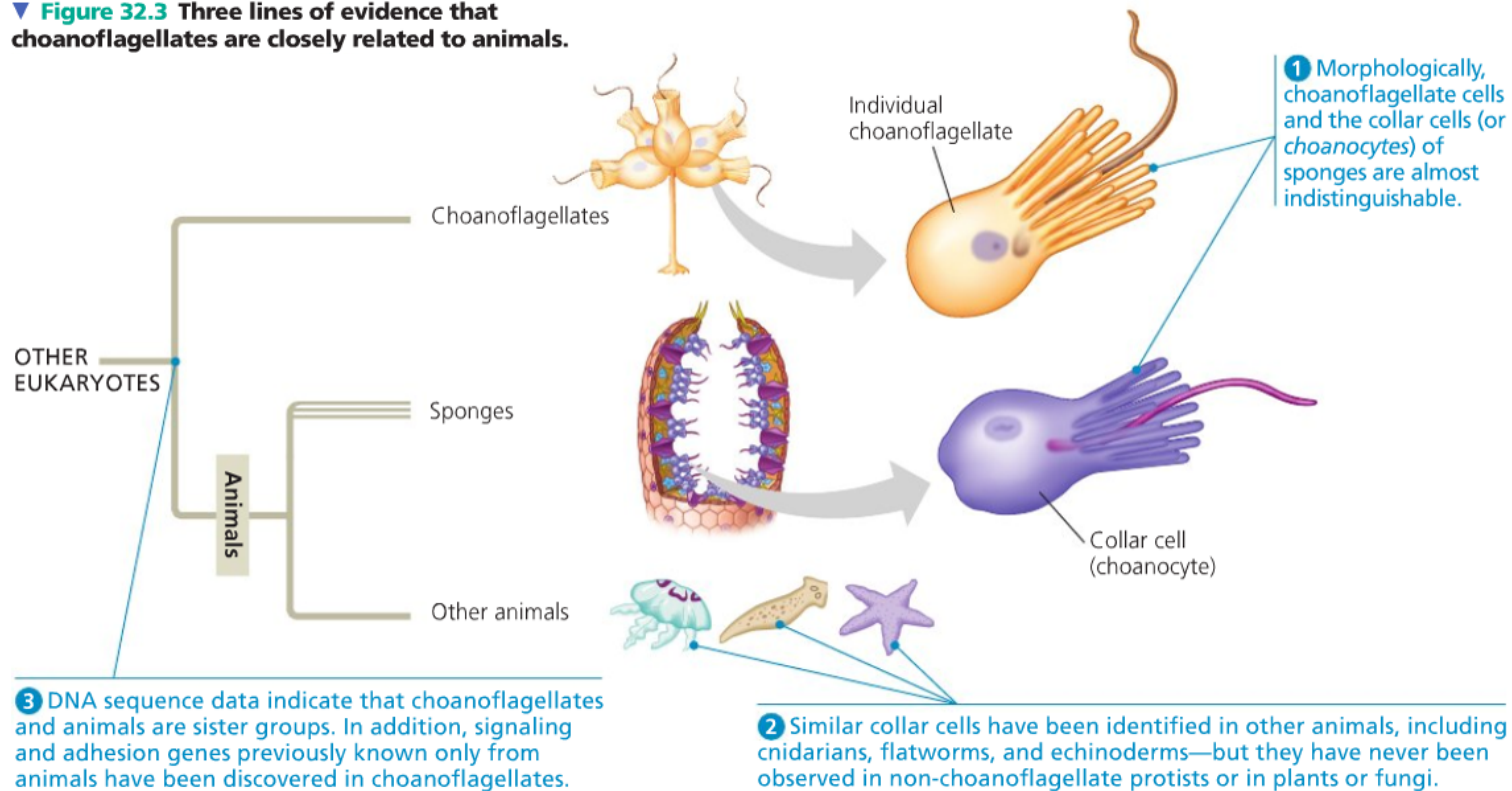
animals

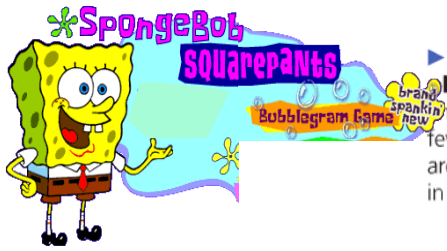
and that their last common ancestor

was a flagellated protist similar to extant choanoflagellates.

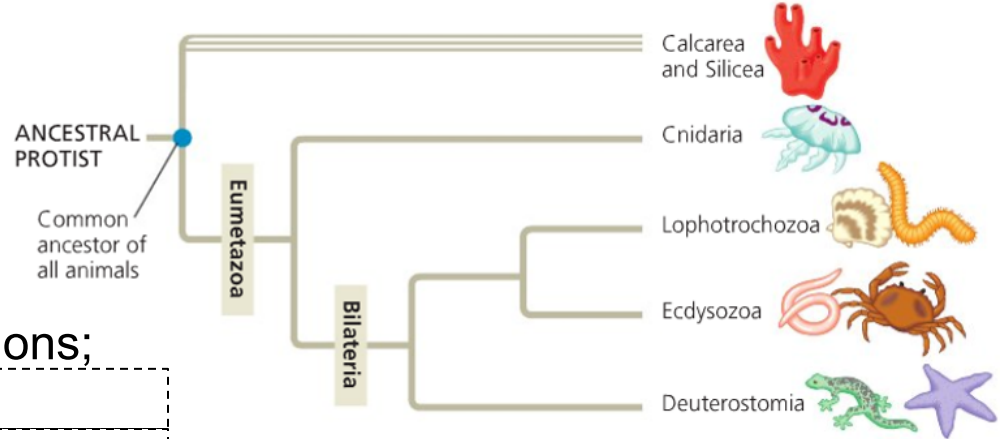


▼ **Figure 32.3** Three lines of evidence that choanoflagellates are closely related to animals.





▶ **Figure 33.2 Review of animal phylogeny.** Except for sponges (basal animals in phyla Calcarea and Silicea) and a few other groups, all animals have tissues and are in the clade Eumetazoa. Most animals are in the diverse clade Bilateria.



Sponges have only a few cell types differentiated to perform specialized functions;



Azure vase sponge (*Callyspongia plicifera*)

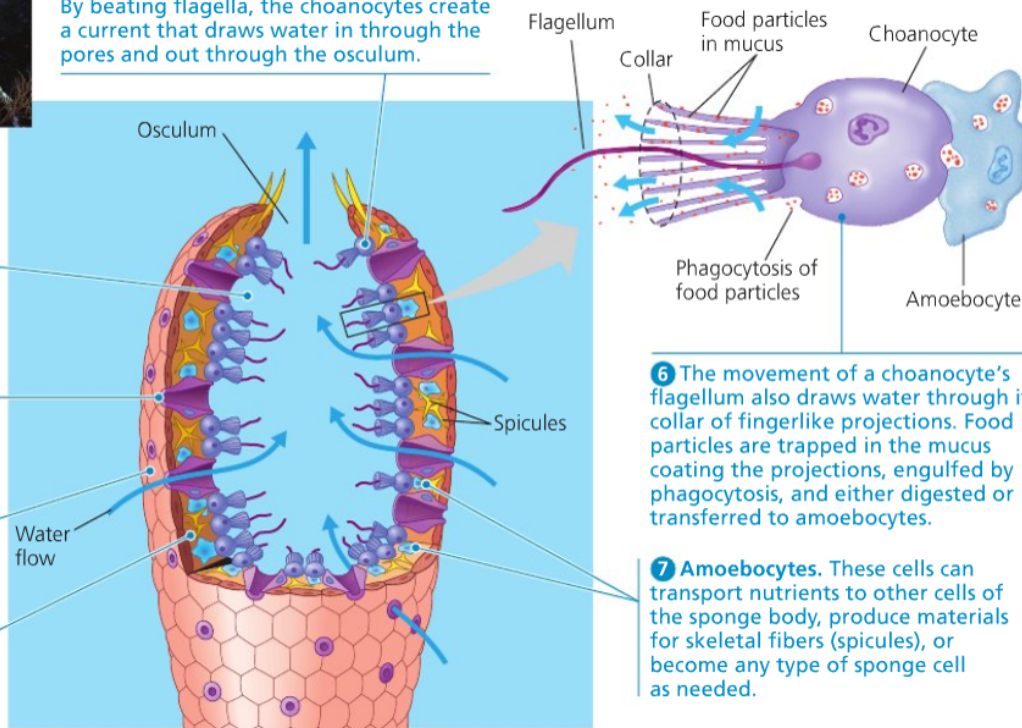
5 **Choanocytes.** The spongocoel is lined with flagellated cells called choanocytes. By beating flagella, the choanocytes create a current that draws water in through the pores and out through the osculum.

4 **Spongocoel.** Water passing through pores enters a cavity called the spongocoel.

3 **Pores.** Water enters the epidermis through pores formed by doughnut-shaped cells that span the body wall.

2 **Epidermis.** The outer layer consists of tightly packed epidermal cells.

1 **Mesohyl.** The wall of this sponge consists of two layers of cells separated by a gelatinous matrix, the mesohyl ("middle matter").



6 **The movement of a choanocyte's flagellum also draws water through its collar of fingerlike projections. Food particles are trapped in the mucus coating the projections, engulfed by phagocytosis, and either digested or transferred to amoebocytes.**

7 **Amoebocytes.** These cells can transport nutrients to other cells of the sponge body, produce materials for skeletal fibers (spicules), or become any type of sponge cell as needed.

Most sponges are sequential hermaphrodites,



and can reproduce asexually by breaking off clones

▲ **Figure 33.4 Anatomy of a sponge.**

Genome of Ancient Sponge Reveals Origins of First Animals, Cancer

In a paper appearing in the August 5 (2010) issue of the journal Nature, researchers ... report the draft genome sequence of the sea sponge *Amphimedon queenslandica* and several insights the genome gives into the origins of both the

All living animals are descended from the common ancestor of sponges and humans, which lived more than 600 million years ago.

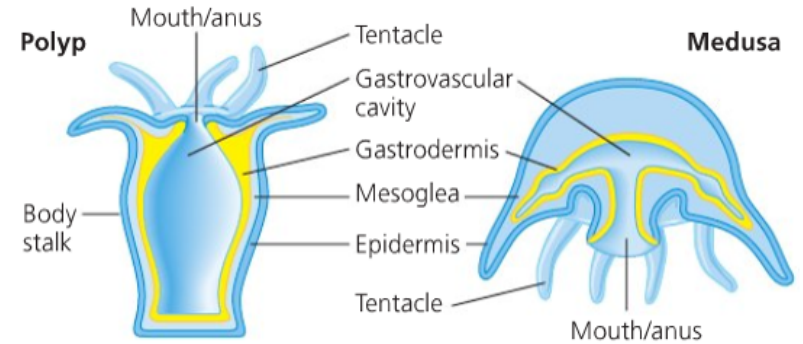
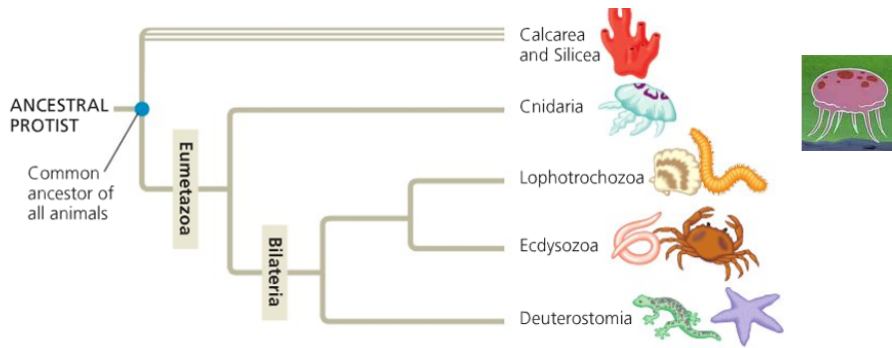
"Our hypothesis is that ... **If you are a cell in a multicellular organism, you have to cooperate with other cells in your body, making sure that you divide when you are supposed to as part of the team.**

The **genes that regulate this cooperation are also the ones whose disruption can cause cells to behave selfishly and grow in uncontrolled ways to the detriment of the organism.**"

the team looked in the sponge genome for more than 100 genes that have been implicated in human cancers and found about 90 percent of them.

Future research will show what roles these genes play in endowing sponge cells with team spirit.

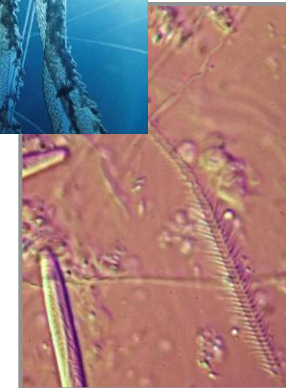
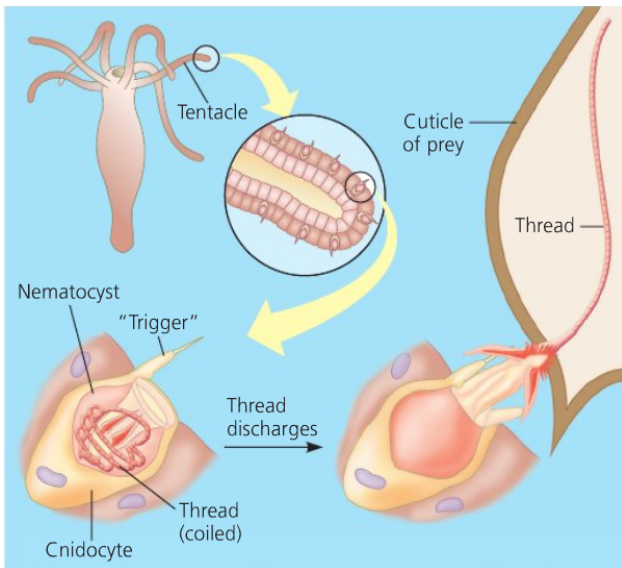




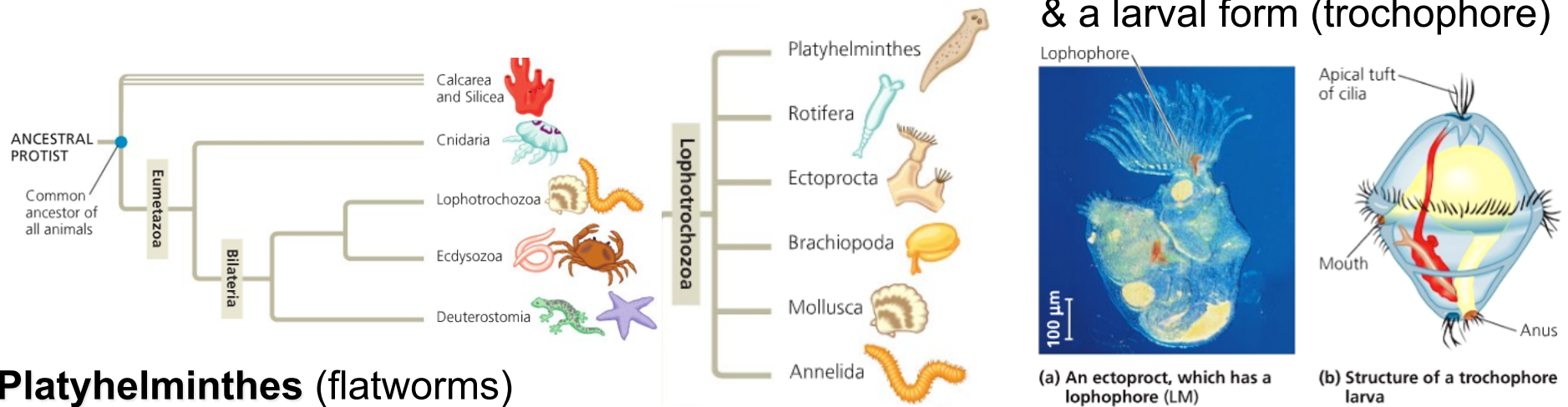
▲ **Figure 33.5 Polyp and medusa forms of cnidarians.** The

Cnidaria are exclusively aquatic,
radially symmetrical,
 w/ **true tissue** sheets,
 uncephalized (no head w/ brain)

with a single body opening, the mouth; the gut is not a 'body cavity' inside mesoderm.
polyps such as hydra, anemones & corals {*mouth up*}.
medusae such as jellyfish {*mouth down*},



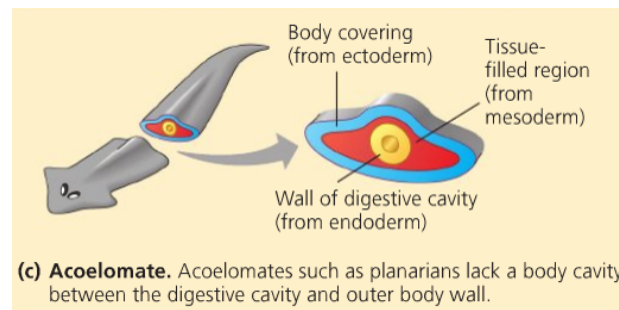
Lophotrochozoa is a clade identified by molecular data;
 the name comes from a ciliated feeding structure (lophophore)
 & a larval form (trochophore)



Platyhelminthes (flatworms)

The simplest animals that are:

They are NOT Deuterostomes
 have **no body cavity** {acoelomate}
 and **lack an anus**; {guess they're protostomes!}
 the mouth takes in food and expels waste.



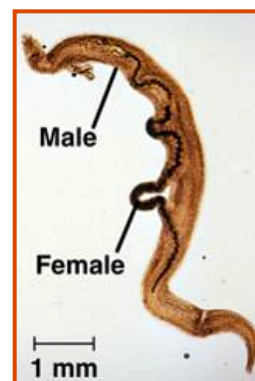
a) Non-parasitic
 Tubellarians:
 Freshwater
 Planeria



Marine
 flat worms

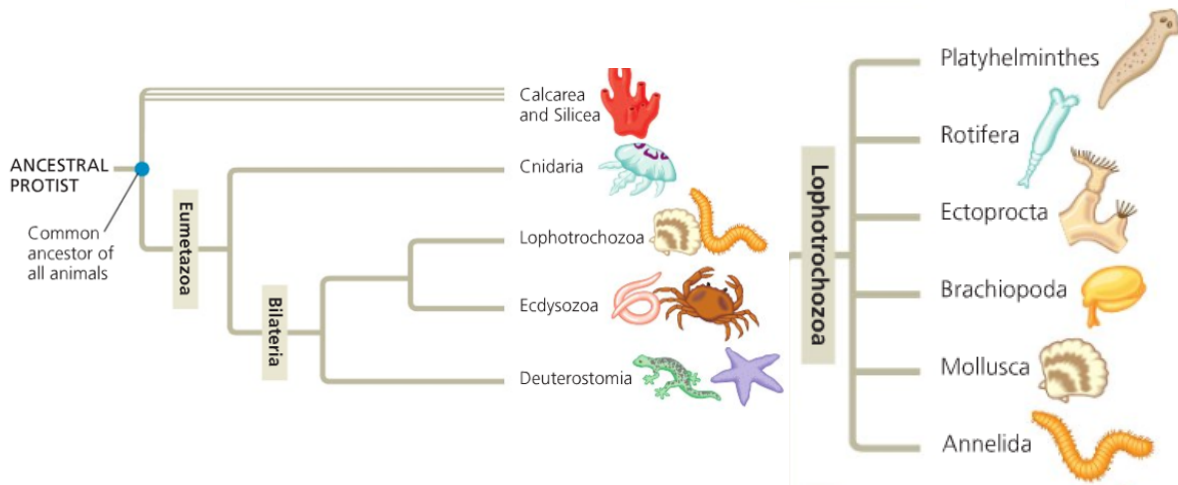


c) Trematode
 b) Monogenean flukes
 fish parasites:



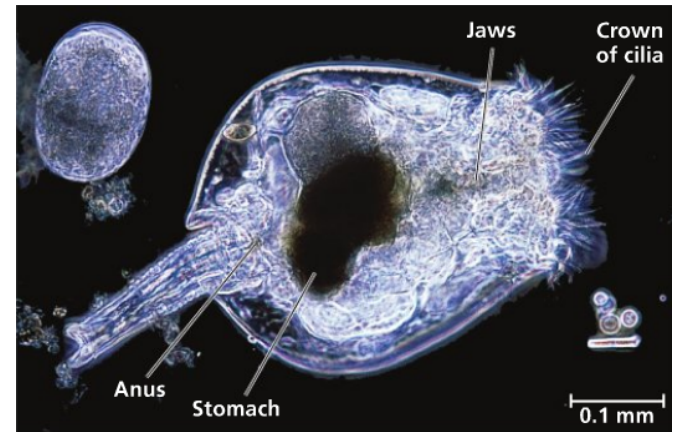
d) Cestode
 tapeworms:





Rotifers are tiny aquatic animals with an anus!

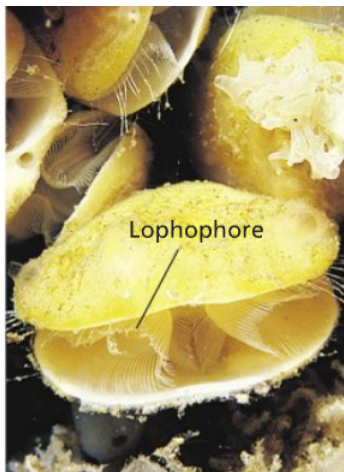
{a big evolutionary breakthrough}



Some species of rotifers have no males, and apparently haven't had sex for 35 million years!



(a) Ectoprocts, such as this sea mat (*Membranipora membranacea*), are colonial lophophorates.



(b) Brachiopods have a hinged shell. The two parts of the shell are dorsal and ventral.

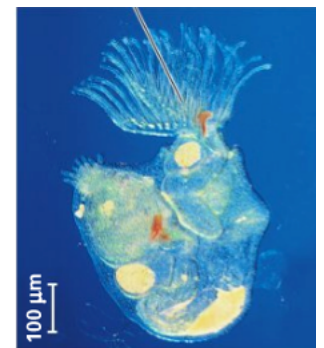
Ectoprocts

are sessile, colonial “bryozoans” or “moss animals”

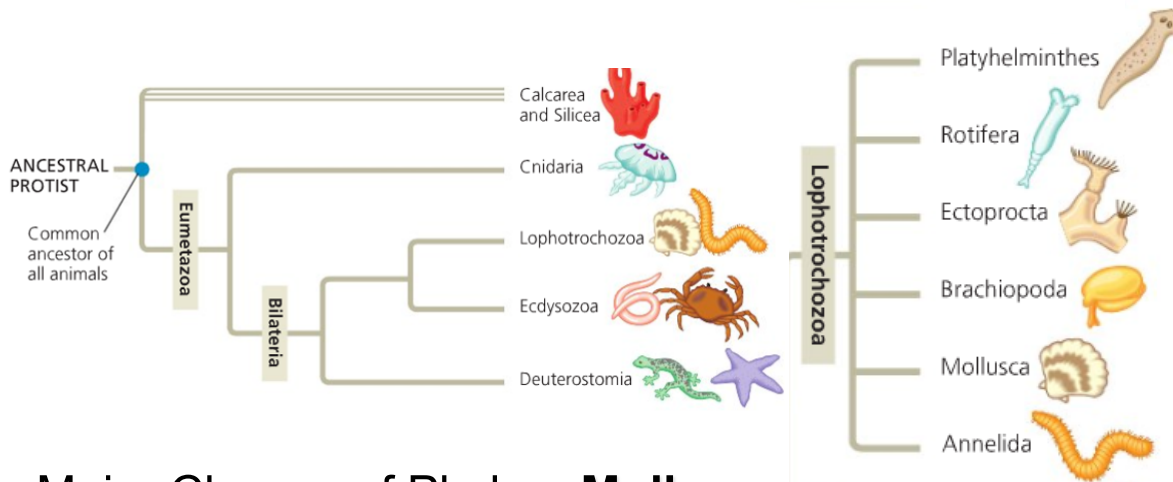
Brachiopods

are sessile, marine “lamp shells” that superficially resemble mollusks

Ectoprocts & Brachiopods are called Lophophorates because adults still feed with a lophophore mouth



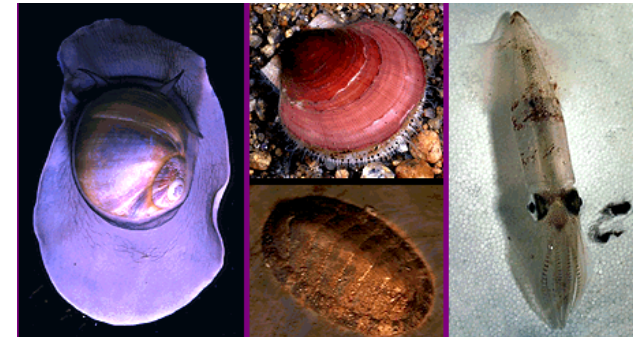
(a) An ectoproct, which has a lophophore (LM)



Mollusks

Most spp have distinct sexes
but many snails
are hermaphroditic

{'love darts'!!!}



Major Classes of Phylum **Mollusca**

Polyplacophora (chitons) Marine;
shell with eight plates; foot used for locomotion;

Gastropoda (snails) Marine, freshwater, or terrestrial;
{secondarily} asymmetric body, usually with a coiled shell;
foot for locomotion; radula present

Bivalvia (clams, mussels, scallops, oysters)

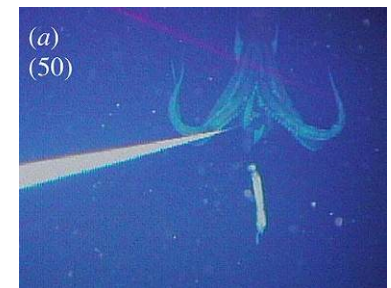
Marine and freshwater, flattened shell with two valves; head reduced;
paired gills; filter-feeders; mantle forms siphons.

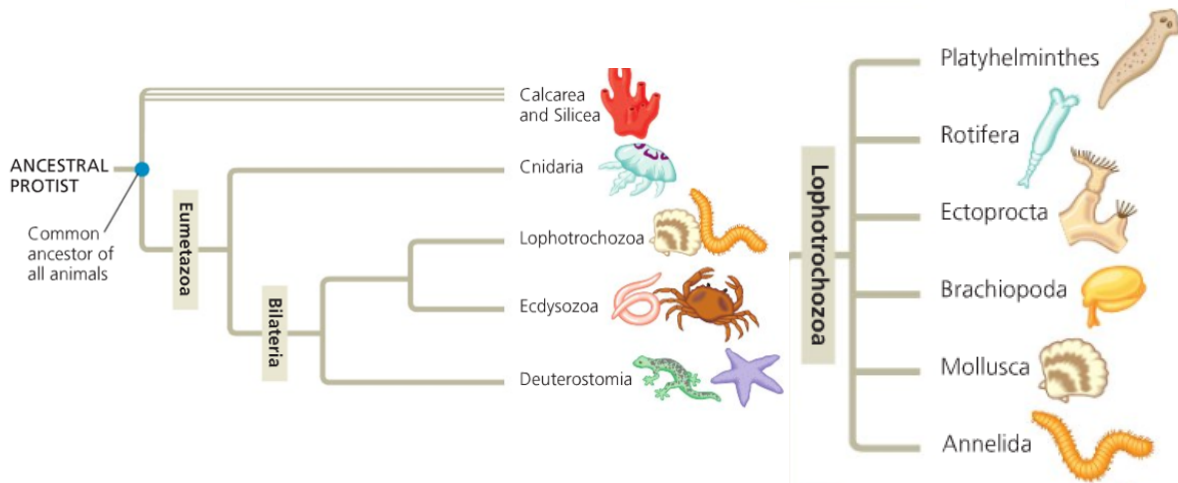
Cephalopoda (squids, octopuses, chambered nautilus) Marine;
head surrounded by grasping tentacles, usually with suckers;
shell external, internal, or absent; mouth with or without radula;
locomotion by jet propulsion using siphon made from mantle.

– *active, great eyes {homology vs analogy?}, & very smart!*

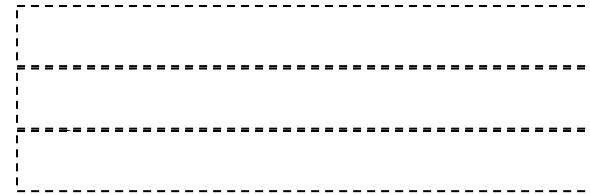
Holy Squid! Photos Offer First Glimpse of Live Deep-Sea Giant

James Owen for [National Geographic News](#) September 27, 2005





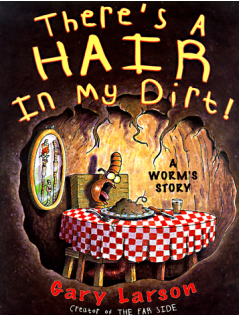
Annelids are Bilateria,



Polychaetes

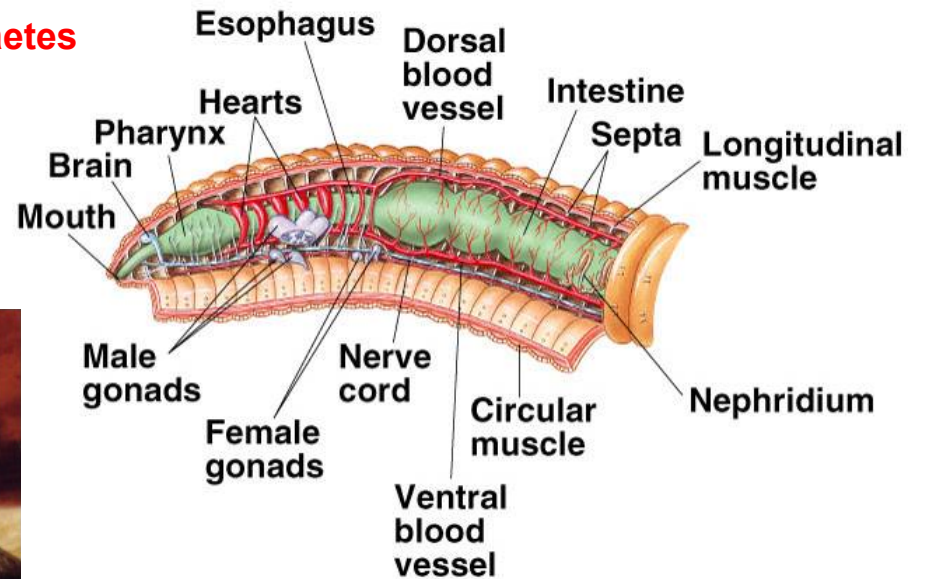


Hirundae



Oligochaetes

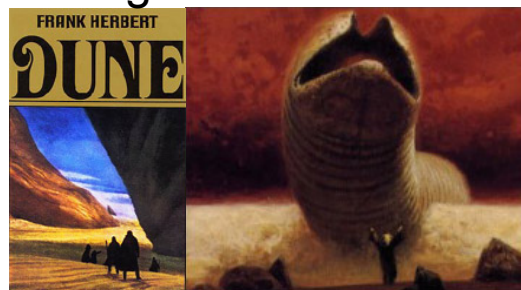
- unlike mollusks & arthropods, annelids have a closed circulatory system w/ tubular hearts; coelom; ventral nerve cord



giant earthworms



giant duneworms





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POSTED 31 AUG 2000



A forest floor without worms (left) and with (right). Spring flowers and tree seedlings both suffer when earthworms munch the decaying litter on the ground.

Courtesy [University of Minnesota, Agricultural Experiment Station](#)

Worms deprive native plants and trees of a place to germinate, leaving a bare forest floor.



Northern forests are under attack by a silent, invisible and deadly plague: an army of introduced earthworms.

By rapidly munching decomposing organic crud on the forest floor, the worms deprive native plants and tree seedlings of a place to germinate and grow. The result is a bare forest floor, lacking most spring flowers and tree seedlings.

Earthworms are a blessing in gardens, where they mix the soil, increase porosity, and leave fertile droppings ... But ... it's not true in ecosystems that are not "used to" worms.

In the upper Midwest, all worms were extirpated by Ice-Age glaciers that smothered the area until about 11,000 years ago. And since worms can't travel far under their own steam, the forests have had essentially no worms.

In contrast, worms reached cities and farms courtesy of settlers who brought plants and soil).

Effects of Earthworm Invasion on Plant Species Richness in Northern Hardwood Forests. A.R. Holdsworth et al. 2007. Conservation Biol 21:997-1008.



Biopharm Leeches

The Biting Edge of Science



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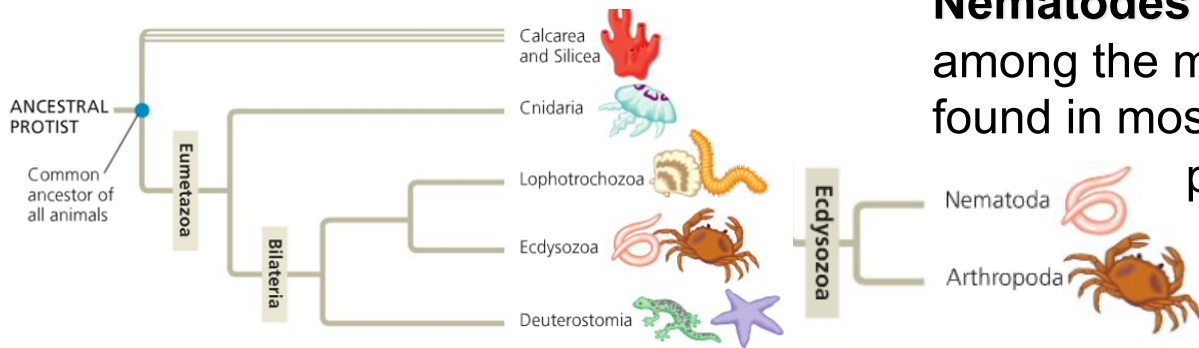
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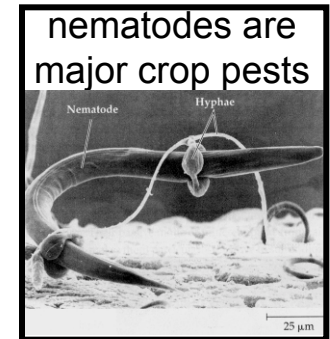
Worldwide Offices

The leech was indispensable in 19th Century medicine for bloodletting, a practice believed to be a cure for anything from headaches to gout. Leeching was largely abandoned as medical science advanced, only occasionally being called upon to treat bruising and black eyes. However, **the medicinal leech is making a comeback** in modern medicine. Biopharm is home to over 50,000 leeches which are supplied to hospitals and research laboratories around the world. Thousands of patients owe the successful reattachment of body parts to miraculous technological advances **in reconstructive surgery**; at least some of these operations might have failed if leeches had not been reintroduced into the operating room. The rationale behind the use of leeches in surgical procedures is fairly straightforward; nonetheless, it is subject to misunderstanding ... The key to success is the exploitation of a unique property of the leech bite, namely, the creation of a puncture wound that bleeds literally for hours. **The leech's saliva contains substances that anaesthetise the wound, dilate the blood vessels to increase blood flow, and prevent the blood from clotting.**



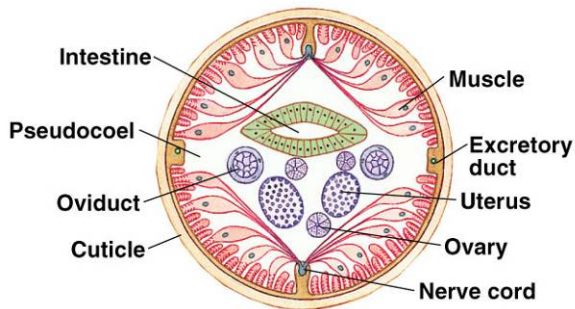
Nematodes (roundworms)

among the most widespread of all animals,
found in most aquatic habitats & soil,
plant & animal tissue (parasites)

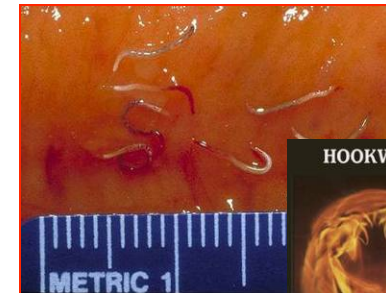


Bilaterally symmetrical,

{Ecdysozoa – tough cuticle}



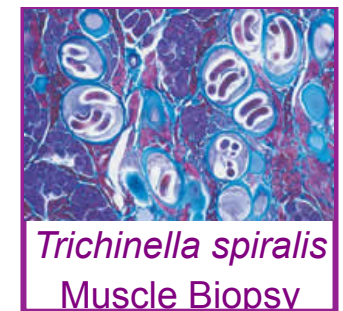
human **hookworms** include
two nematode (roundworm) species
-leading causes of maternal
& child morbidity
in the tropics

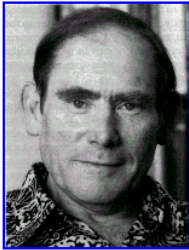


Nematodes possess digestive, nervous,
excretory, & repro systems,
but lack a discrete circulatory or respiratory system.

Their digestive system has two openings
- at the mouth and anus. {which 1st?}

Why we don't eat pork rare:





Sydney Brenner

In late 1962, Francis Crick and I began a long series of conversations about the next steps to be taken in our research.

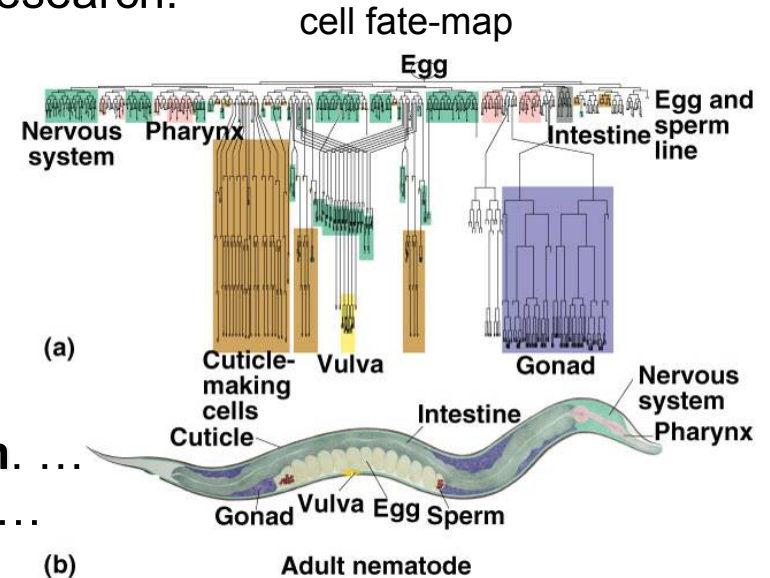
Both of us felt very strongly that most of the classical problems of molecular biology had been solved and that the future lay in tackling more complex biological problems. ...

... which are **new, mysterious and exciting**.

... the fields which we should now enter are

development and the nervous system. ...

... *{the nematode}* ***C. elegans*** was selected ...



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The Prize Winners for 2002

■ The Nobel Prize in Physiology or Medicine
"for their discoveries concerning genetic regulation of organ development and programmed cell death"

Sydney Brenner
United Kingdom

H. Robert Horvitz
USA

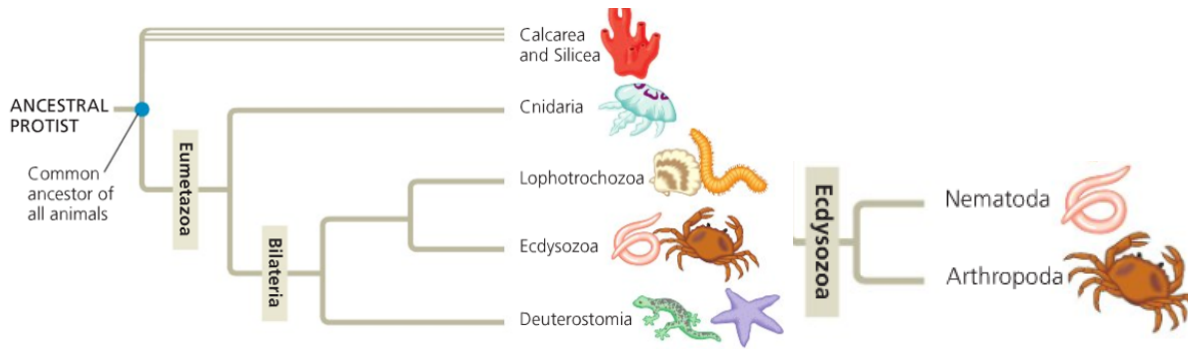
John E. Sulston
United Kingdom

Press Release:
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This year's Nobel Laureates in Physiology or Medicine have made seminal discoveries concerning **the genetic regulation of organ development and programmed cell death.**

By establishing the nematode *Caenorhabditis elegans* as an experimental model system, possibilities were opened to follow cell division and differentiation from the fertilized egg to the adult. The Laureates have identified key genes regulating organ development and programmed cell death and have shown that corresponding genes exist in higher species, including man. ...



Arthropoda



The body of an arthropod is completely covered by the cuticle, an exoskeleton

1. 'jointed feet'
2. exoskeleton
3. segmentation

Cephalization is extensive, w/ well-developed sensory organs, including eyes, olfactory receptors, and antennae for touch and smell & ventral nerve cord.

Arthropods have **open circulatory systems**

Most aquatic species have gills.

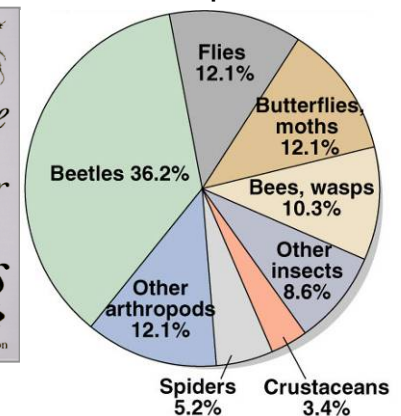
Terrestrial arthropods have internal tracheal surfaces for gas exchange.

2/3 of all named organisms on earth are **arthropods**

J.B.S. Haldane



insect species





Palaemonias ganteri
(Mammoth cave)

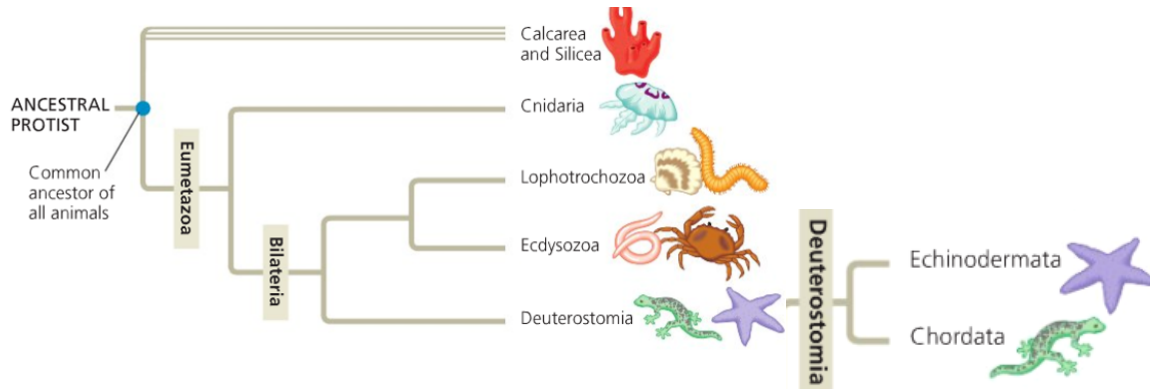


Table 33.5 Subphyla of Phylum Arthropoda

Subphylum and Examples	Main Characteristics
Cheliceriformes (horseshoe crabs, spiders, scorpions, ticks, mites; see Figures 33.30–33.32)	Body having one or two main parts; six pairs of appendages (chelicerae, pedipalps, and <u>four pairs of walking legs</u>); mostly terrestrial or marine
Myriapoda (millipedes and centipedes; see Figures 33.33 and 33.34)	Distinct head bearing antennae and chewing mouthparts; terrestrial; millipedes are herbivorous and have two pairs of walking legs per trunk segment; centipedes are carnivorous and have one pair of walking legs per trunk segment and poison claws on first body segment
Hexapoda (insects, springtails; see Figures 33.35–33.37)	Body divided into head, thorax, and abdomen; antennae present; mouthparts modified for chewing, sucking, or lapping; <u>three pairs of legs</u> and usually two pairs of wings; mostly terrestrial
Crustacea (crabs, lobsters, crayfish, shrimp; see Figures 33.29 and 33.38)	Body of two or three parts; antennae present; chewing mouthparts; three or more pairs of legs; mostly marine and freshwater

Trilobites

extinct



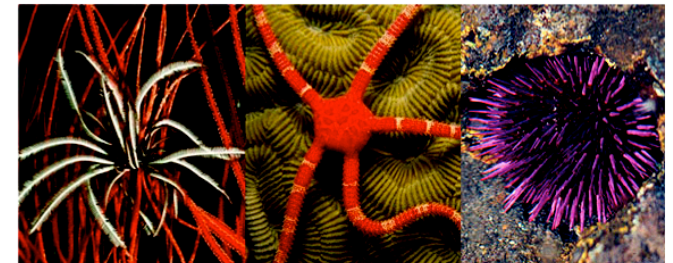
Deuterostomia



Echinodermata

Spiny-skinned animals: sea urchins, starfish, and their allies

Gregory A. Wray



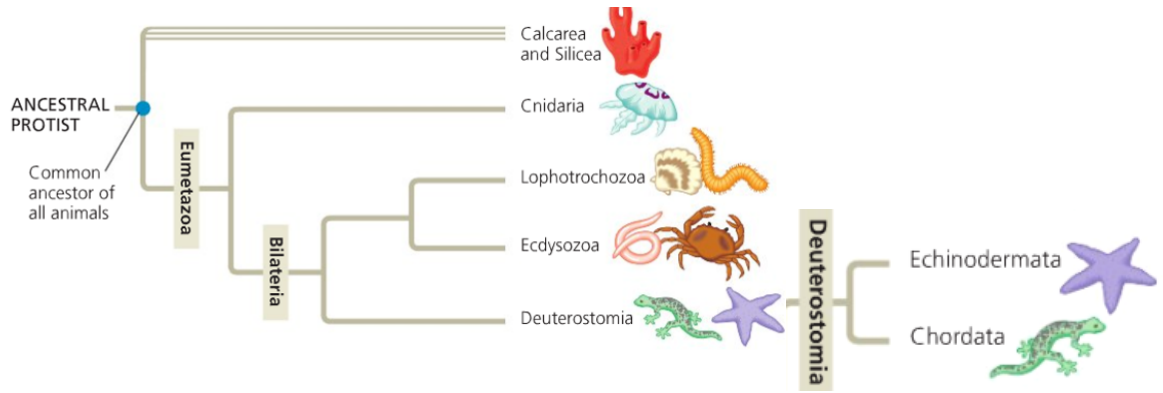
Echinoderms

are among the most distinctive of all animal phyla

... four synapomorphies *{shared derived characters}* :

1. **Calcitic skeleton** Embryologically a true endoskeleton; functionally like an exoskeleton.
2. **Water vascular system**
 - performs many important functions in echinoderms, including locomotion, respiration, and feeding;
3. **Mutable collagenous tissue.** ligaments of collagen are under neuronal control ... can be temporarily "unlocked" (loosened) then "relocked" at different length. ... maintain a variety of postures with no muscular effort. *{pry open bivalve mollusks}*

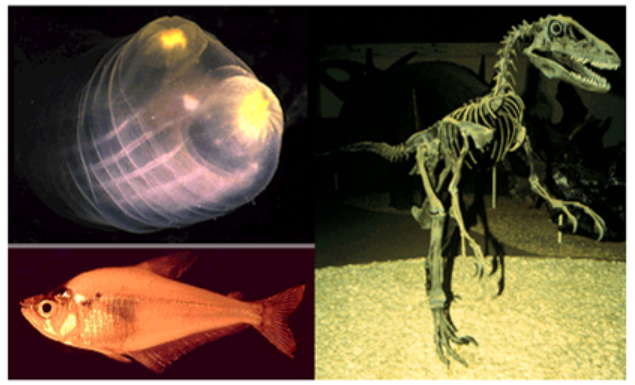
4.



TREE OF LIFE web project

Chordata

John G. Lundberg



The **Chordates**,

to which we belong, consists of

two subphyla of **invertebrate chordates** {*Urochordates & Cephalochordates*}

plus the subphylum **Vertebrata**,

the animals with backbones.



Address: <http://novasties.com/mahoney/nutshell2.htm>

Dr. Kevin Mahoney's **spinal column** in a nutshell

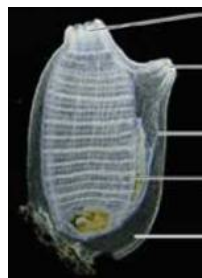
- kids
- adults
- seniors
- gait analysis
- resources
- faq's

Chiropractic is a Healing Art, Science and Philosophy.












The art of Chiropractic (which incidentally means "to do or perform by hand") is not readily put across with words, aural description, and is at best poorly conveyed by picture; moving or still.

In a Nutshell understanding chiropractic

- About Chiropractic
- The Spine - 101
- Spine / Nervous System
- Nerves & Communication



Selected Animal Phyla

Key Concept	Phylum	Description
Concept 33.1 Sponges are basal animals that lack true tissues (pp. 670–671)	Cnidaria (hydras, jellies, sea anemones, corals)	 Lack true tissues; have choanocytes (collar cells—flagellated cells that ingest bacteria and tiny food particles)
Concept 33.2 Cnidarians are an ancient phylum of eumetazoans (pp. 671–673)	Cnidaria (hydras, jellies, sea anemones, corals)	 Unique stinging structures (nematocysts) housed in specialized cells (cnidocytes); diploblastic; radially symmetrical; gastrovascular cavity (digestive compartment with a single opening)
Concept 33.3 Lophotrochozoans, a clade identified by molecular data, have the widest range of animal body forms (pp. 674–682)	Platyhelminthes (flatworms)	 Dorsoventrally flattened, unsegmented acoelomates; gastrovascular cavity or no digestive tract
	Rotifera (rotifers)	 Pseudocoelomates with alimentary canal (digestive tube with mouth and anus); jaws (trophi) in pharynx; head with ciliated crown
	Lophophorates: Ectoprocta, Brachiopoda	 Coelomates with lophophores (feeding structures bearing ciliated tentacles)
	Mollusca (clams, snails, squids)	 Coelomates with three main body parts (muscular foot, visceral mass, mantle); coelom reduced; most have hard shell made of calcium carbonate
	Annelida (segmented worms)	 Coelomates with segmented body wall and internal organs (except digestive tract, which is unsegmented)
Concept 33.4 Ecdysozoans are the most species-rich animal group (pp. 683–692) MEDIA Investigation How Are Insect Species Identified?	Nematoda (roundworms)	 Cylindrical, unsegmented pseudocoelomates with tapered ends; no circulatory system; undergo ecdysis
	Arthropoda (crustaceans, insects, spiders)	 Coelomates with segmented body, jointed appendages, and exoskeleton made of protein and chitin
Concept 33.5 Echinoderms and chordates are deuterostomes (pp. 693–695) MEDIA Activity Characteristics of Invertebrates	Echinodermata (sea stars, sea urchins)	 Coelomates with bilaterally symmetrical larvae and five-part body organization as adults; unique water vascular system; endoskeleton
	Chordata (lancelets, tunicates, vertebrates)	 Coelomates with notochord; dorsal, hollow nerve cord; pharyngeal slits; post-anal tail (see Chapter 34)

Metazoa

Eumetazoa

Bilateria

Lophotrochozoa

Ecdysozoa

Deuterostomia

