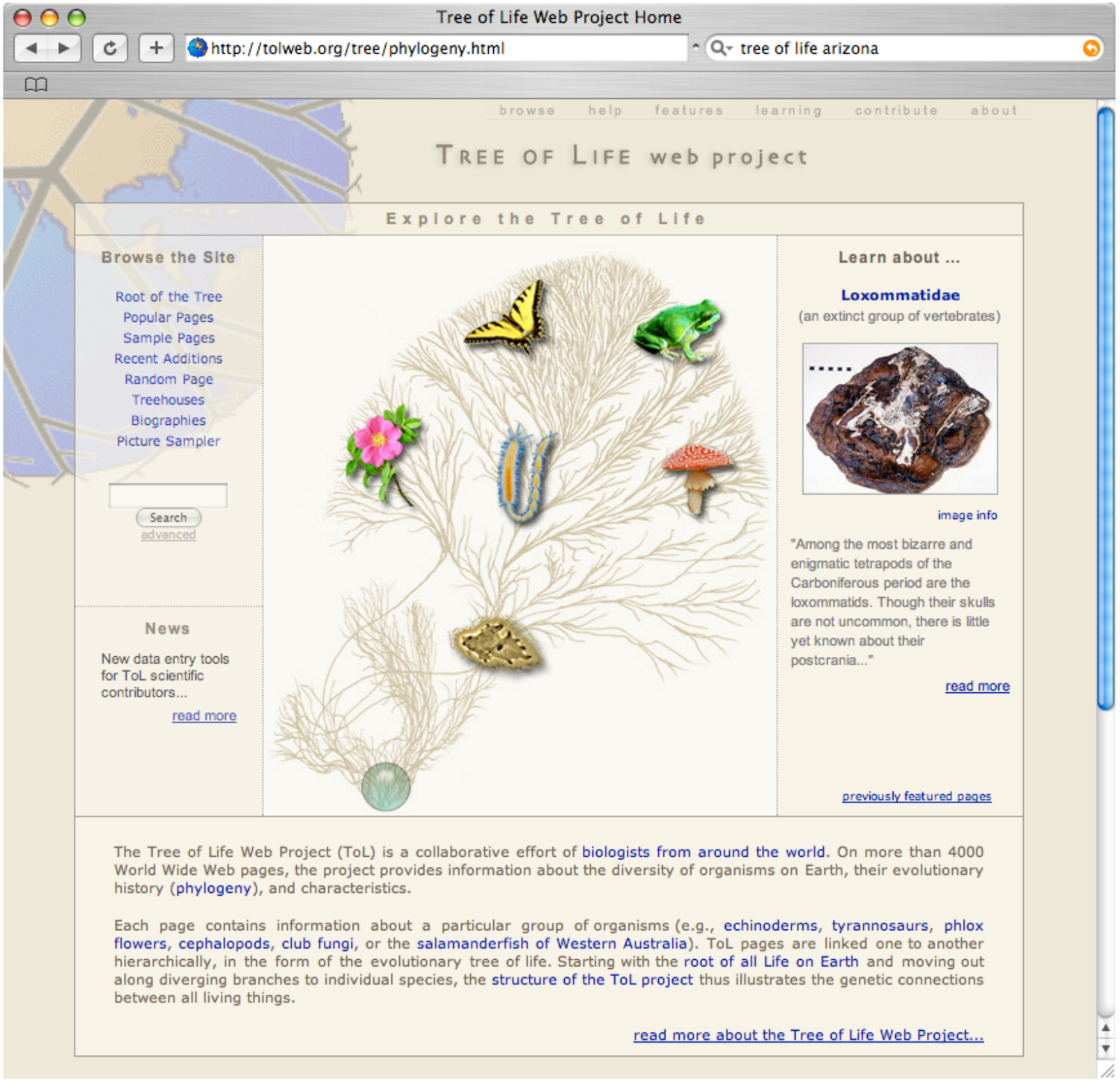
An Introduction to Animal Diversity

Tree of Life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(an extinct group of vertebrates)
image info
"Among the most bizarre and enigmatic tetrapods of the Carboniferous period are the loxommatids. Though their skulls are not uncommon, there is little yet known about their postcrania..."
read more
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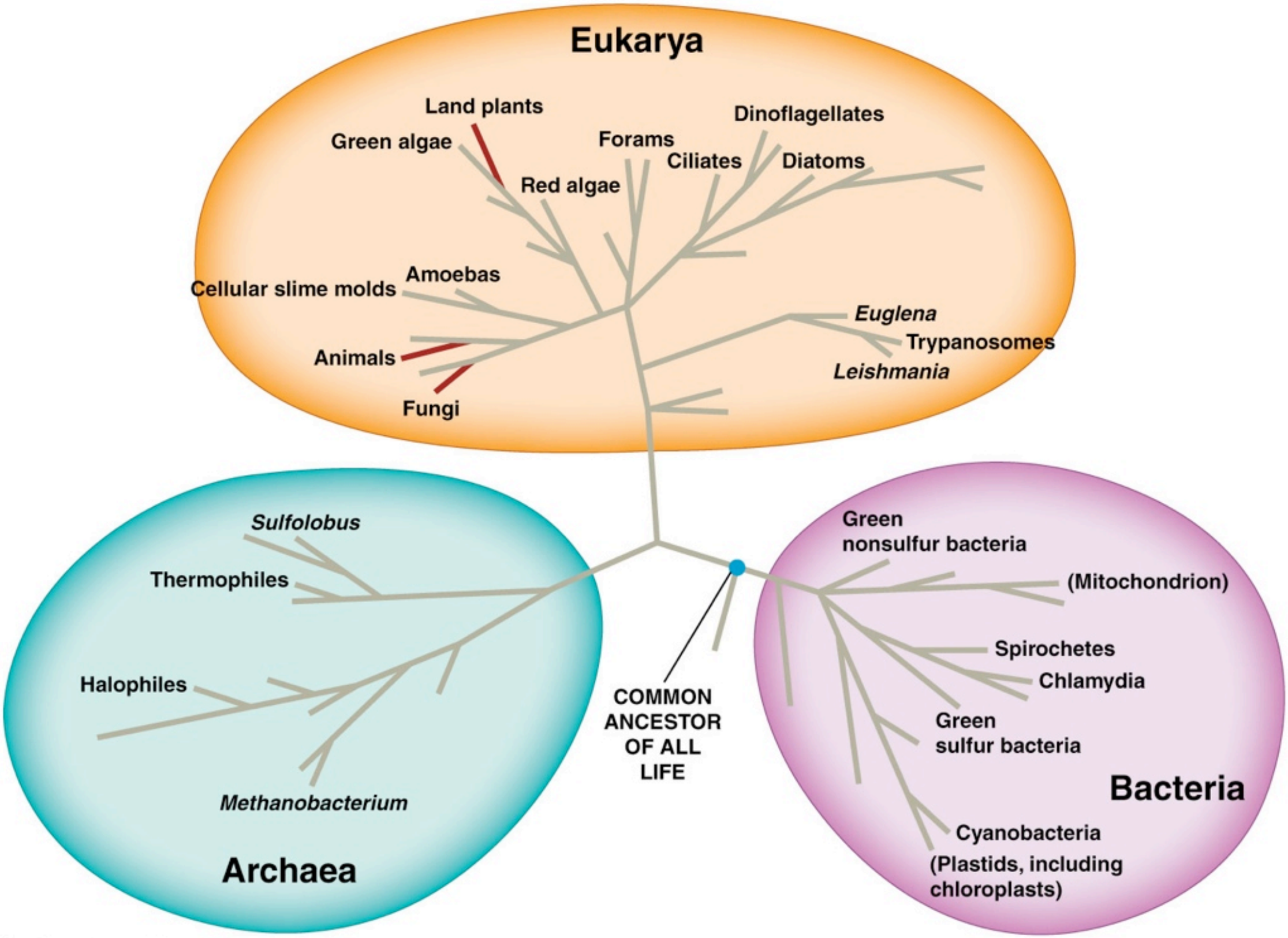
The Tree of Life Web Project (ToL) is a collaborative effort of biologists from around the world. On more than 4000 World Wide Web pages, the project provides information about the diversity of organisms on Earth, their evolutionary history (phylogeny), and characteristics.
Each page contains information about a particular group of organisms (e.g., echinoderms, tyrannosaurs, phlox flowers, cephalopods, club fungi, or the salamanderfish of Western Australia). ToL pages are linked one to another hierarchically, in the form of the evolutionary tree of life. Starting with the root of all Life on Earth and moving out along diverging branches to individual species, the structure of the ToL project thus illustrates the genetic connections between all living things.
read more about the Tree of Life Web Project...

Animal Diversity

- 3 domains (Archaea, Bacteria, Eukarya)
- Within the Eukarya (protists, plants, fungi, animals)
- 35 phyla of animals --- 95% of all animals are INVERTEBRATES!

Animal Diversity

Three Domains of life



Animals are an extremely diverse kingdom of life

- Millions of species
- Many of the phyla arose ~530 mya
- Vertebrates and invertebrates
- Most animal species are invertebrates

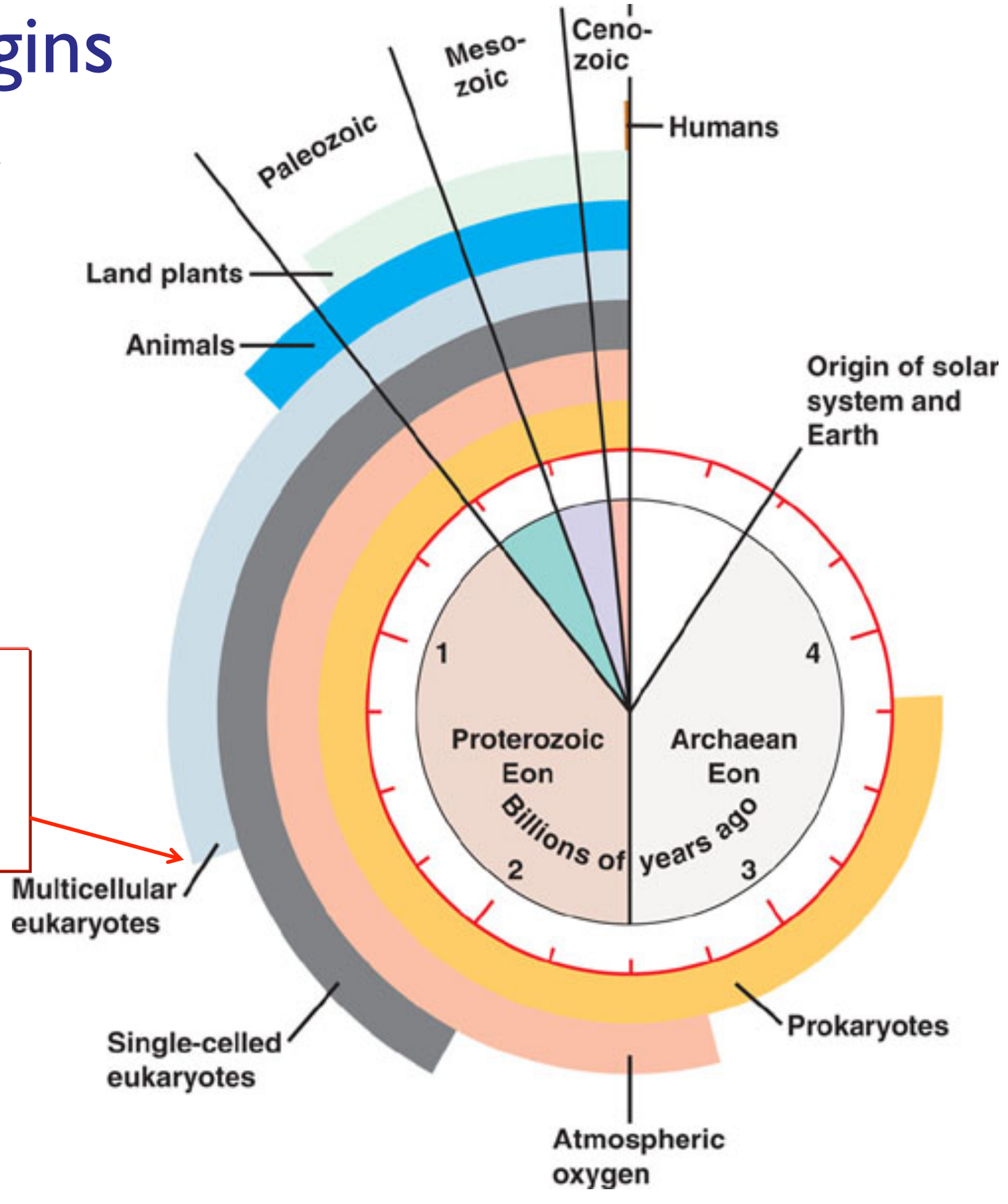
Animal Life Begins

- Animals have been around for more than a billion years

- The animal kingdom includes not only great diversity of living species, but even greater diversity of extinct ones

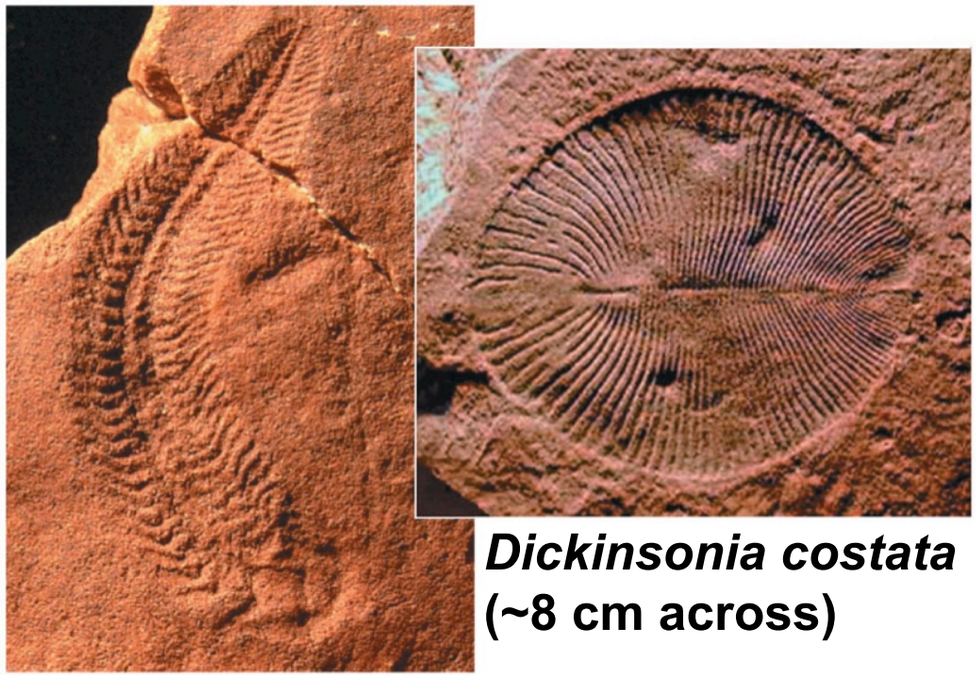
No multicellular organisms for 2/3^{rds} of earth history!

565 MYA



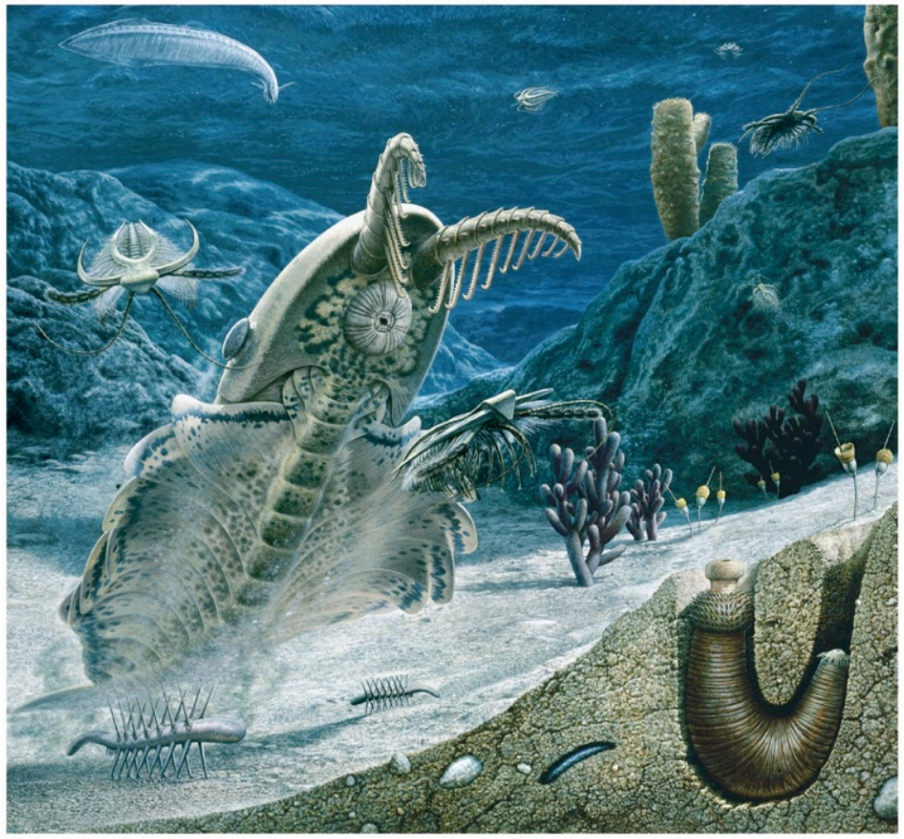
Animal diversification began more than half a billion years ago

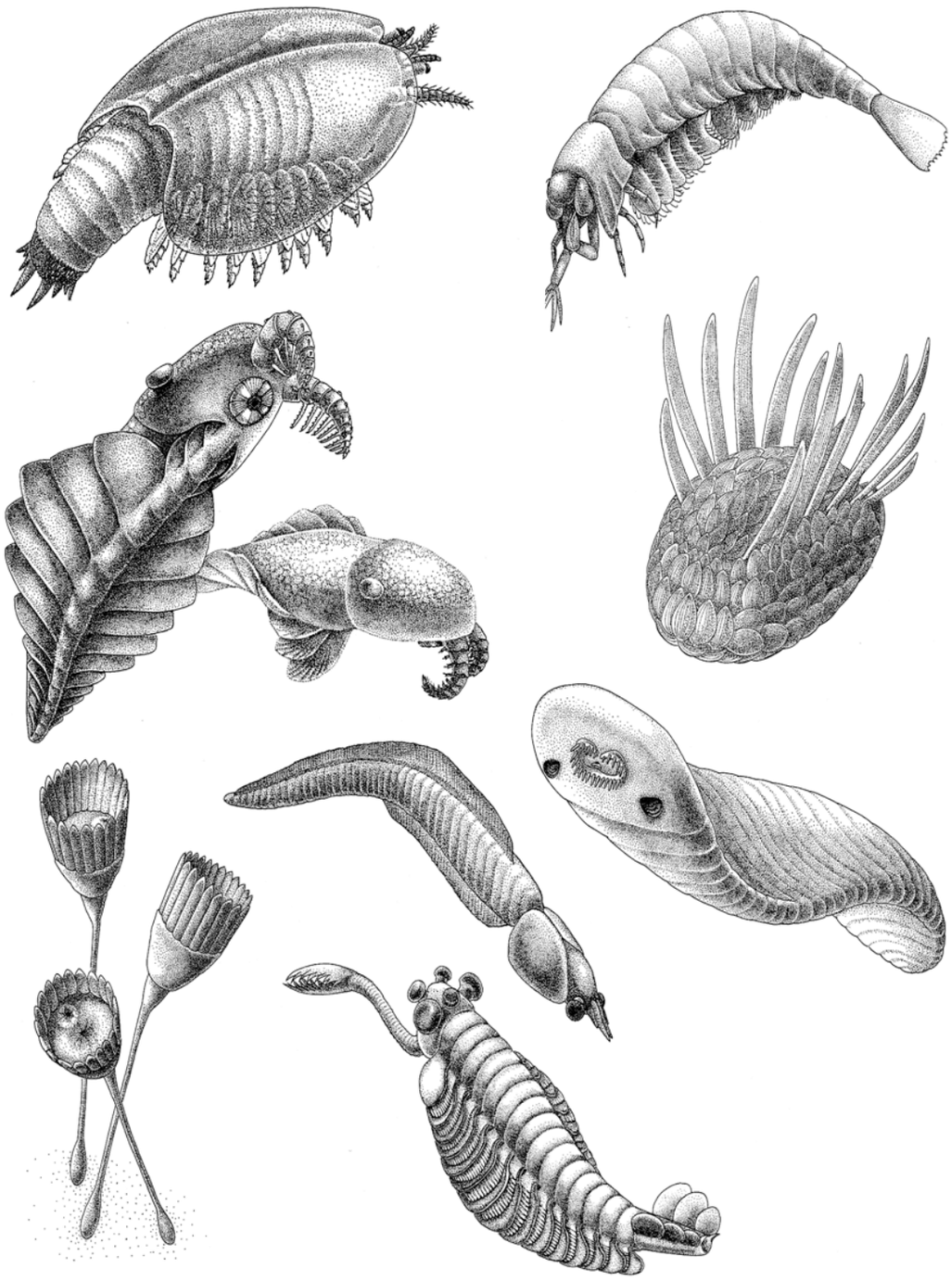
- The oldest generally accepted animal fossils that have been found are 575–550 million years old.
- Animal diversification appears to have accelerated rapidly from 535 to 525 MYA, during the Cambrian period, known as the Cambrian explosion.
- The most celebrated source of Cambrian fossils is the Burgess Shale containing a cornucopia of perfectly preserved animal fossils.



Dickinsonia costata
(~8 cm across)

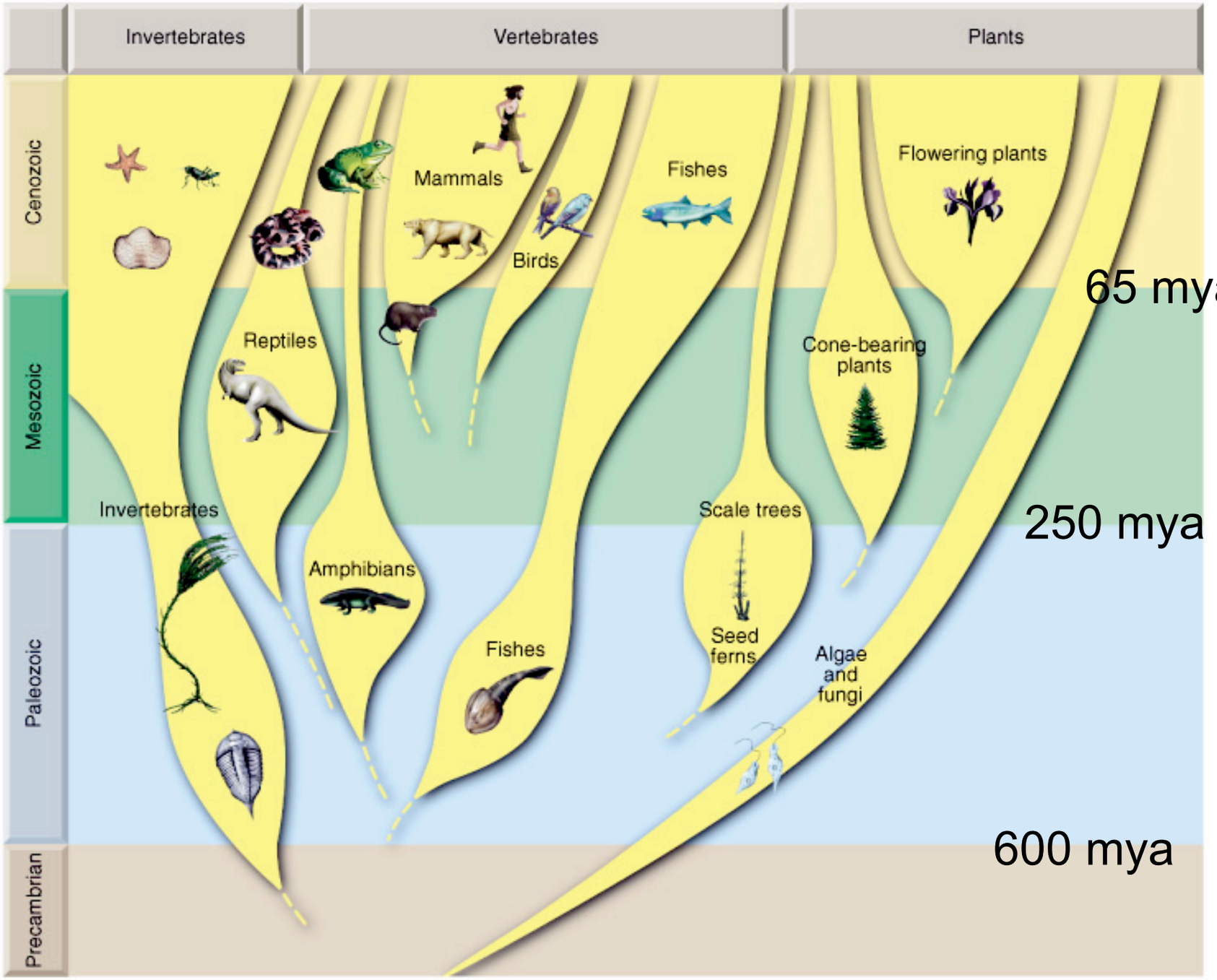
Spriggina floundersi
(~3 cm long)





Burgess Shale deposits
(Canada Rockies)

Cambrian explosion →








Details on the Cambrian explosion

Possibly caused by

- increasingly complex predator-prey relationships or
- an increase in atmospheric oxygen.

Much of the diversity in body form among the animal phyla is associated with variations in where and when homeotic genes are expressed within developing embryos.

Of the 35 or so animal phyla, all but one are invertebrates, (they lack vertebra).

www.ucmp.berkeley.edu/cambrian/camb.html

Properties of animals

Eukaryotes

Heterotrophs

No cell walls

Eat by ingestion (mostly true)

- Some exceptions (e.g. tape worms)

Diploid (mostly true)

- Some exceptions (e.g. some social insects)

Sexual (mostly true)

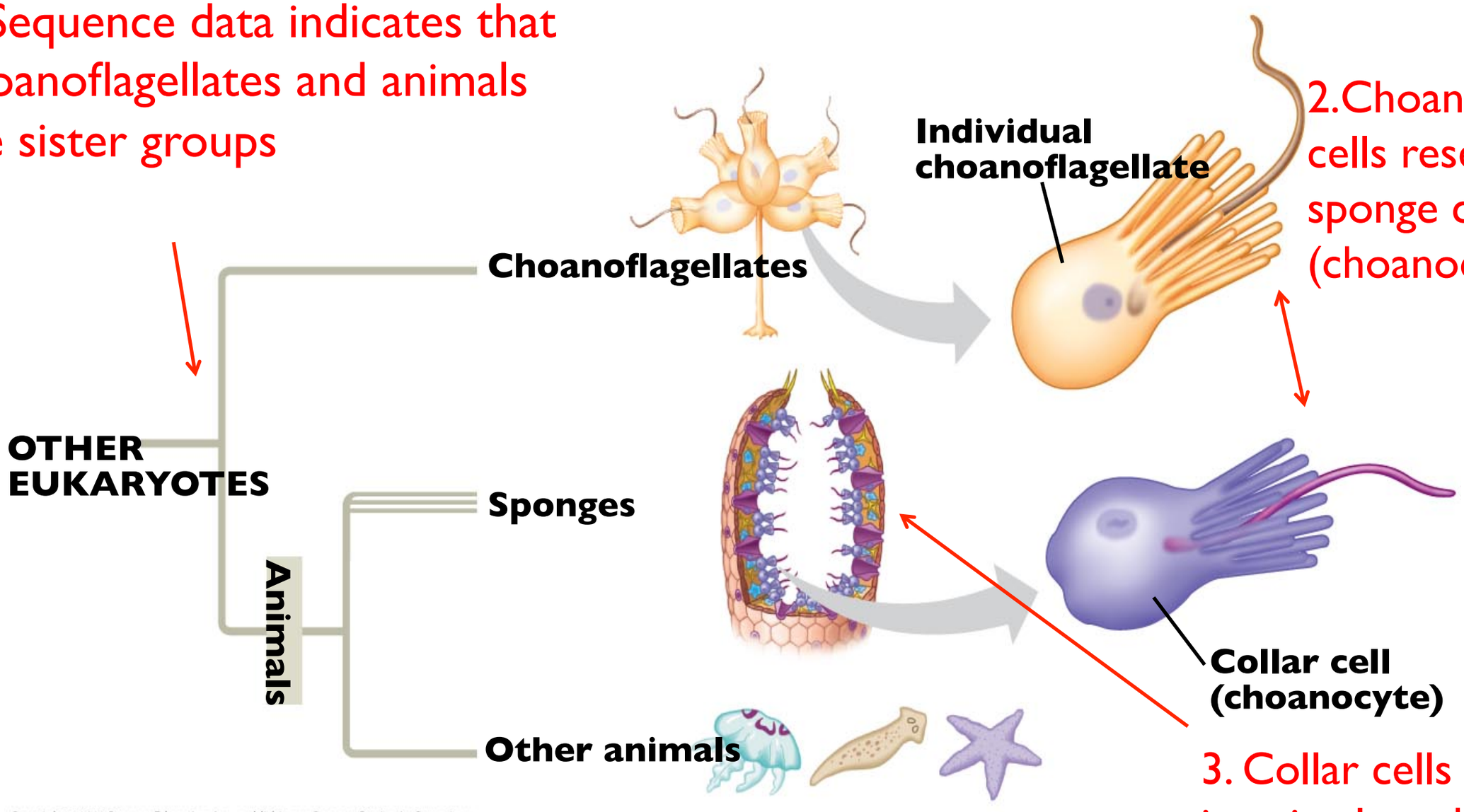
- Some exceptions (e.g. parthenogenesis in some sharks or jellyfish)

Choanoflagellate-like organisms are thought to be the animal "ancestor"

Common ancestor of animals probably a colonial flagellated protist related to **choanoflagellates**, a protistan group that arose between 675 and 875 MYA

EVIDENCE

1. Sequence data indicates that choanoflagellates and animals are sister groups

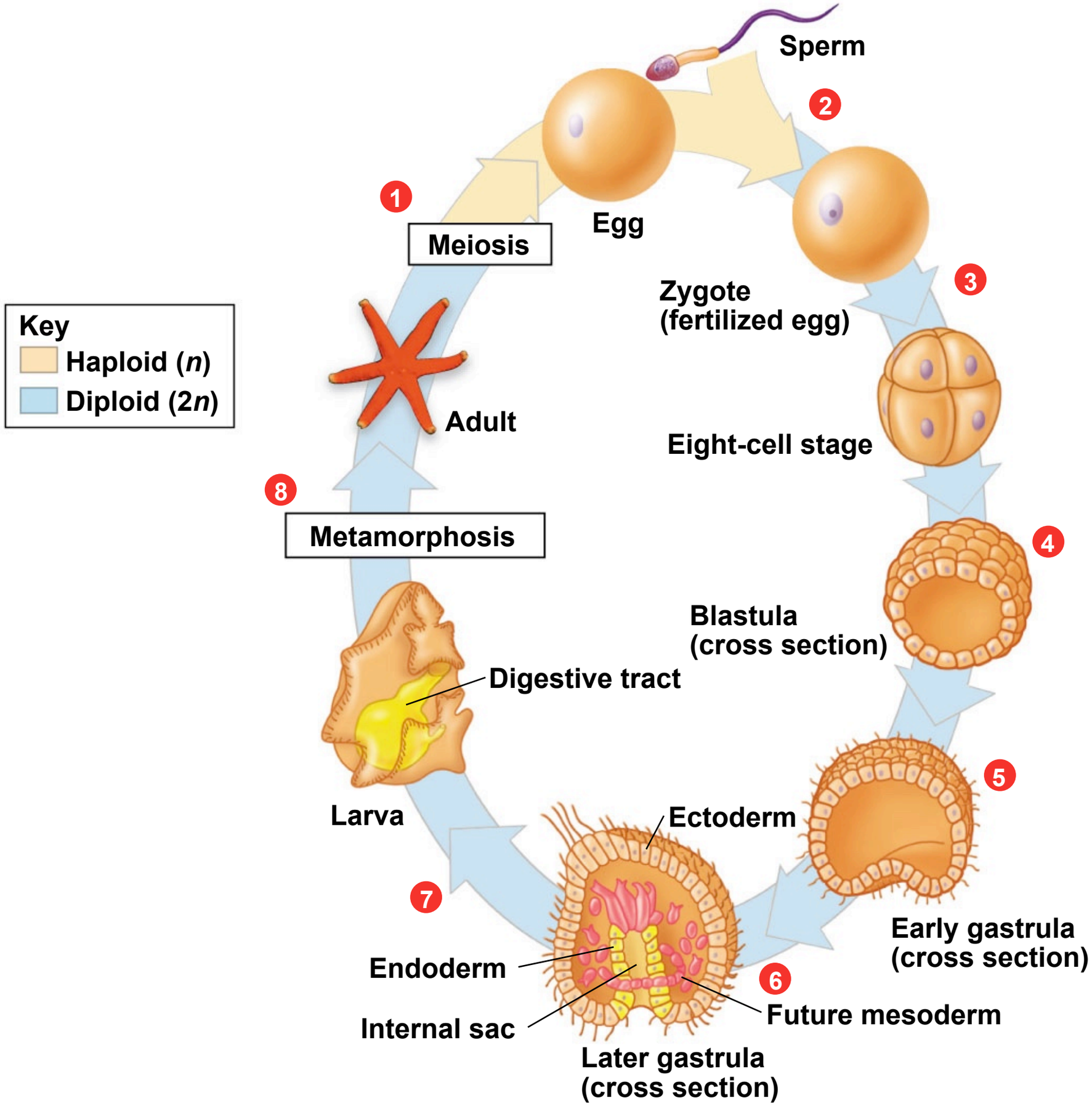


2. Choanoflagellate cells resemble sponge collar cells (choanocytes)

3. Collar cells only found in animals and not in protists

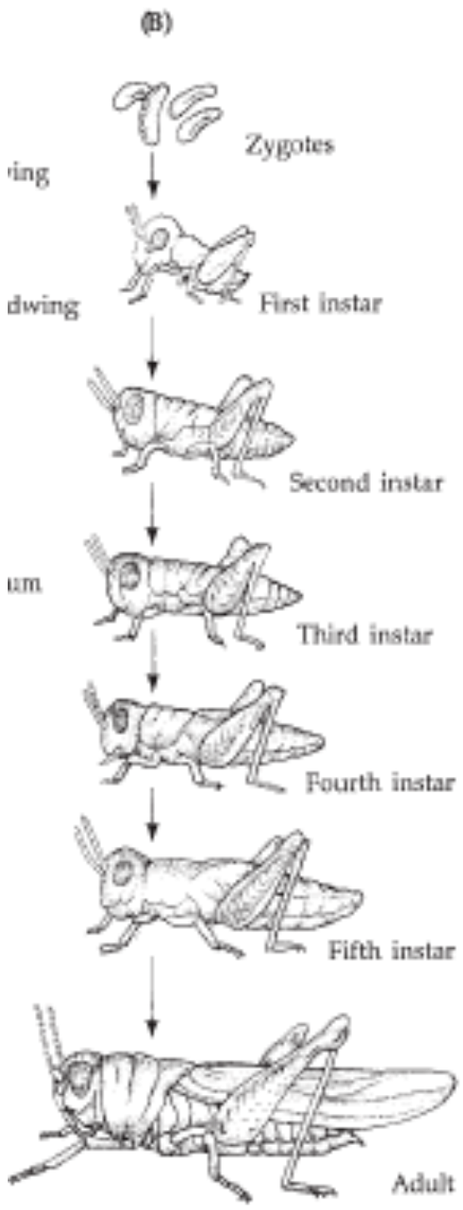
9 General Animal Characteristics

1. Animals are multicellular
2. Cells lack cell walls
3. Animals are heterotrophic (vs. autotrophic)
4. Most reproduce sexually w/diploid stage usually dominating life cycle
5. After a sperm fertilizes an egg the zygote undergoes cleavage, leading to the formation of a blastula, embryonic tissues and gastrula.
6. Cell specialization: specialized neural cells (nervous tissue) and muscle cells (muscle tissue) are unique to animals
7. During development three germ layers give rise to the tissues and organs of the animal embryo. Animal body plans vary by organization of tissues.
8. Tissues are held together by structural proteins such as collagen.
9. All animals, and only animals, have the highly conserved *Hox* family of genes that regulate the development of diverse body form.


Key
Haploid (n)
Diploid (2n)
Sperm
Egg
1
Meiosis
2
Zygote
(fertilized egg)
3
Eight-cell stage
4
Blastula
(cross section)
5
Early gastrula
(cross section)
6
Future mesoderm
Later gastrula
(cross section)
Ectoderm
Endoderm
Internal sac
7
Larva
Digestive tract
8
Metamorphosis
Adult

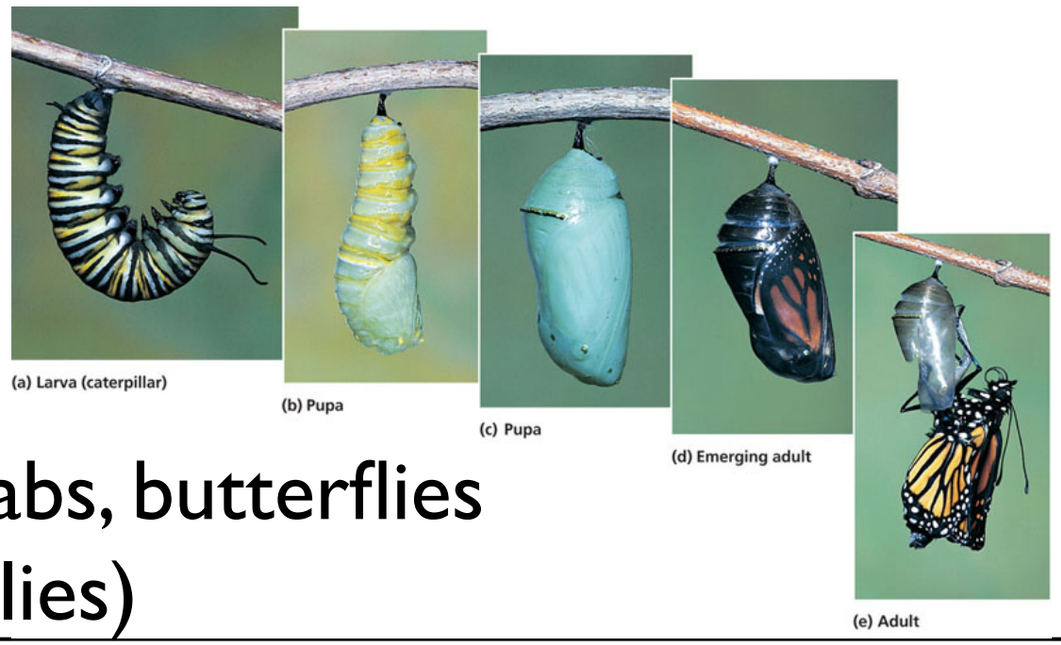
Differences in development across animals

Direct development



- After the gastrula stage, many animals develop directly into adults.
- Other animals develop into one or more larval stages before taking the adult form.
  - A **larva** is an immature individual that looks different from the adult animal.
  - A larva undergoes a major change in body form, called **metamorphosis**, and becomes a reproductively mature adult.

Metamorphosis



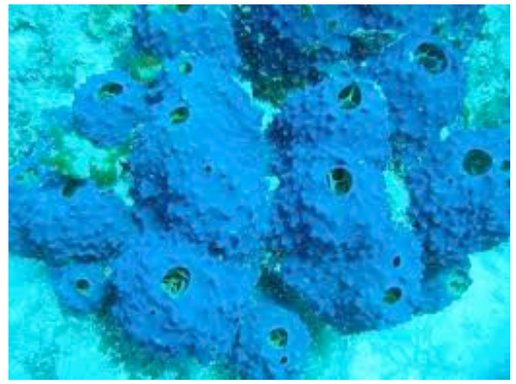
Examples: sea star, crabs, butterflies
Not pillbugs (rollypollies)

Animals can be characterized by basic features of their "body plan"

- Animal body plans vary in
  - presence of true tissues
  - symmetry
  - number of embryonic layers
  - presence of a body cavity
  - details of their embryonic development
- These characters, as well as DNA sequence, can be used to determine the phylogeny of animals.

Types of symmetry in animals

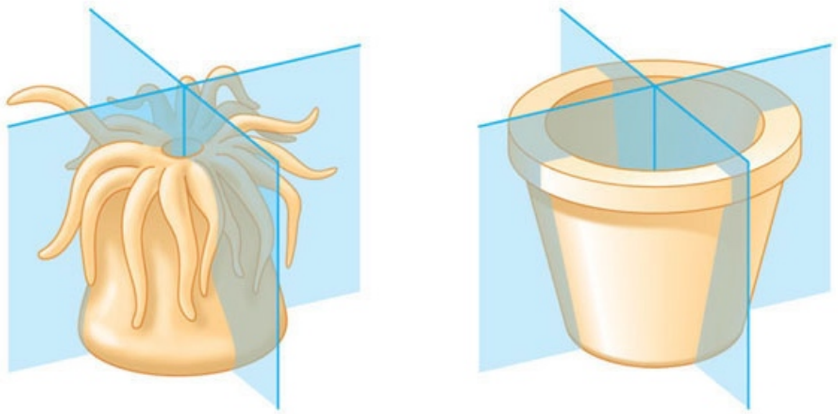
- Animals can be categorized according to body symmetry (or lack of it) – both present in fossil record for 550 million years
- In general – symmetry fits lifestyle
- Animals either have **radial** or **bilateral** symmetry
- (note exception of sponges)



Radial symmetry

have a top and bottom but lack back and front or R and L sides. An imaginary slice through the central axis divides them into mirror images.

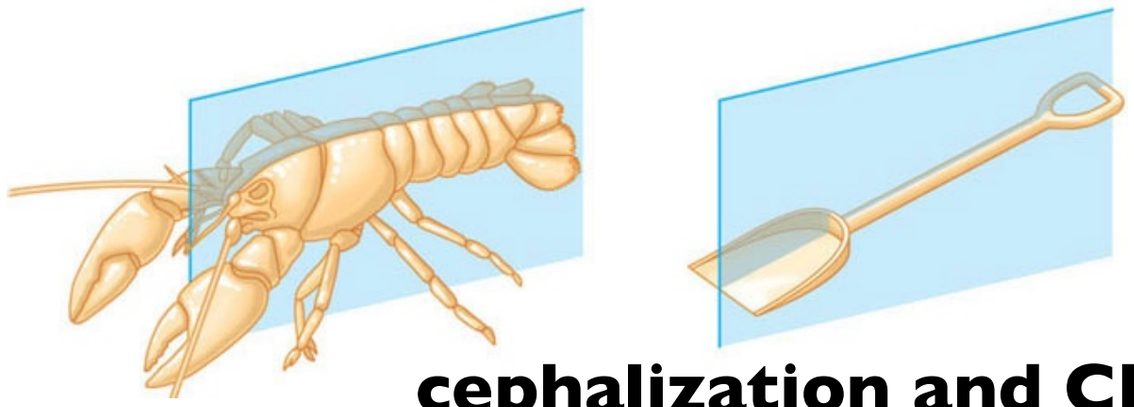
Most sessile or passive planktonic
Allows organisms to meet environment well from all sides



Bilateral (two-sided) symmetry

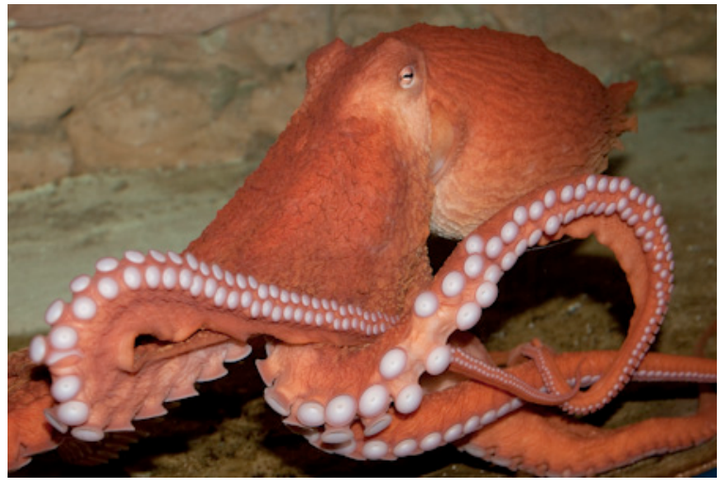
Animals with **bilateral symmetry** have mirror-image right and left sides and a

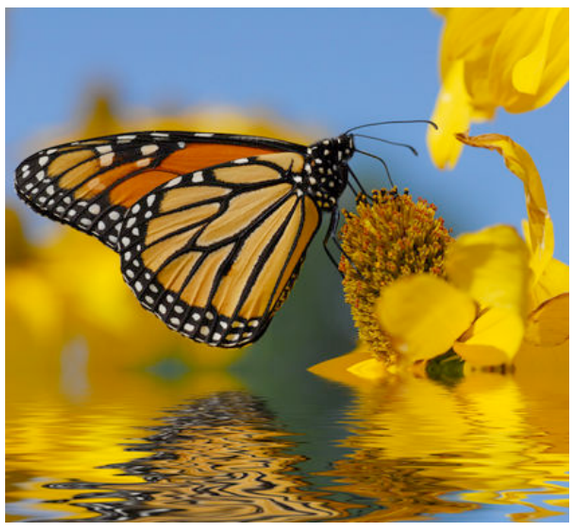
- distinct head, or **anterior** end,
- tail, or **posterior** end,
- back, or **dorsal**, surface, and
- bottom, or **ventral**, surface.



cephalization and CNS

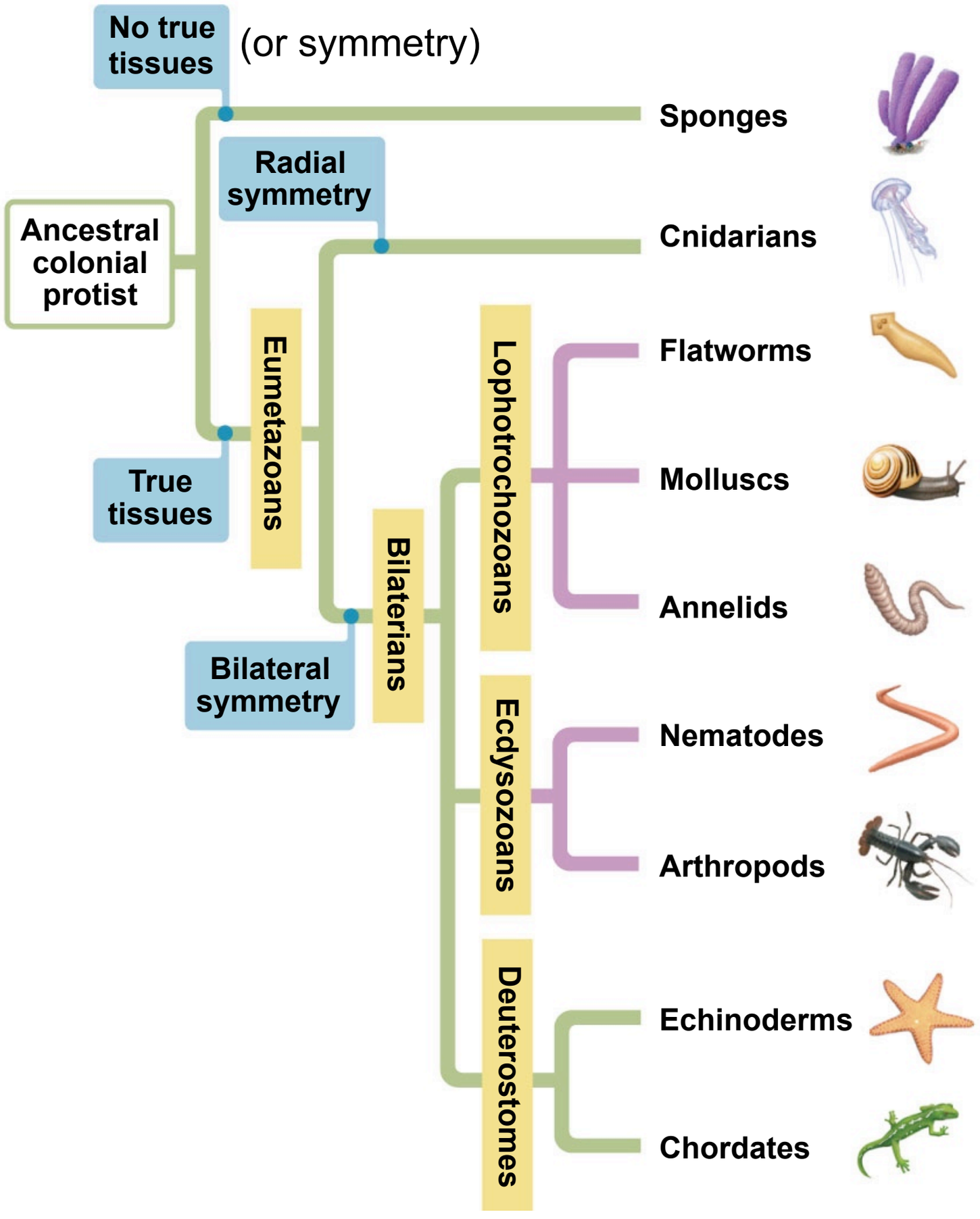
Invertebrates: animals without backbones



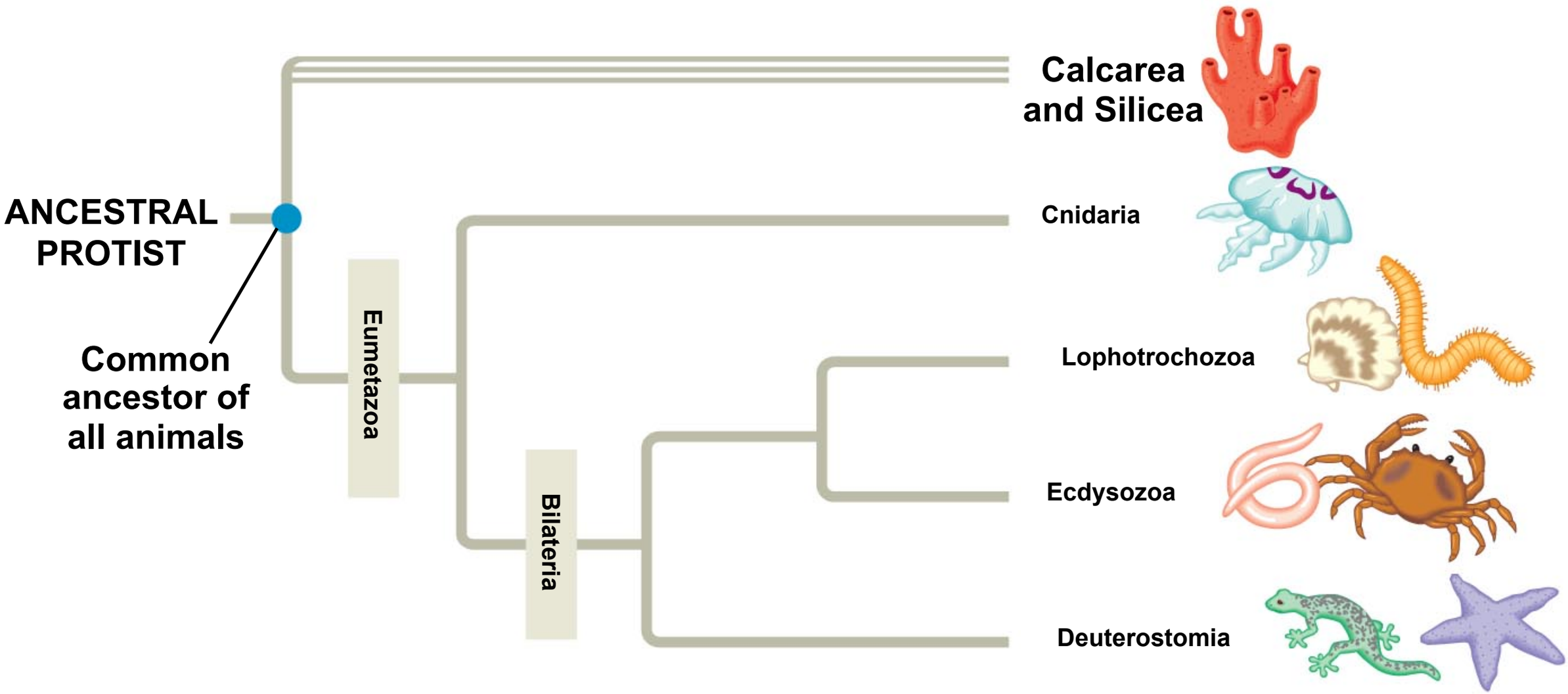


THE MARCH OF THE PHYLA!

Invertebrate Phyla



(Figure 18.4)



Phylum Arthropoda

The most abundant phylum!

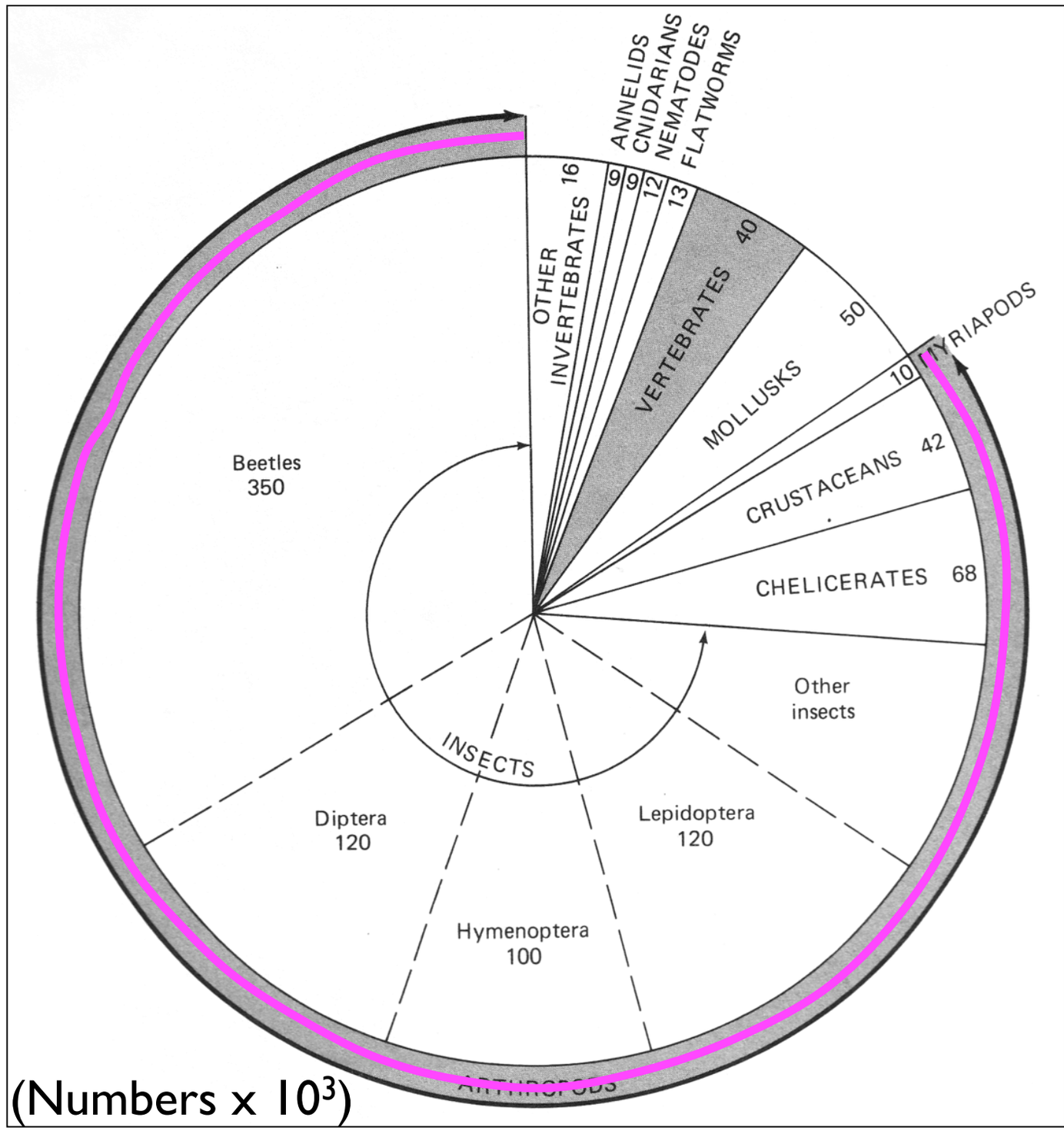
- There are > 1 million species of **arthropods** (including crayfish, lobsters, crabs, barnacles, spiders, ticks, and insects, many zooplankton).
- Arthropods have
  - an **open circulatory system** and
  - an **exoskeleton of chiton**, an external skeleton that protects the animal but must be shed in the process of **molting** to permit growth.
  - The body of most arthropods includes a **head, thorax, and abdomen**, although these segments may be fused.

What are the numbers?

2/3 of described species of animals are arthropods. The vast majority of known animal species (> 1 million! spp)

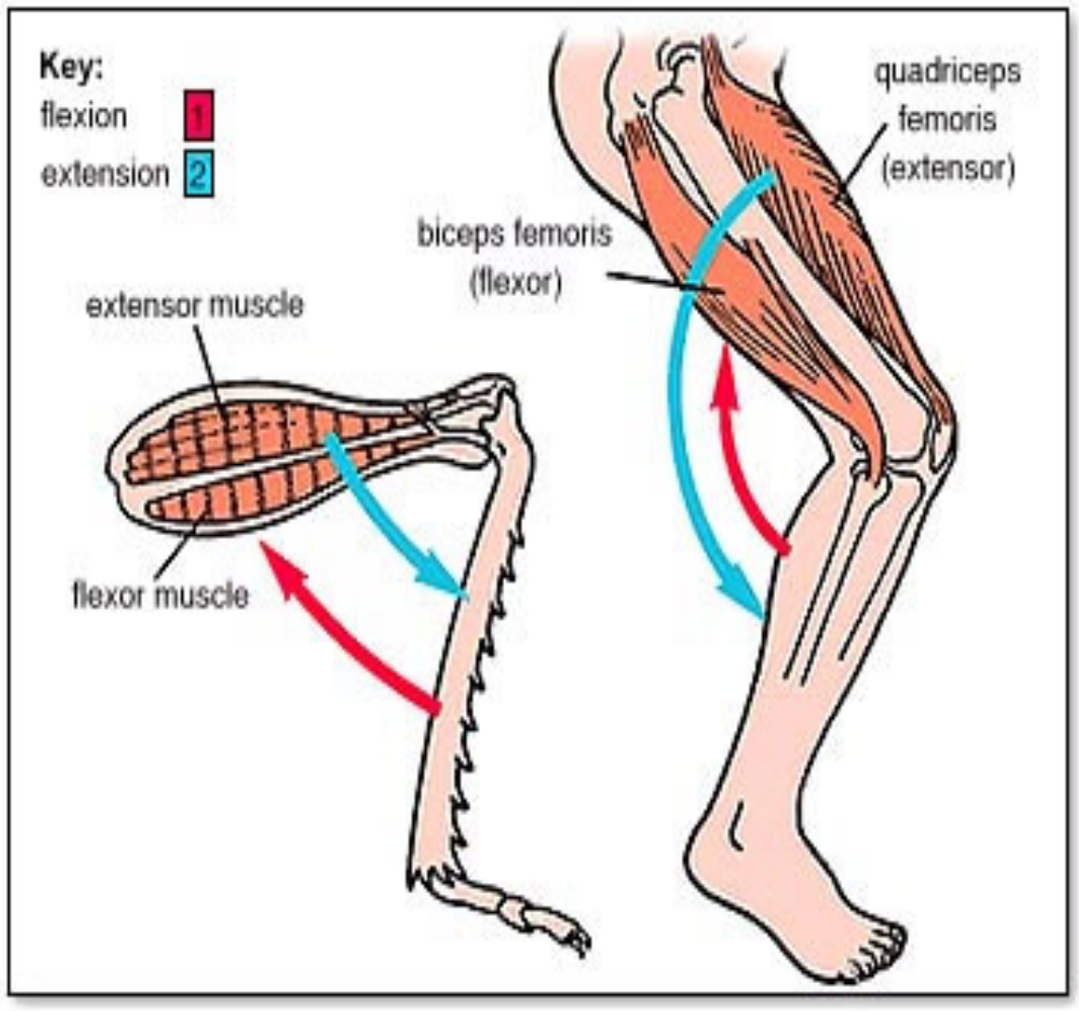
On the criteria of species diversity, distribution, and sheer numbers, arthropods are the most successful animal phylum! Found in nearly all habitats of the biosphere

Think JOINTED EXOSKELETON!



(Numbers x 10^3)

The Exoskeleton



- made of a tough fibrous material called chitin.
- gives the skeleton strength and flexibility.
- several pairs (5 or more) of jointed appendages (movable arms and legs).

Arthropod Diversity

- The body of an arthropod

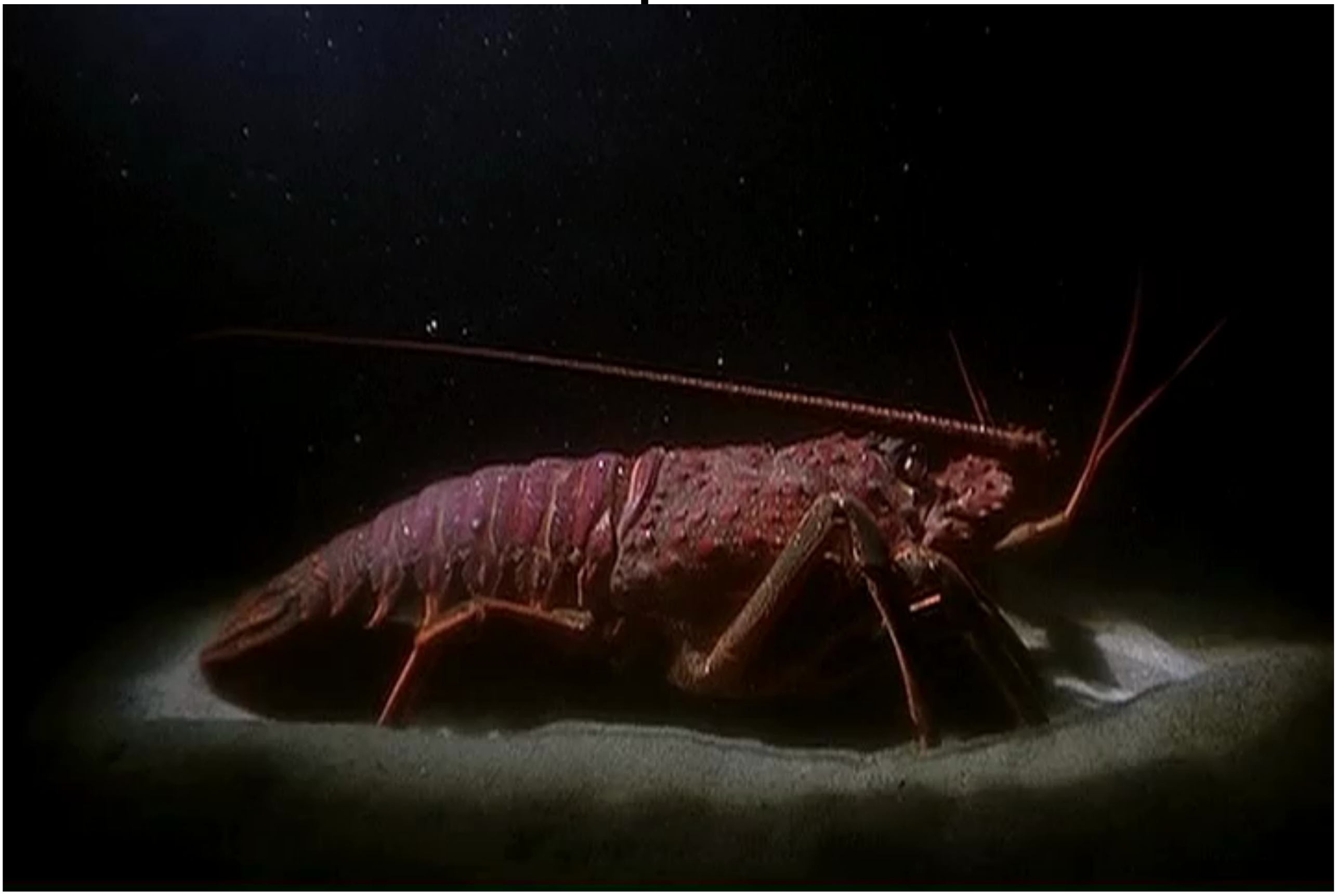
  – is completely covered by the cuticle, an exoskeleton made of chitin

- When an arthropod grows

  – it molts its exoskeleton in a process called ecdysis

  – ecdysiast = stripper

Arthropod Limbs



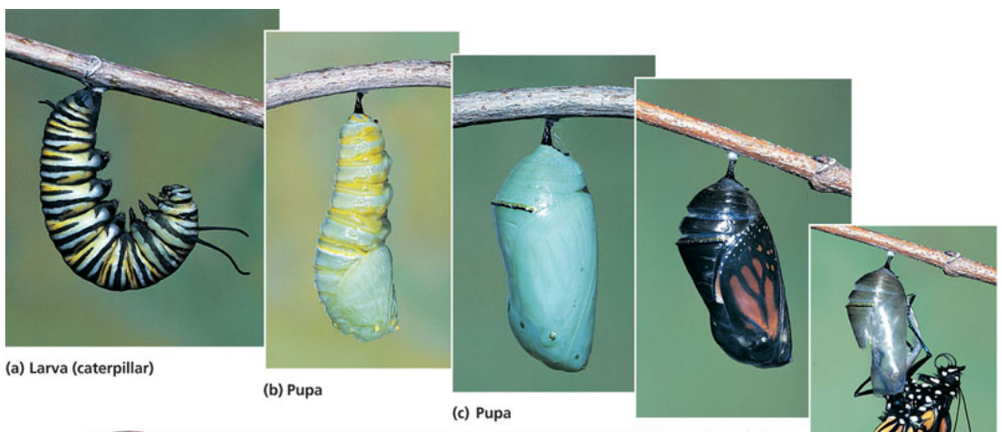
Arthropod Molting

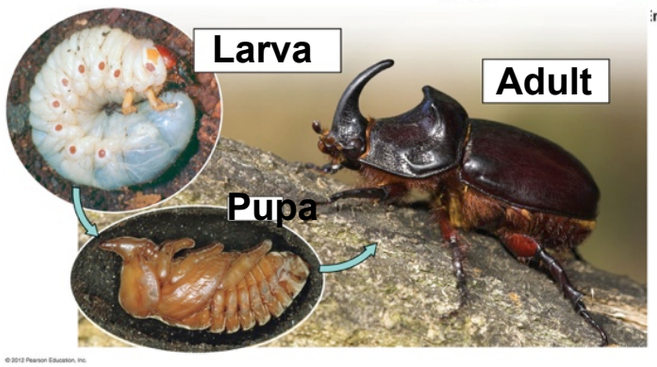
Arthropod Flight

Types of metamorphosis in insects

- Insect life cycles often include **metamorphosis**, during which the animal takes on different body forms as it develops from larva to adult.
  - More than 80% of insect species undergo **complete metamorphosis** in which a free-living larva transforms from a pupa into an adult.

Other insect species undergo **incomplete metamorphosis** in which the transition from larva to adult is achieved through multiple molts, but without forming a pupa.

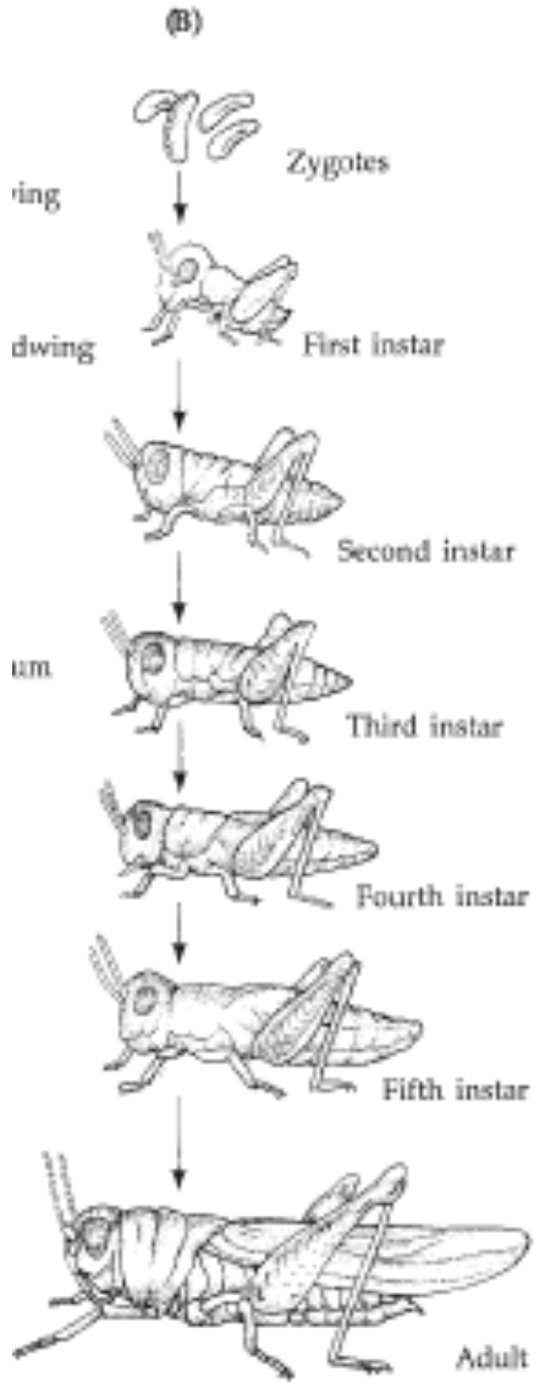




Complete metamorphosis (indirect development)

(example: butterflies and beetles); not pillbugs

Incomplete metamorphosis (direct development)



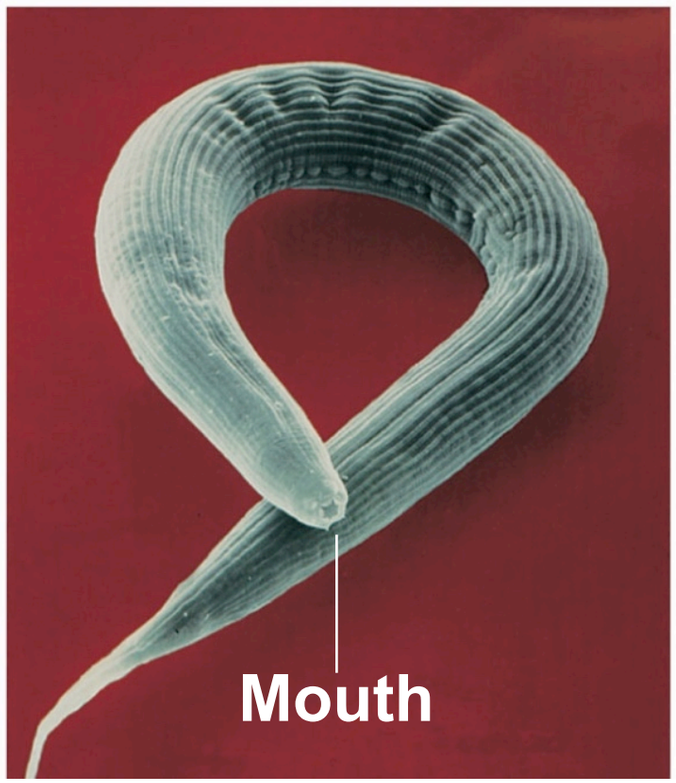
Phylum Nematoda

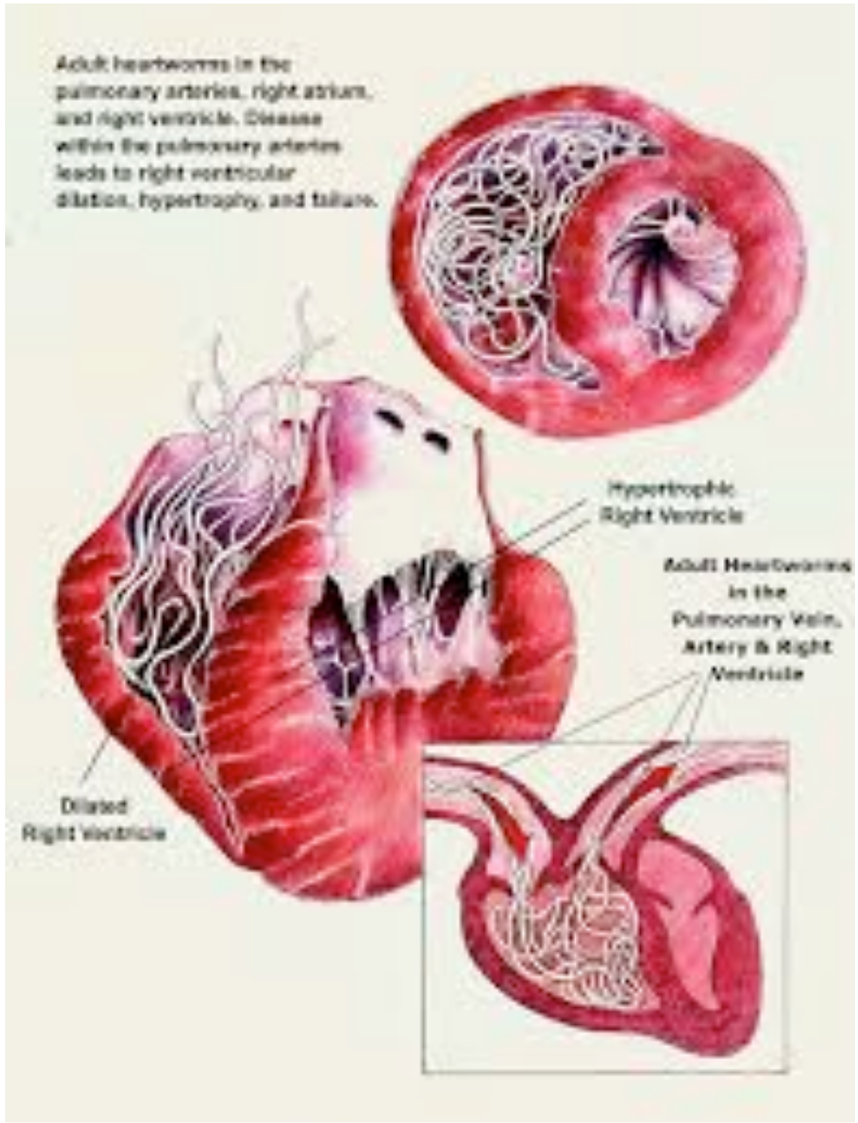
Have a pseudocoelom and a complete digestive tract

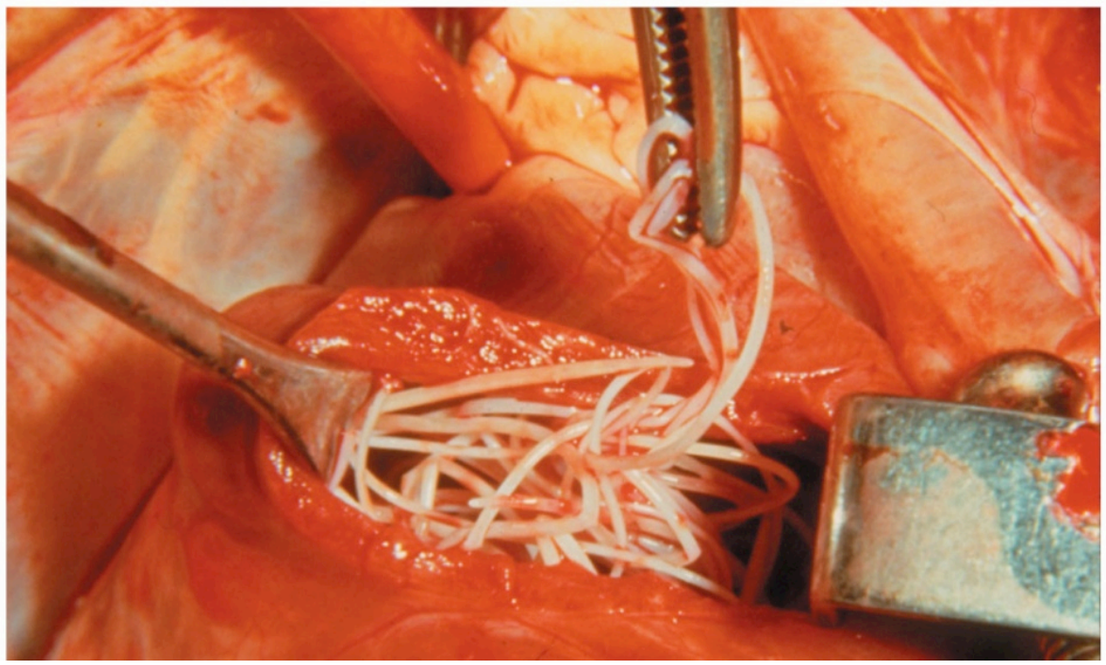
- **Nematodes** or roundworms (phylum Nematoda) are abundant and diverse, with ~500,000 species. Nematodes have
  - bilateral symmetry,
  - three tissue layers = triploblastic
  - a nonliving **cuticle** covering the body that prevents them from drying out,
  - a pseudocoelom body cavity that functions to distribute nutrients and as a hydroskeleton, and
  - a **complete digestive tract** with a mouth and anus.

Nematodes

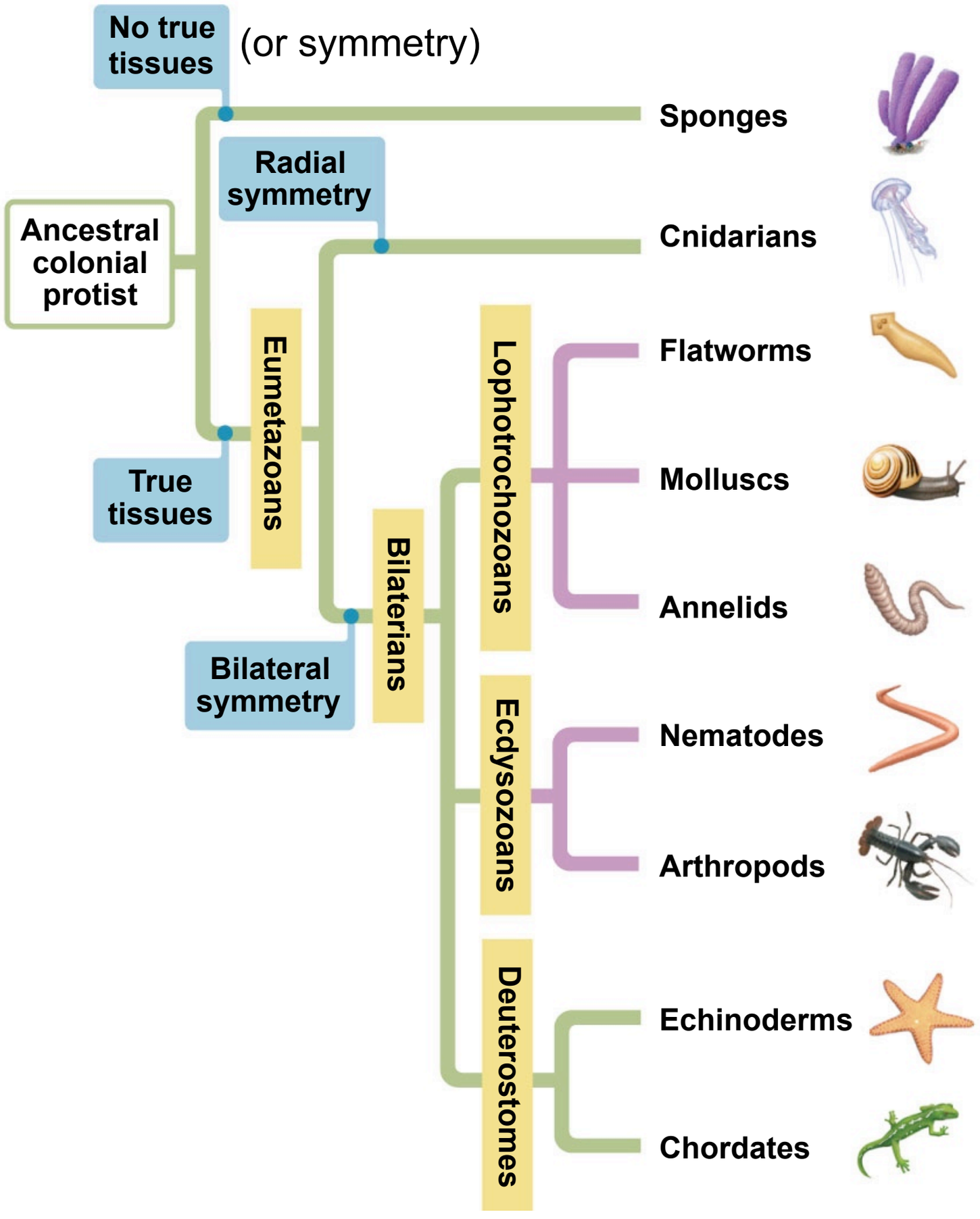
- Although about 25,000 species of nematodes have been named, estimates of the total number of species range >500,000.
- Humans host at least 50 species of parasitic nematodes.







Invertebrate Phyla



(Figure 18.4)

Phylum Platyhelmenthes (Flatworms): the simplest bilateral animals

- The vast majority of animal species belong to the clade Bilateria, consisting of animals with bilateral symmetry.
- **Flatworms** are the simplest bilaterians.
- Live in marine, freshwater, and damp terrestrial habitats.
- Some are parasitic and others are free-living.

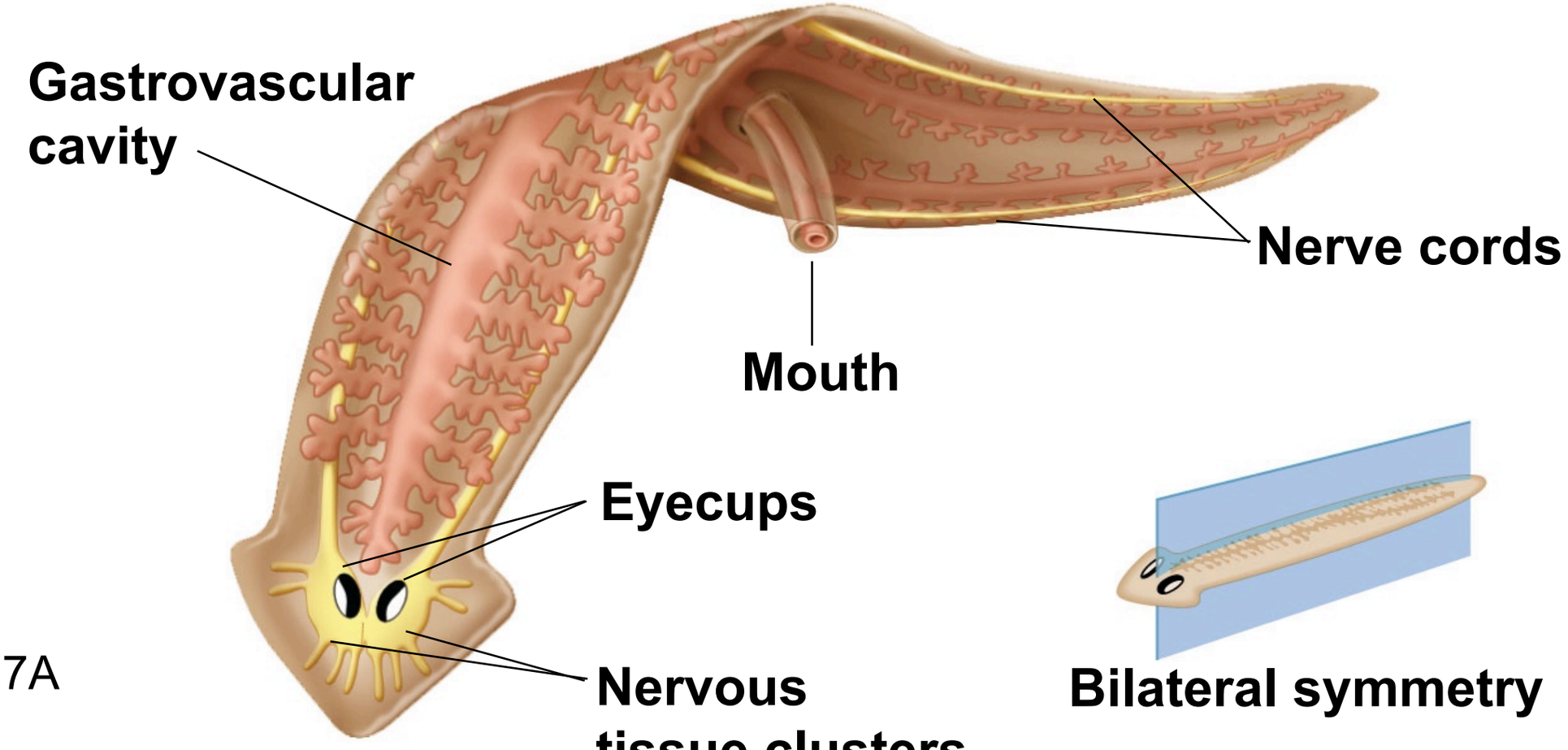
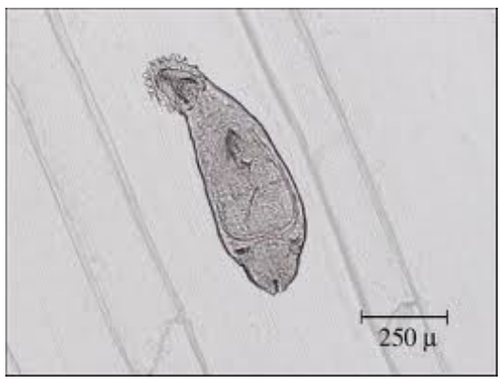


Figure 18.7A

There are three major groups of flatworms

1. **Free-living flatworms** (planarians) have
   - heads with light-sensitive eyespots,
   - flaps to detect chemicals**,**
   - dense clusters of nerve cells that form a simple brain and a pair of nerve cords that runs the length of the body
   - a branched gastrovascular cavity with a single opening.

2. **Flukes** are parasitic flatworms with complex life cycles and suckers to attach to their hosts.



3. **Tapeworms**

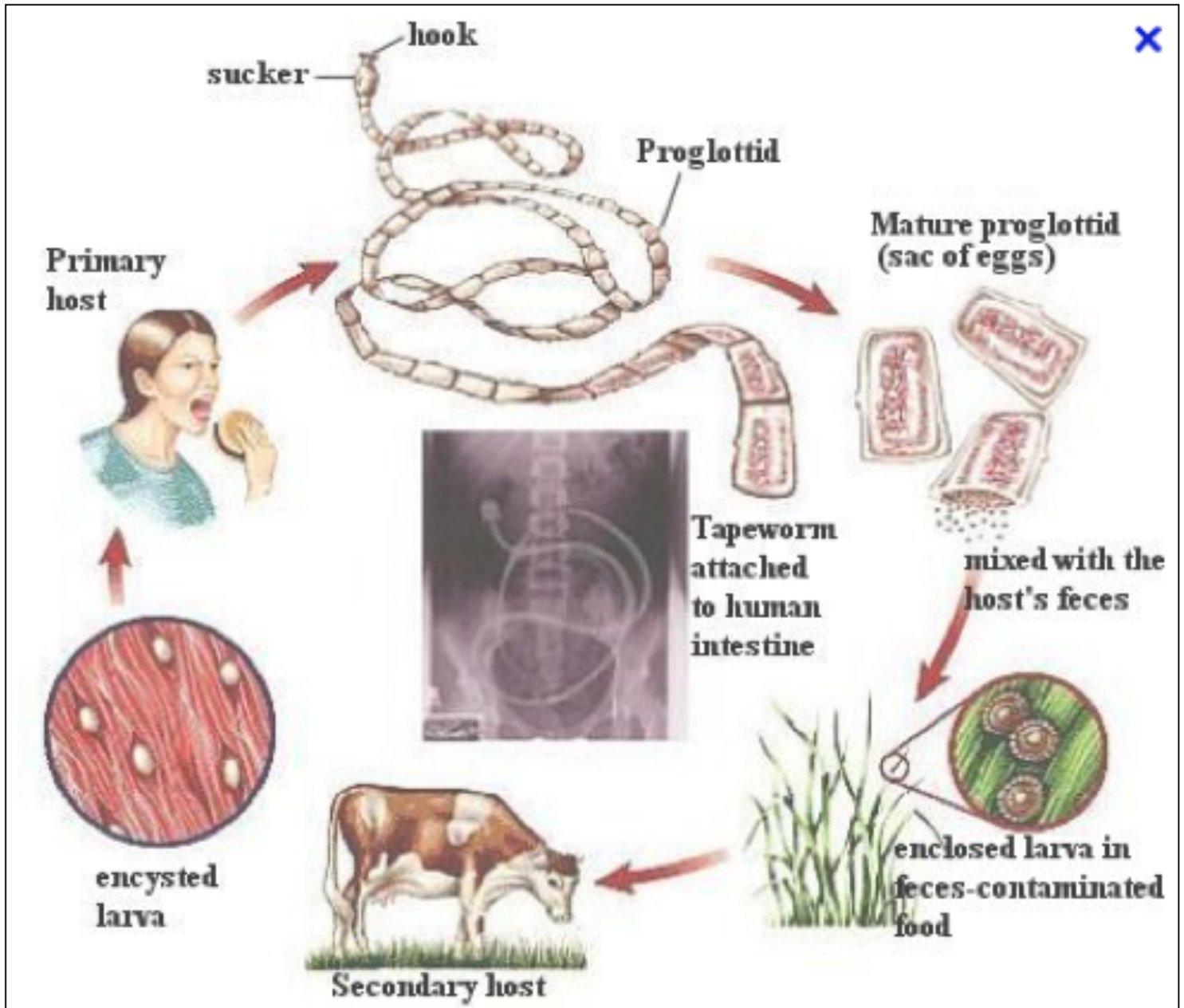
are parasitic inhabitants of the digestive tracts of vertebrates,

consist of a ribbon-like body with repeated units,

have an anterior *scolex* armed with hooks and suckers that grasp the host,

have no mouth, and simply absorb nutrients across their body surface.

Units at the end of tapeworms are full of ripe eggs that pass out of host.




OZ


LOSE WEIGHT
LARD-B-GONE
The Easy Way!
TRY
New & Improved
LARD-B-GONE
NOW WITH LIVE TAPEWORM EGGS!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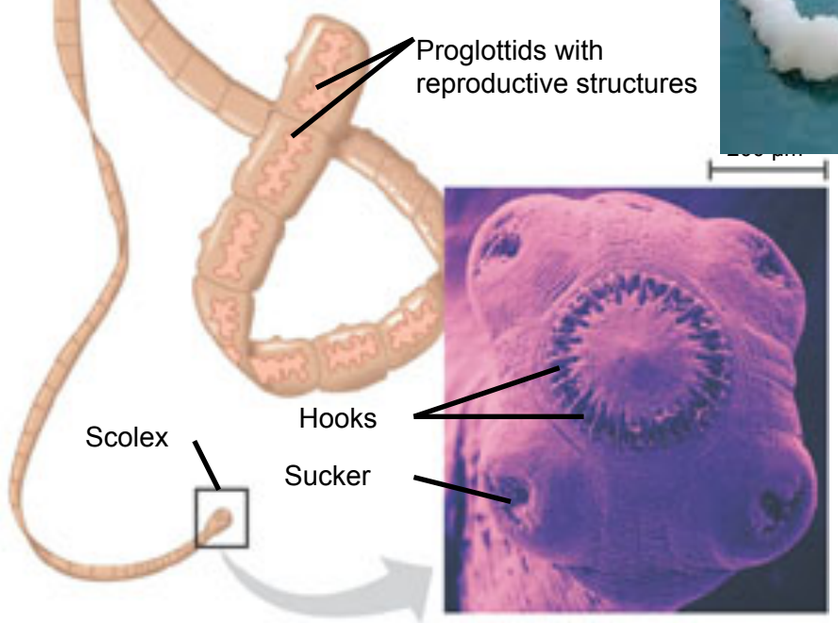
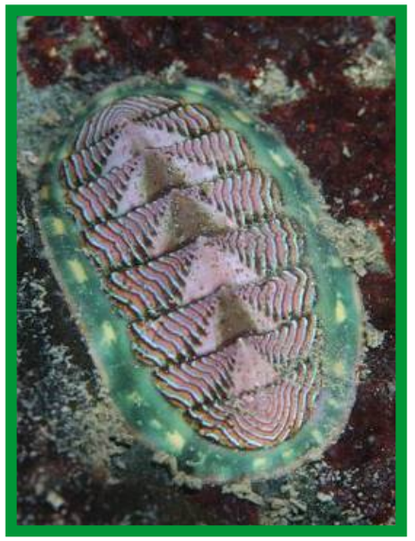
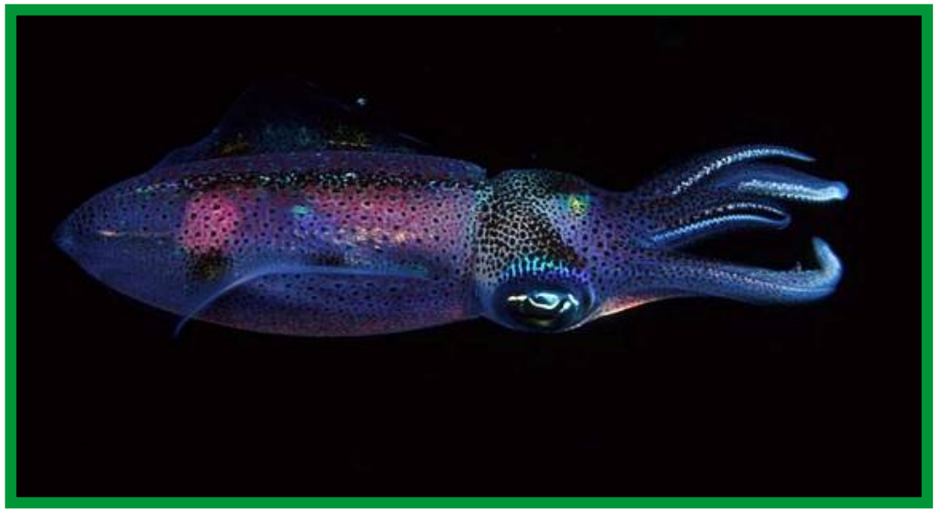

Proglottids with reproductive structures
Hooks
Scolex
Sucker


NO DIET - NO BATHS
NO EXERCISE!
FAT
the ENEMY that is shortening Your Life
BANISHED!
SANITIZED
TAPE WORMS
Jar Packed
Easy To Swallow!
No Ill Effects!
FREE

Phyla Mollusca



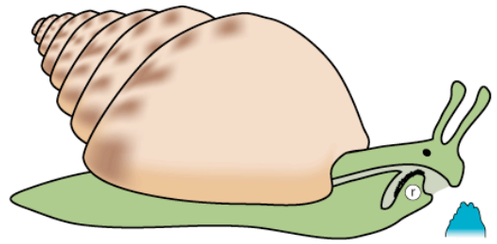


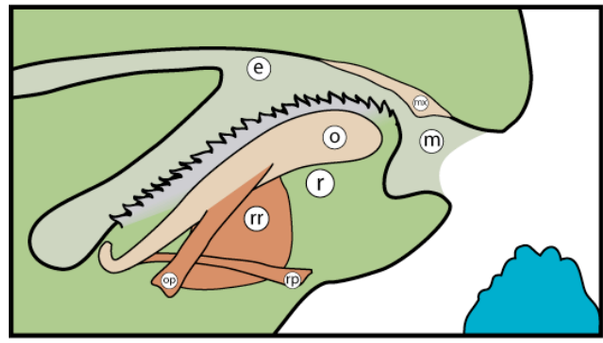
Eye candy

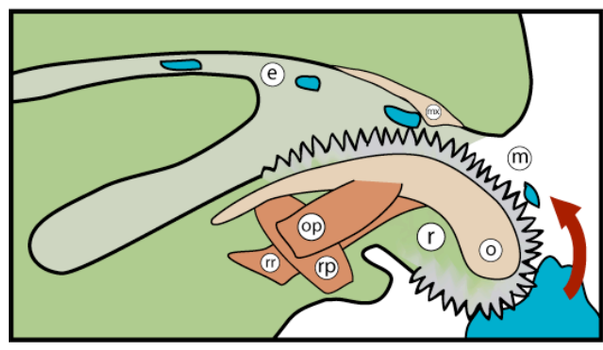
Diverse variations on a common body plan

Molluscs (phylum Mollusca) have

- a **muscular foot** that functions in locomotion,
- a **visceral mass** containing most internal organs,
- a **mantle**, which may secrete a shell that encloses the visceral mass, and
- a **true coelom** and a circulatory system that pumps blood throughout the body.
- Many molluscs feed with a rasping **radula**, used to scrape up food.
- The life cycle of many marine molluscs includes a **ciliated trochophore larval stage**.







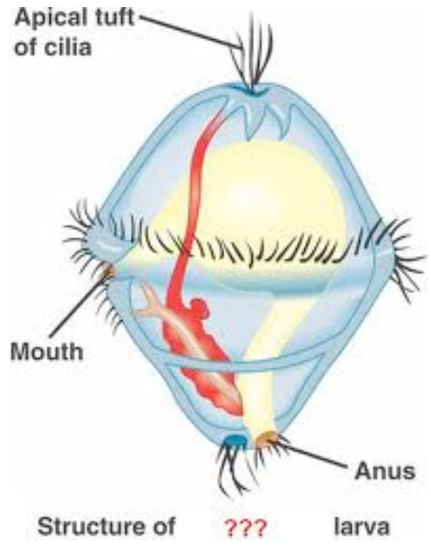
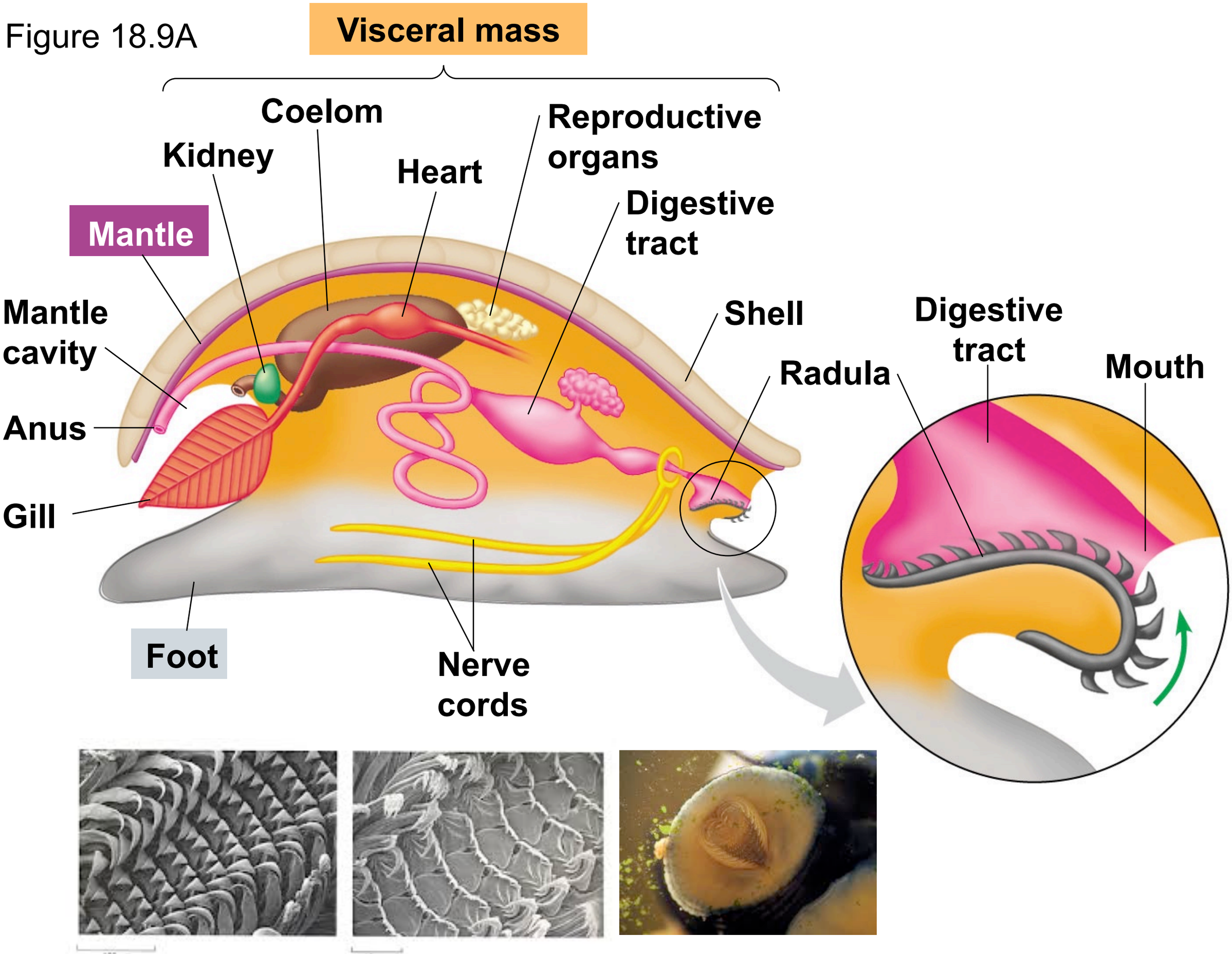


Figure 18.9A


Visceral mass
Coelom
Kidney
Heart
Reproductive organs
Digestive tract
Mantle
Mantle cavity
Shell
Anus
Radula
Gill
Foot
Nerve cords
Digestive tract
Mouth

100 µm

40 µm

Molluscs: Gastropods

The largest group of molluscs and include the snails and slugs.

- found in fresh water, marine, and terrestrial environments,
- the only molluscs that live on land, using the mantle cavity as a lung, and
- often protected by a single, spiral shell.
- Slugs have lost their mantle and shell and some have long colorful projections that function as gills.

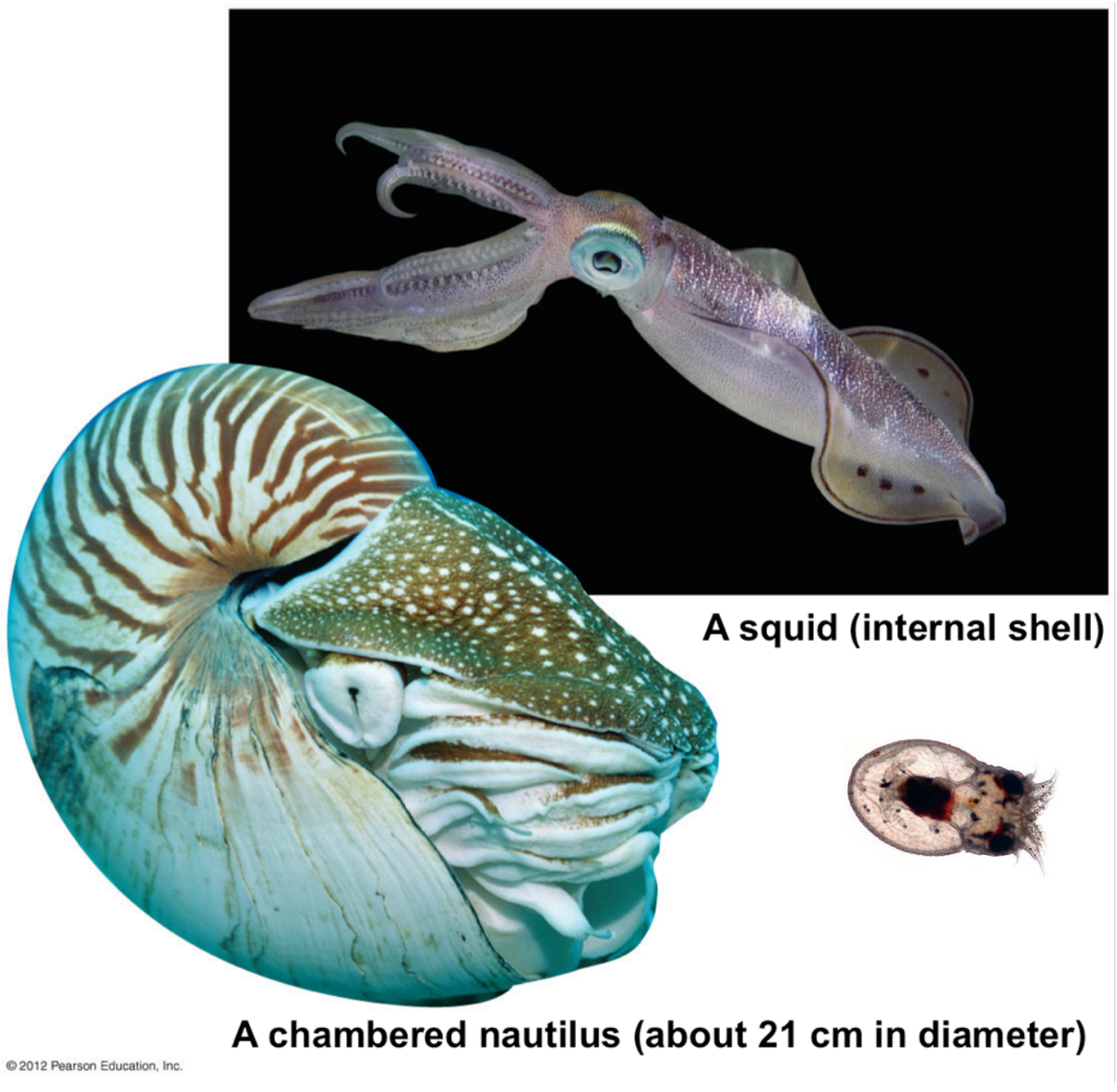
Molluscs: Bivalves

Mussels (each about 6 cm long)

A scallop (about 10 cm in diameter)

- Include clams, oysters, mussels, and scallops and
- Have shells divided into two halves that are hinged together.
- Most bivalves are sedentary suspension feeders, attached to the substrate by strong threads.

Phyla Mollusca: Cephalopods



- Are fast, agile predators,
- Have large brains and sophisticated sense organs, including complex image-focusing eyes,
- Have a shell that is large in a nautilus, small and internal in a squid, or missing in an octopus.
- Squid are fast, streamlined predators that use a muscular siphon for jet propulsion.
- Octopuses live on or near the seafloor, where they are active predators.

(direct development in octopuses)

Squid are the largest invertebrates

Phylum Annelida: The segmented worms

Annelids have

- **segmentation**, the subdivision of the body along its length into a series of repeated parts,
- a **true coelom** that functions as a hydrostatic skeleton,
- **triploblastic** tissue organization
- a **nervous system** that includes a simple brain and ventral nerve cord, and
- a **closed circulatory system** in which blood remains enclosed in vessels throughout the body.

Annelids are found in damp soil, the sea, and most freshwater habitats.

Figure 18.10A

A giant Australian earthworm

3 classes: Oligochaetes, Polychaetes and Leeches

Types of annelids

Oligochaetes (earthworms) ingest soil and extract nutrients, aerating soil and improving its texture.

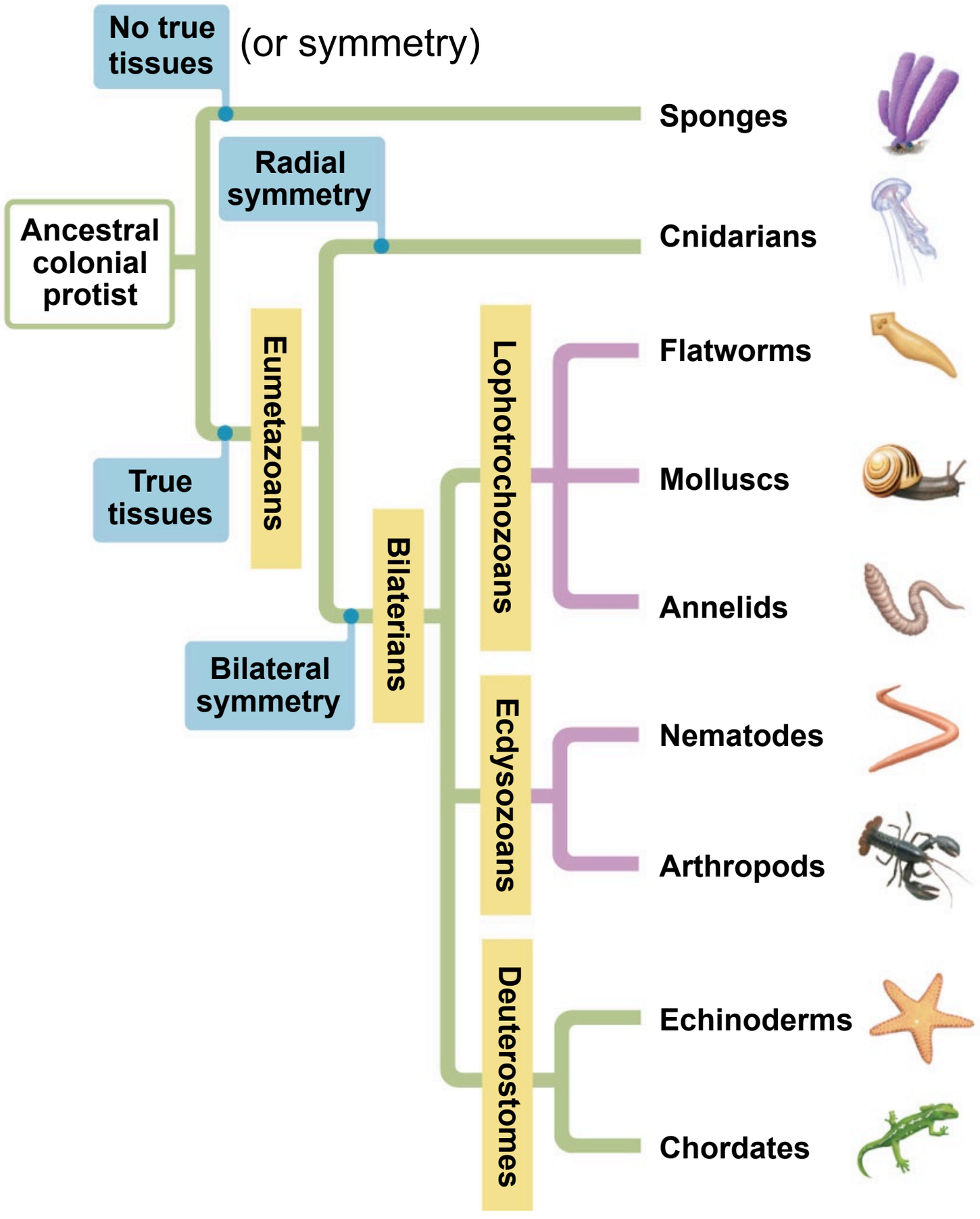
Polychaetes are the largest group of annelids.

- Each polychaete segment has a pair of fleshy appendages with stiff bristles or chaetae.
- Polychaetes search for prey on the seafloor or live in tubes and filter food particles.

Most **leeches** are free-living carnivores; or blood suckers.

- Blood-sucking leeches use razor-like jaws, secrete an anesthetic and an anticoagulant, and suck up to 10 times their own weight in blood.

Invertebrate Phyla



(Figure 18.4)

Phylum: Cnidaria

- Characterized by radial symmetry
- Two tissue layers—epidermis and digestive lining—with a jelly-filled middle region.
- Cnida (nematocysts) – stinging cells (hallmark of the phyla)

Cnidarians exhibit two kinds of body forms.

- The most sedentary **polyp** body is cylindrical with tentacles projecting from one end and/or
- The more mobile **medusa** form is exemplified by a jellyfish.

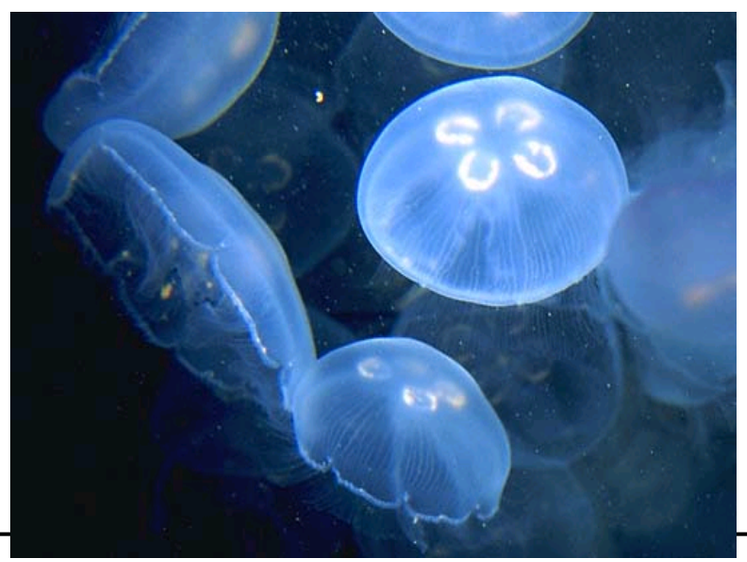
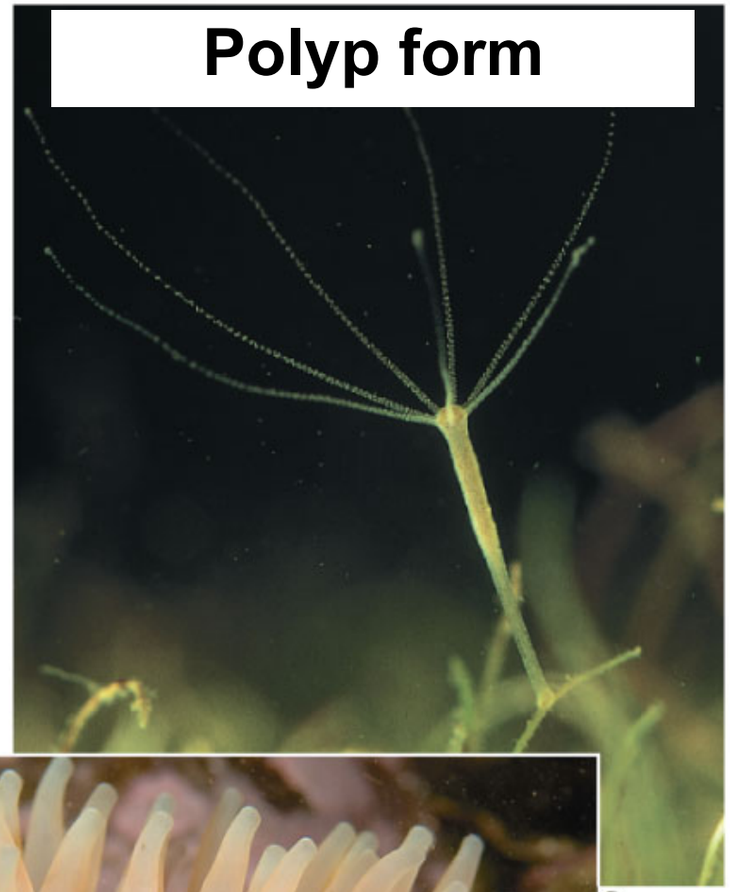


Figure 18.6A&B

A marine jellyfish
(~6 cm in diameter)

A hydra
(~2–25
mm tall)



A sea anemone
(~6 cm in diameter)

Phylum Cnidaria: with stinging cells

Cnidarians are carnivores that use their tentacles to capture prey and to push prey into their mouths.

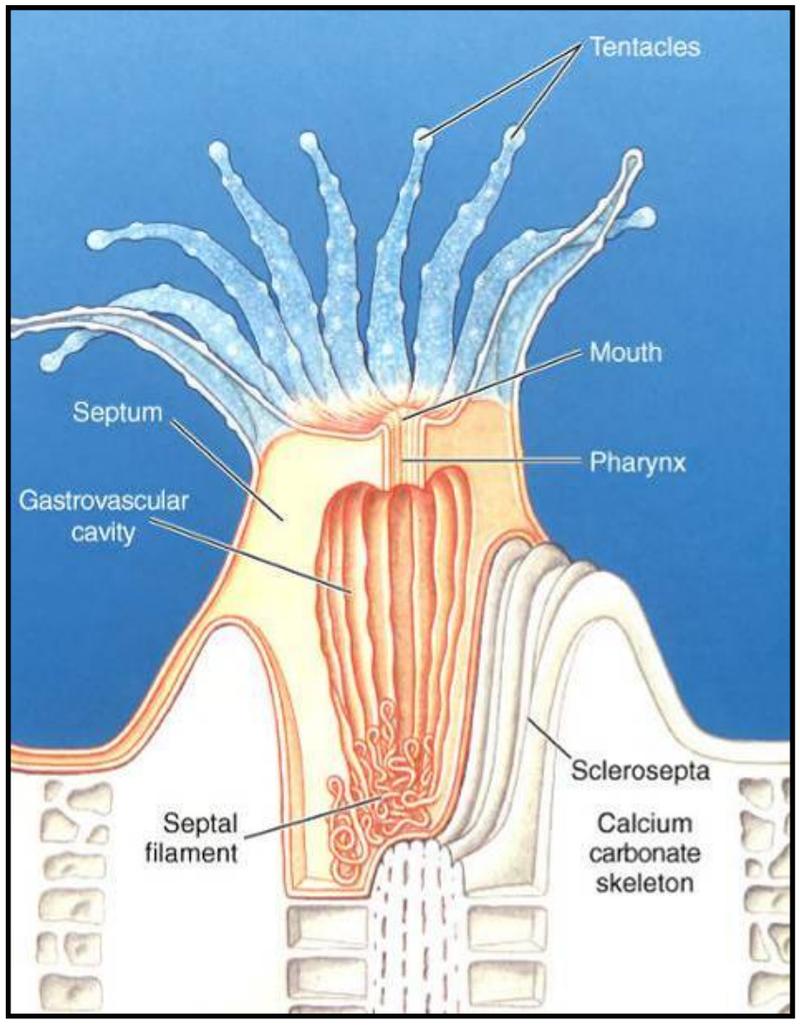
- The mouth leads to the **gastrovascular cavity**, which functions in digestion and circulation and as a hydrostatic skeleton.

- **Cnidocytes** are unique stinging cells that capture prey and function in defense.

Anthopleura elegantissima

Metridium senile

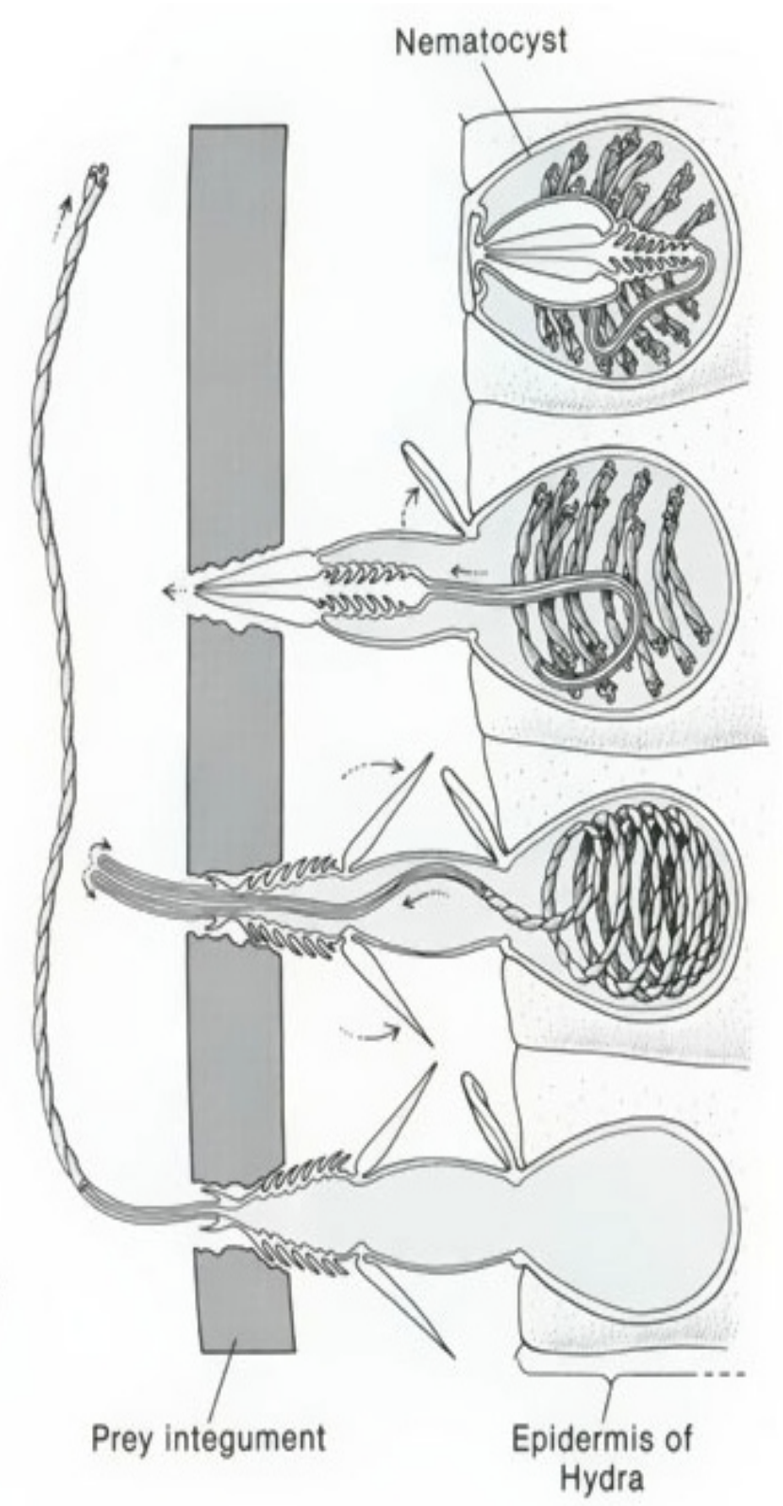
Many have **zooxanthellae**



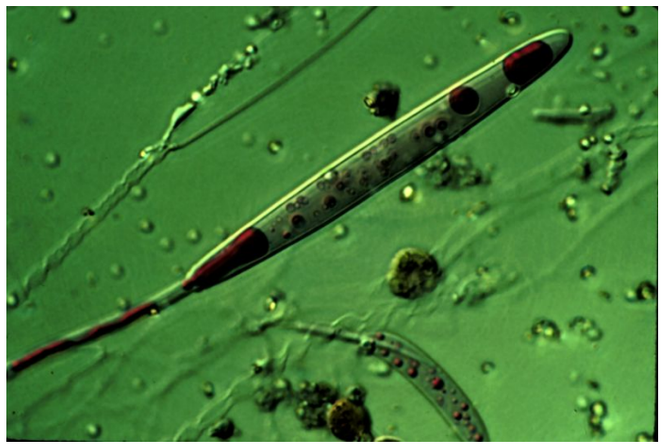
Cnidocytes

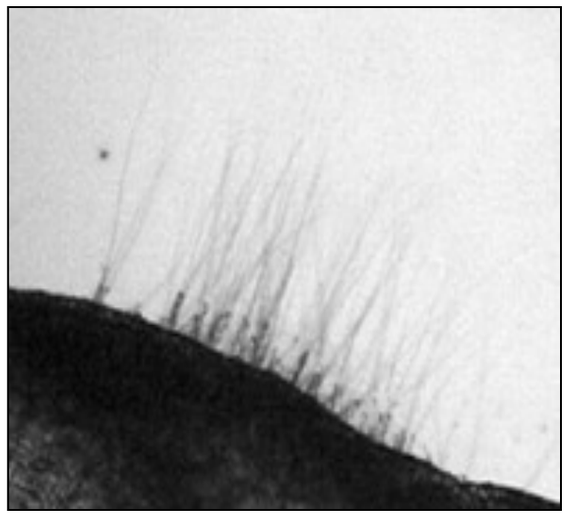
- Complex intracellular organelles cnidocytes (specialized cells that produce nematocysts)

PURPOSE
- Food capture
- Protection

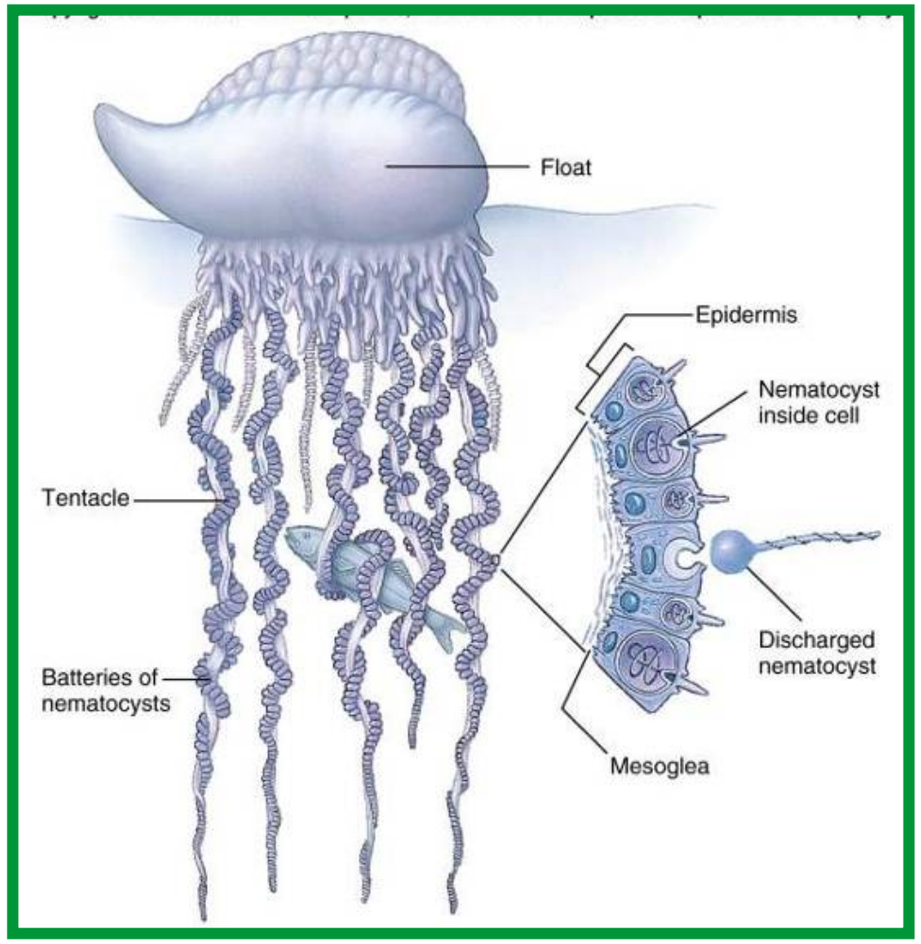


Cnidocil - triggered chemically or mechanically; operculum pops open, rapid change in pressure discharges thread (~ 3 msec.)





Prey Mimicry



Ex: Portuguese man-of-war (*Physalia*)

passive feeders; lure prey by wriggling individual specialized tentacles

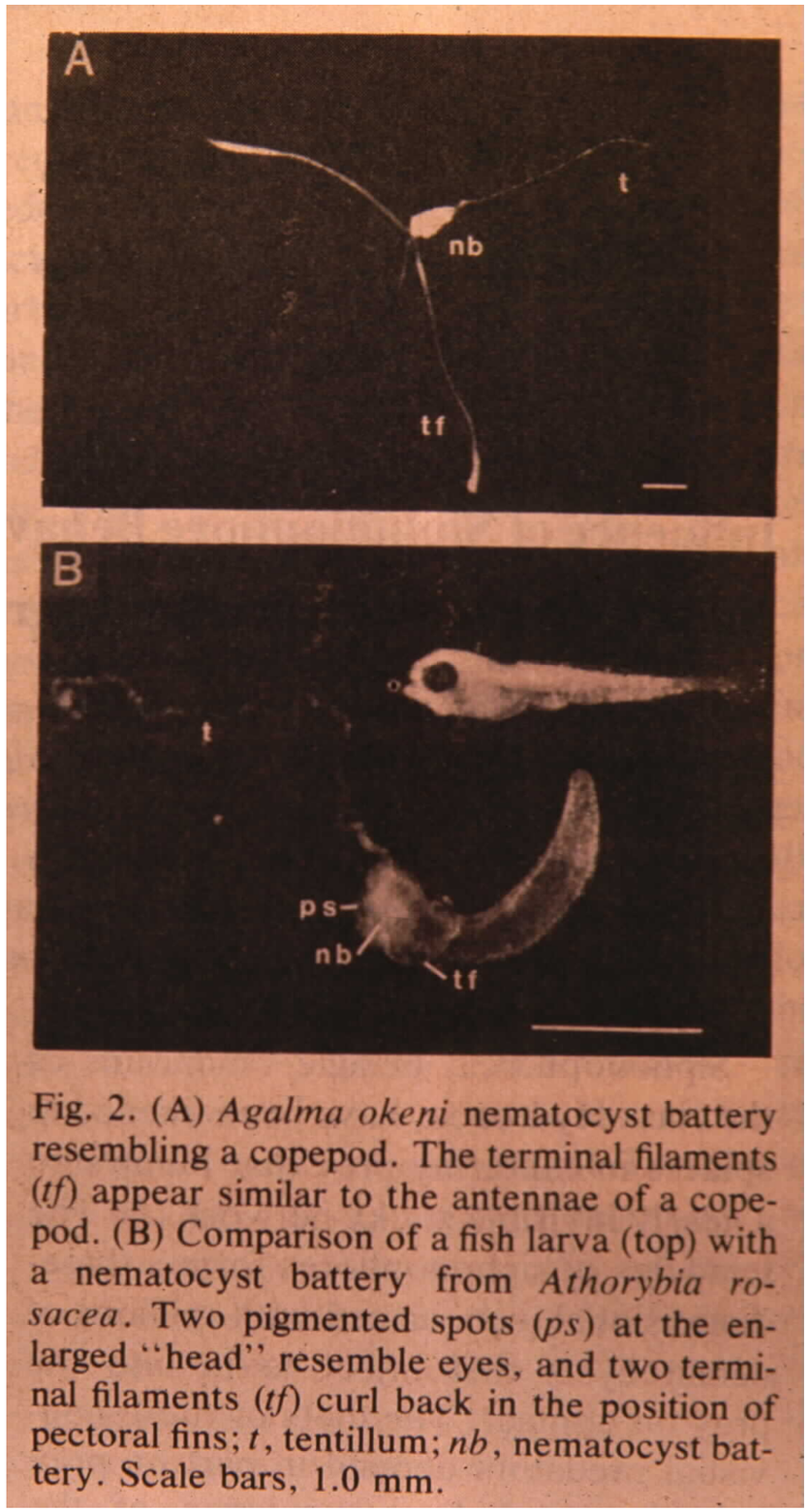


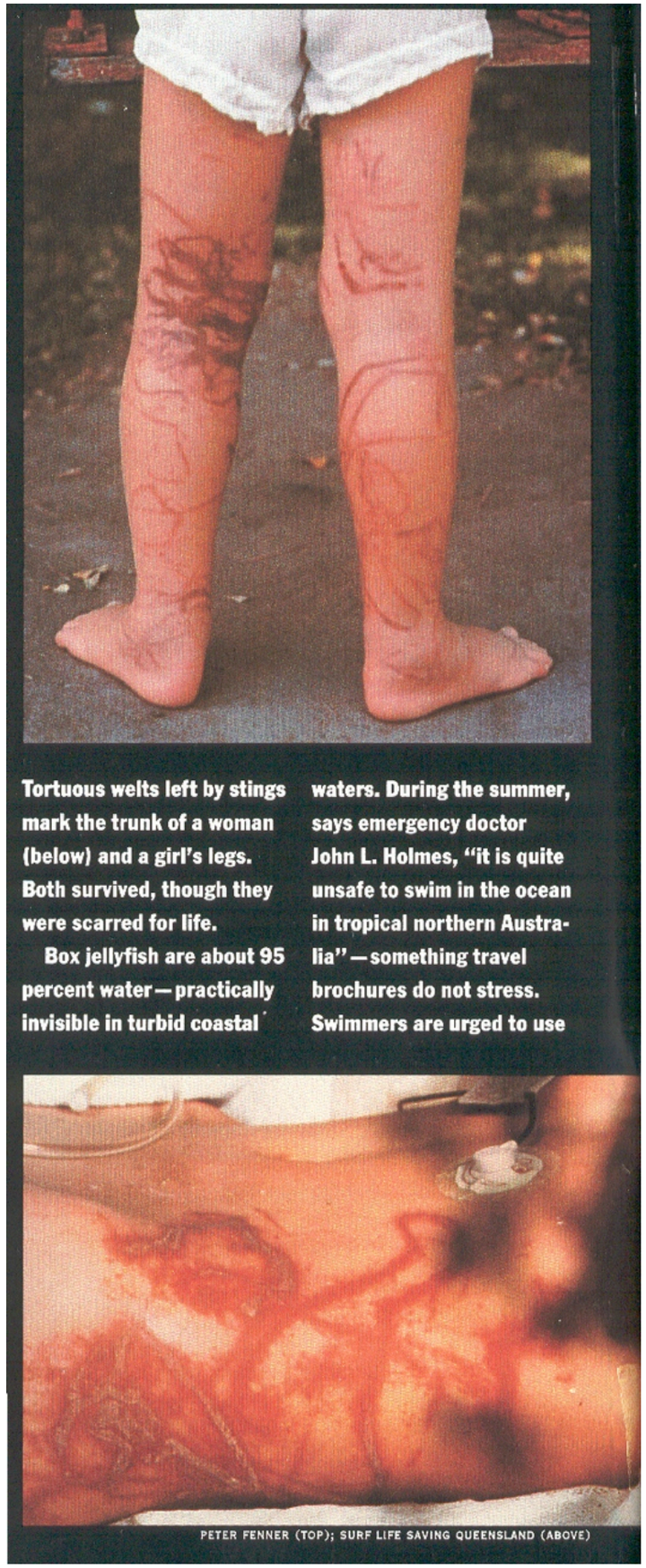
Fig. 2. (A) *Agalma okeni* nematocyst battery resembling a copepod. The terminal filaments (*tf*) appear similar to the antennae of a copepod. (B) Comparison of a fish larva (top) with a nematocyst battery from *Athorybia rosacea*. Two pigmented spots (*ps*) at the enlarged "head" resemble eyes, and two terminal filaments (*tf*) curl back in the position of pectoral fins; *t*, tentillum; *nb*, nematocyst battery. Scale bars, 1.0 mm.

(Purcell 1980)

Box Jellyfish/Cubomedusae (*Chironex fleckeri*)

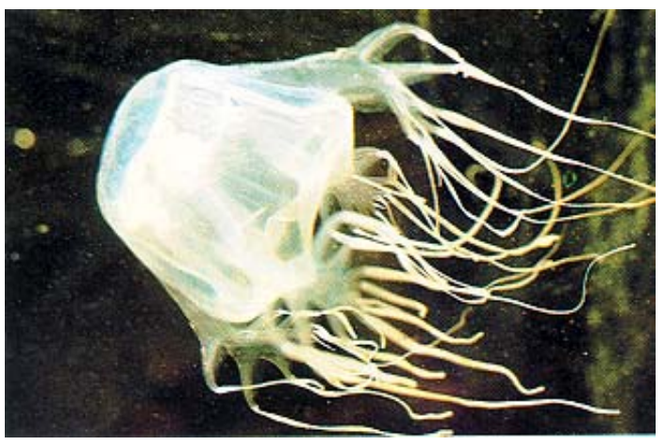
- Medusa is cuboidal
- Tentacles hang from corners
- Polyps reduced or absent

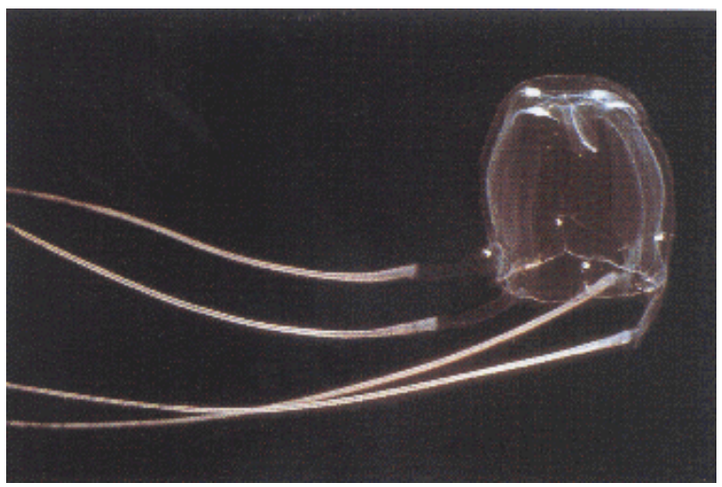
- Highly toxic nematocysts
- Can eat large fish


Tortuous welts left by stings mark the trunk of a woman (below) and a girl's legs. Both survived, though they were scarred for life.

Box jellyfish are about 95 percent water—practically invisible in turbid coastal waters. During the summer, says emergency doctor John L. Holmes, "it is quite unsafe to swim in the ocean in tropical northern Australia"—something travel brochures do not stress. Swimmers are urged to use

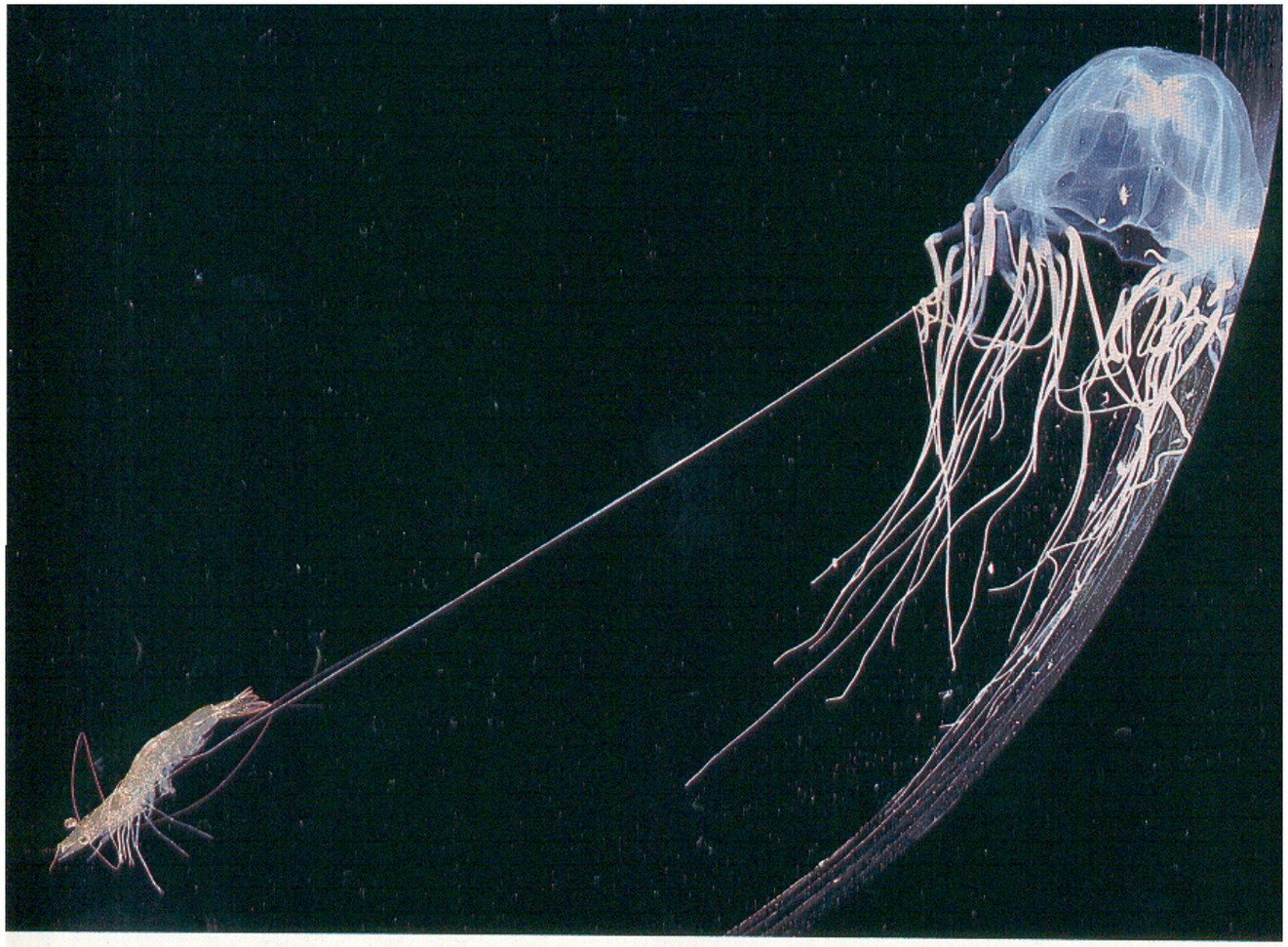
PETER FENNER (TOP); SURF LIFE SAVING QUEENSLAND (ABOVE)





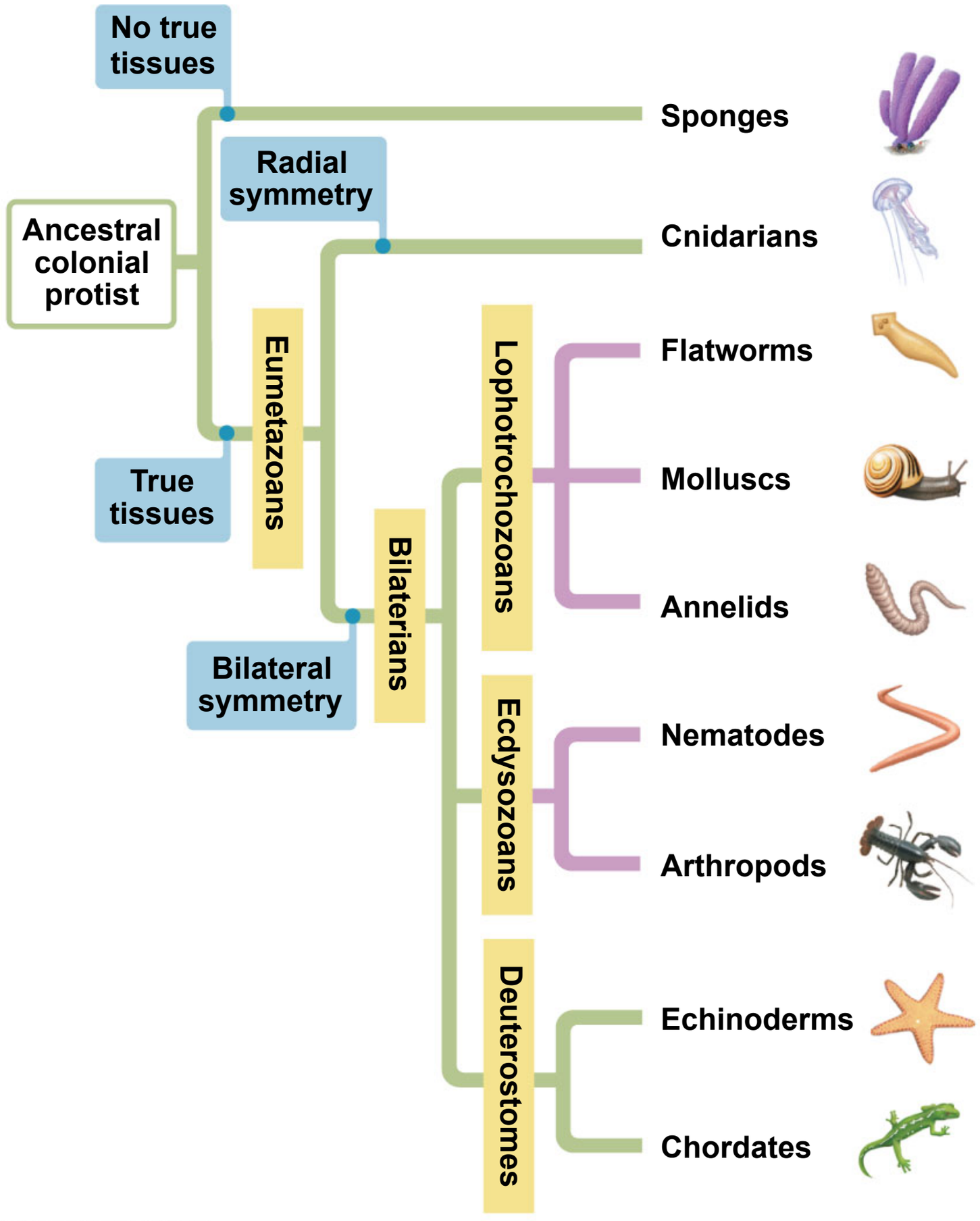
death can occur 3-20 min after sting

Why so deadly?



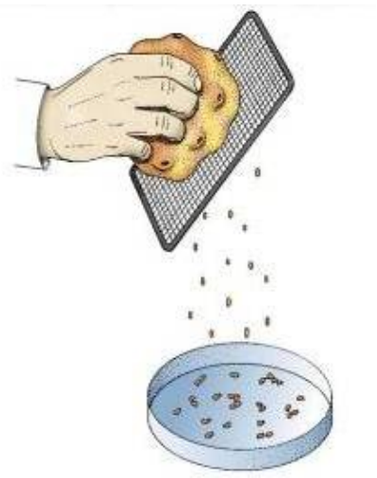
Lethal lasso snags a banana prawn and draws the meal mouthward. The victim's carapace was instantly punctured by the jelly's stinger capsules, unleashing a multipronged arsenal of toxins that attack breathing and blood cells.

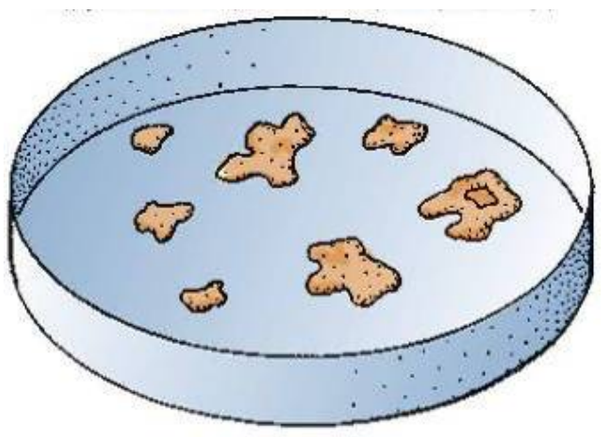
Figure 18.15

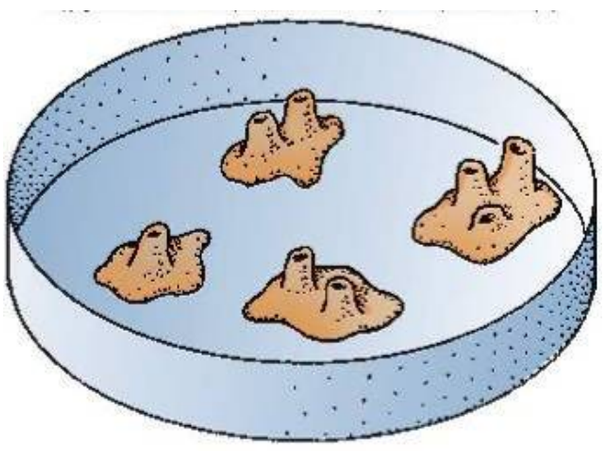


Phylum Porifera (sponges)

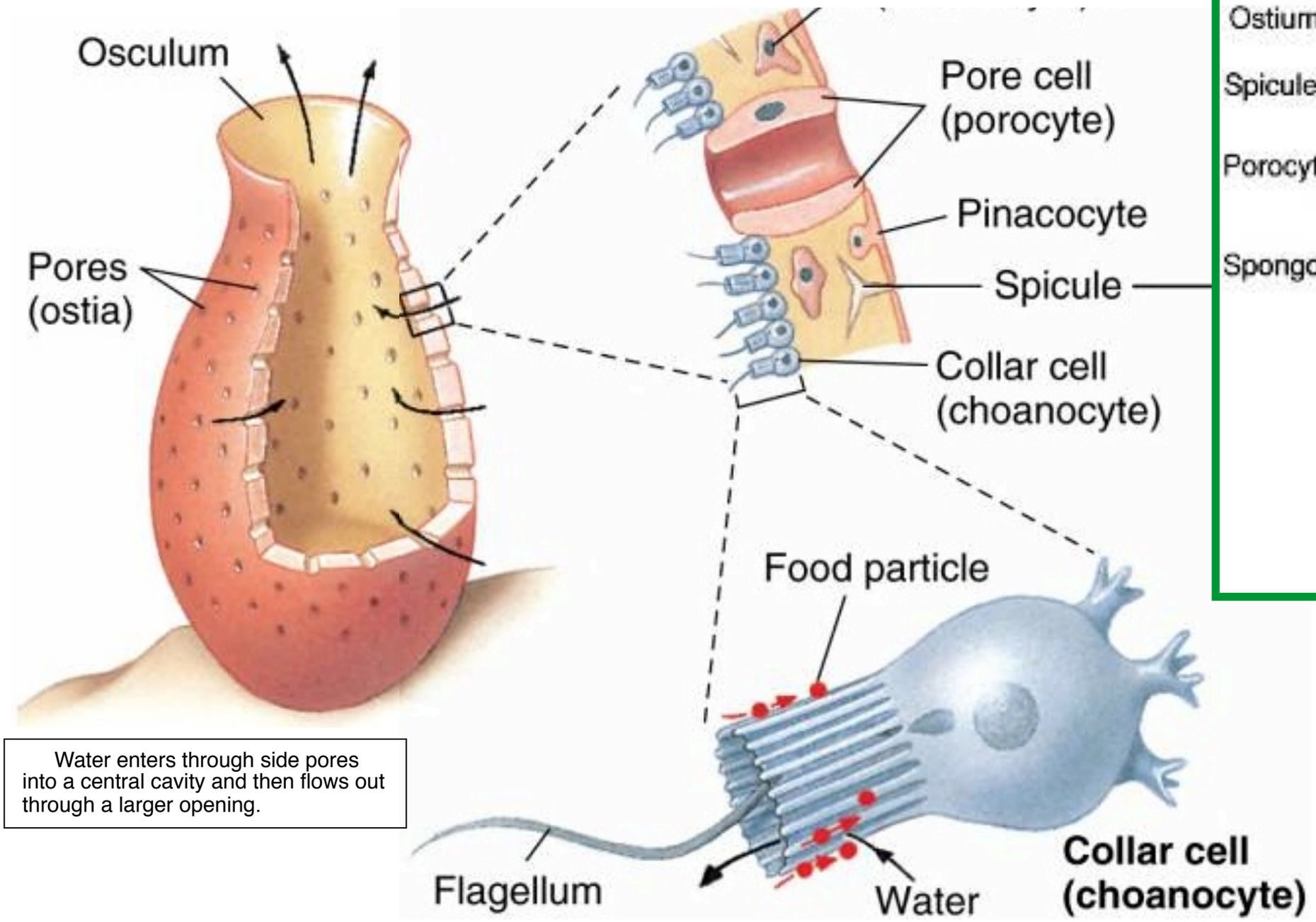
- No symmetry
- No tissues
- Spicules
- Very primitive/basal



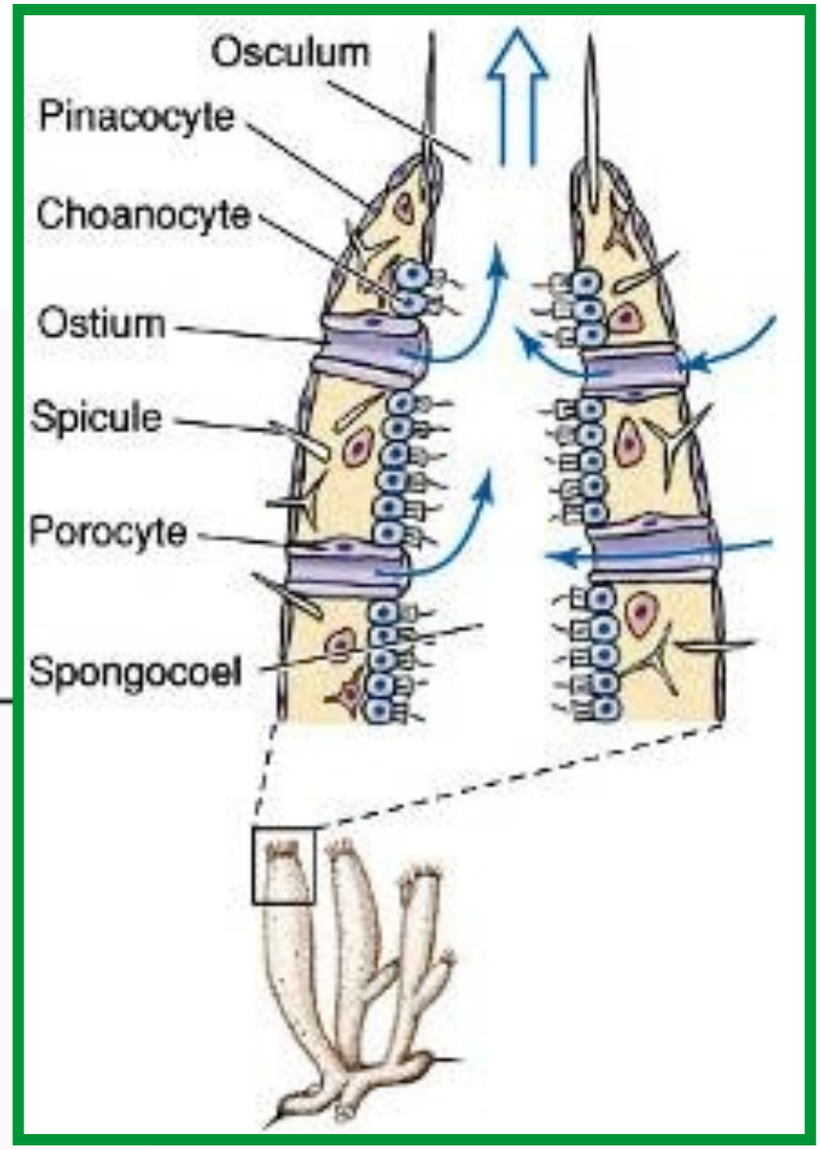




Sponge Anatomy

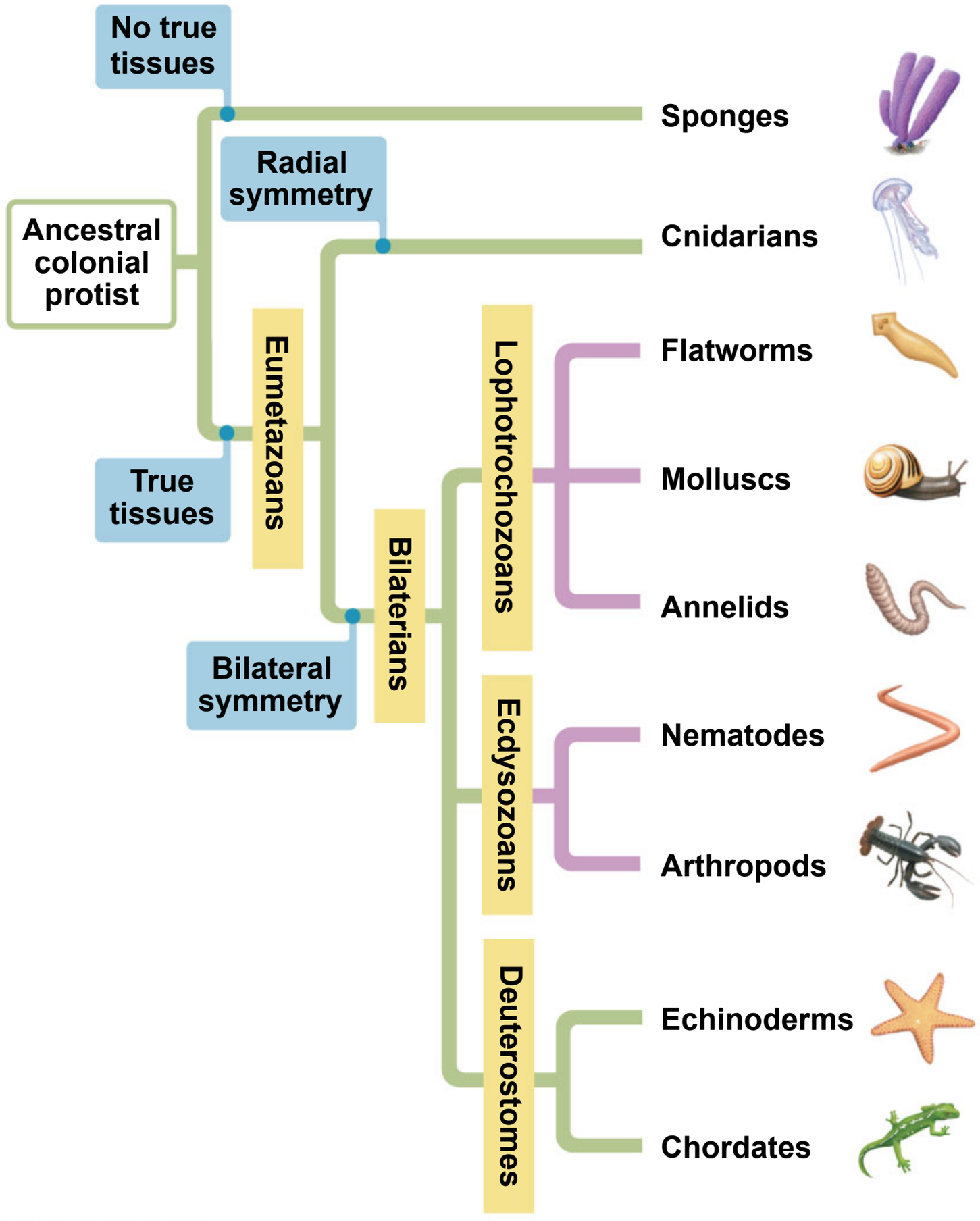


Water enters through side pores into a central cavity and then flows out through a larger opening.



The inner layer of flagellated **choanocytes** filters food and engulfs it by phagocytosis

Figure 18.15



Phyla Echinodermata

Echinoderms have spiny skin, an endoskeleton, and a water vascular system for movement

---

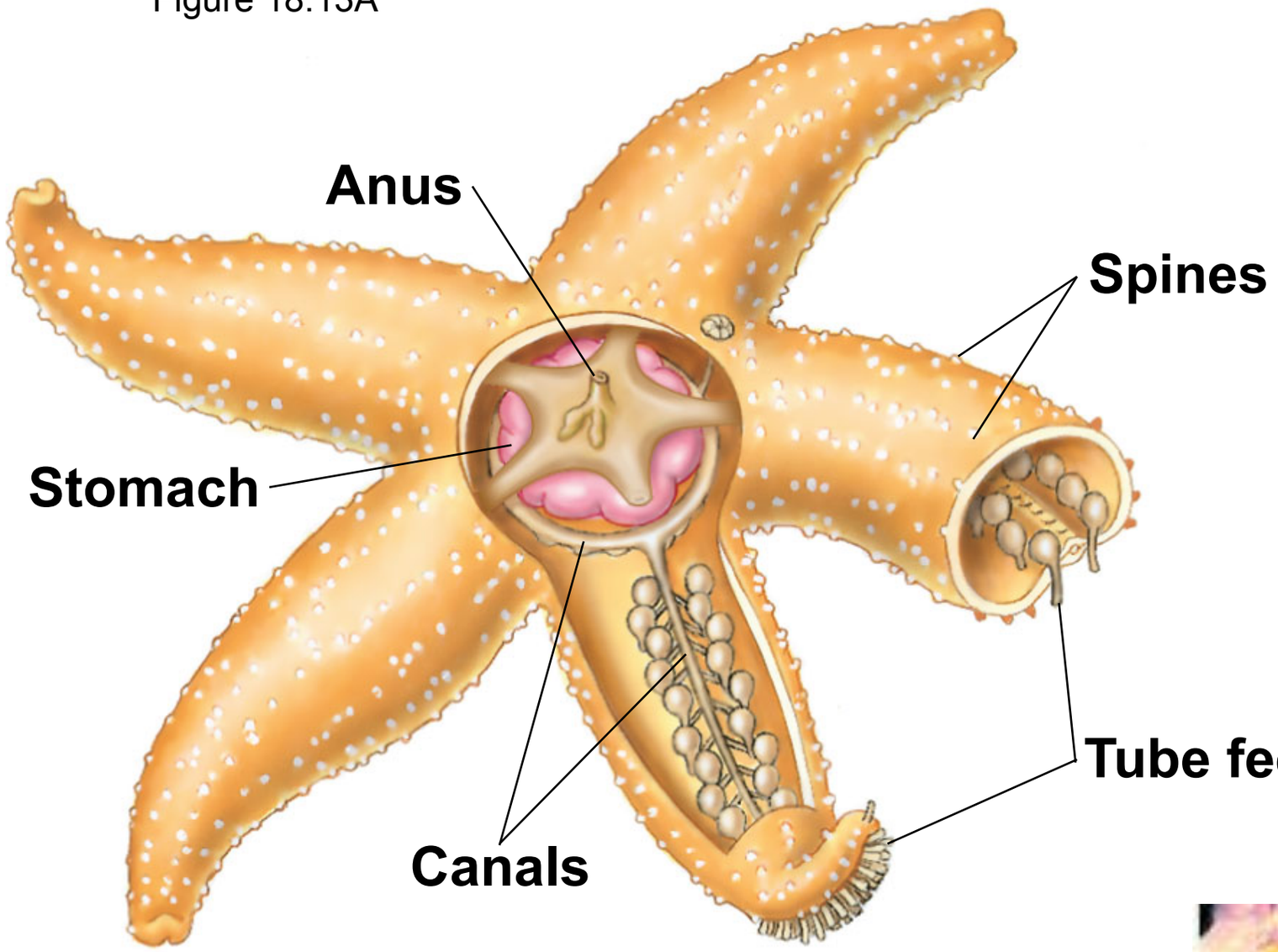
Echinoderms: a diverse group including sea stars, sea cucumbers sand dollars, and sea urchins,

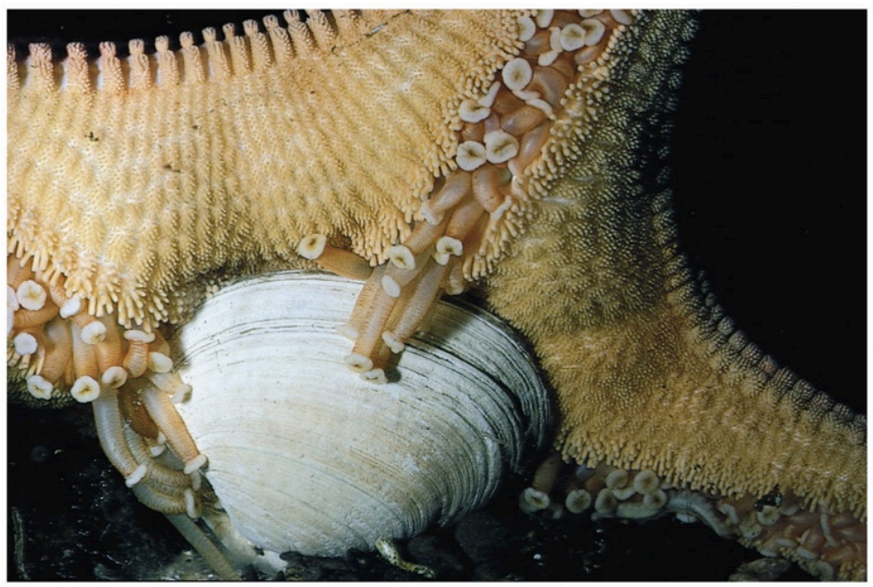
- slow-moving or sessile
- all marine
- radially symmetrical, and
- deuterostomes (along with the chordates).

Echinoderms have

- an **endoskeleton** of hard calcareous plates under a thin skin,
- a **water vascular system** based on a network of water-filled canals that branch into extensions called tube feet, and
- the ability to regenerate lost arms.

Figure 18.13A





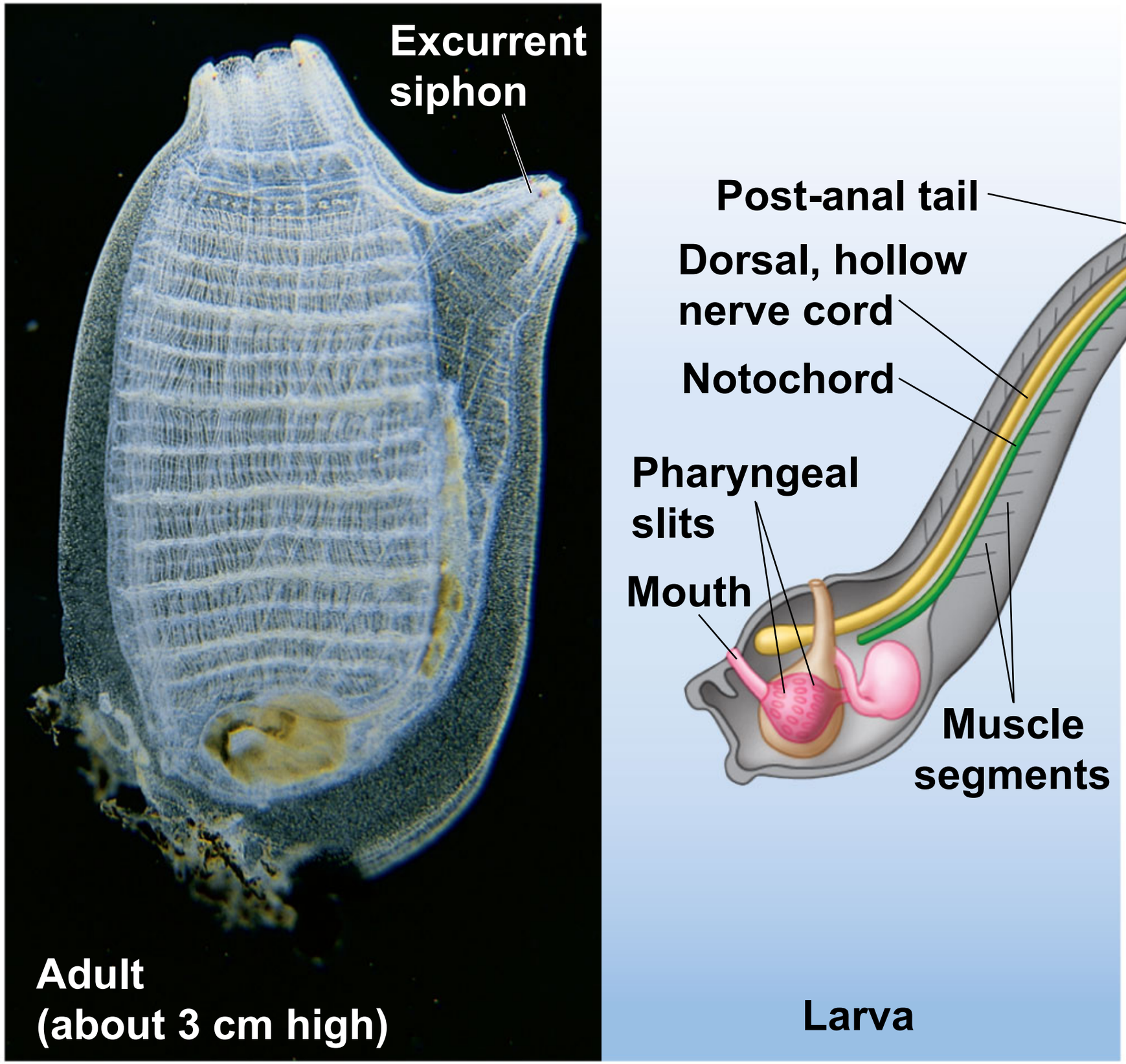
Features of our own phylum, Chordata

Contains vertebrates and their invertebrate ancestors.

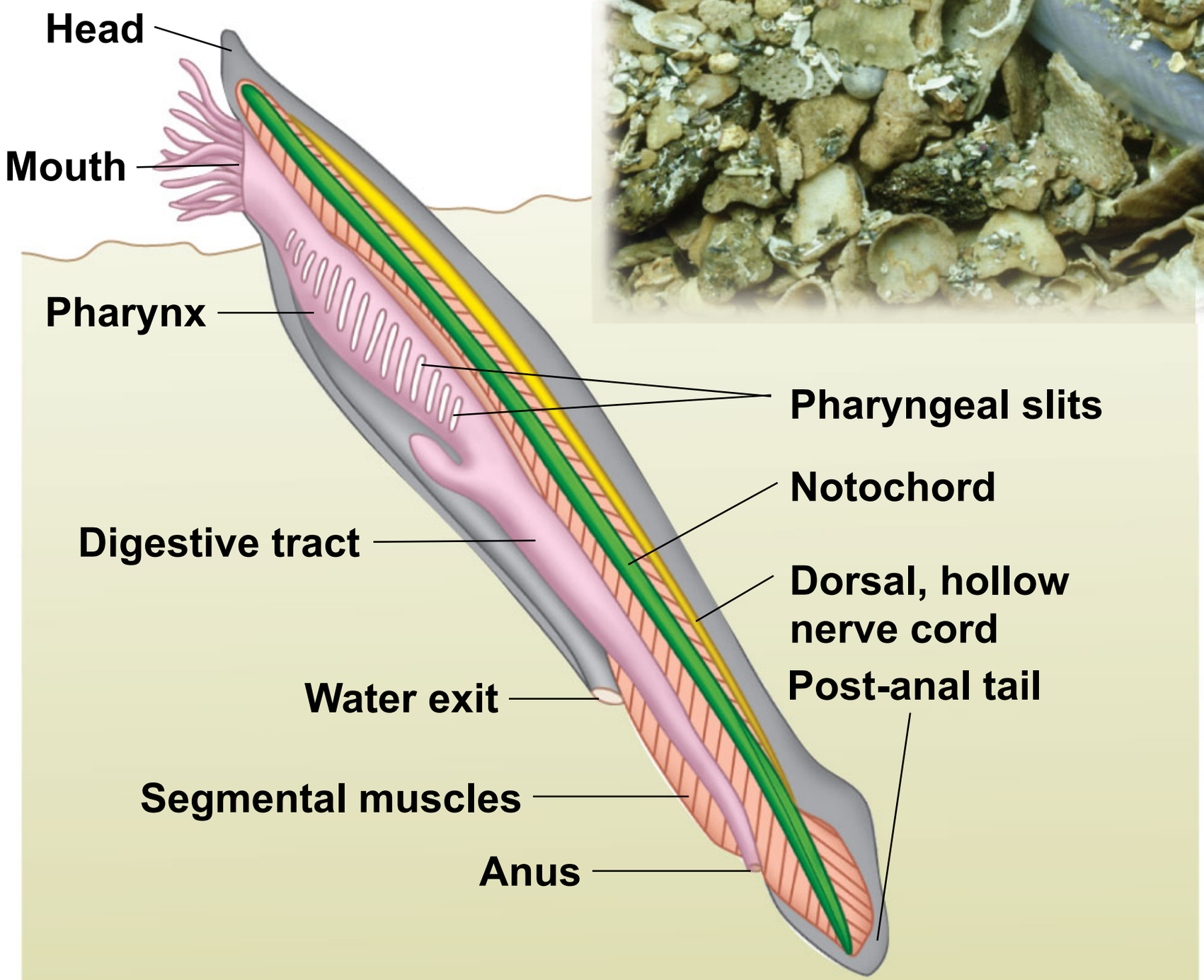
The simplest chordates (tunicates and lancelets) lack a backbone.

Most **chordate** embryos and/or adults possess

- a **dorsal, hollow nerve cord**,
- a flexible, supportive **notochord**
- **pharyngeal slits**, and
- a muscular **post-anal tail**.



Lancets

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