BIOL 01112
General Biology II Lecture

CHAPTER 33
An Introduction to Invertebrates

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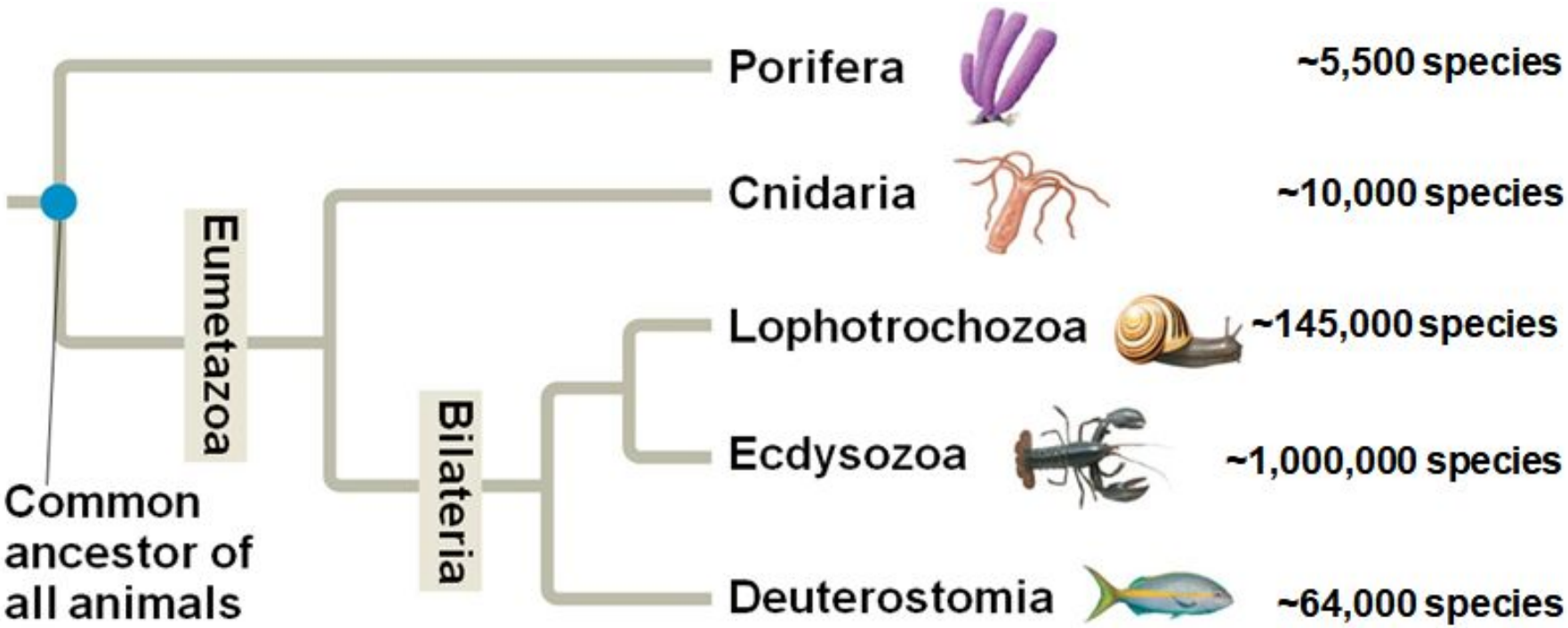
CH 33 Learning Objectives

1. Describe the structure of the sponge body.
2. Characterize cnidarians and their life cycles.
3. Give examples of lophotrochozoans and describe their characteristics.
4. Give examples of ecdysozoans and describe their characteristics.
5. Identify major phylogenetic groups of deuterostomes and describe their characteristics.

I would suggest completing the crossword puzzle to help you understand the terminology and correlate how the terms relate to topics covered in this chapter.

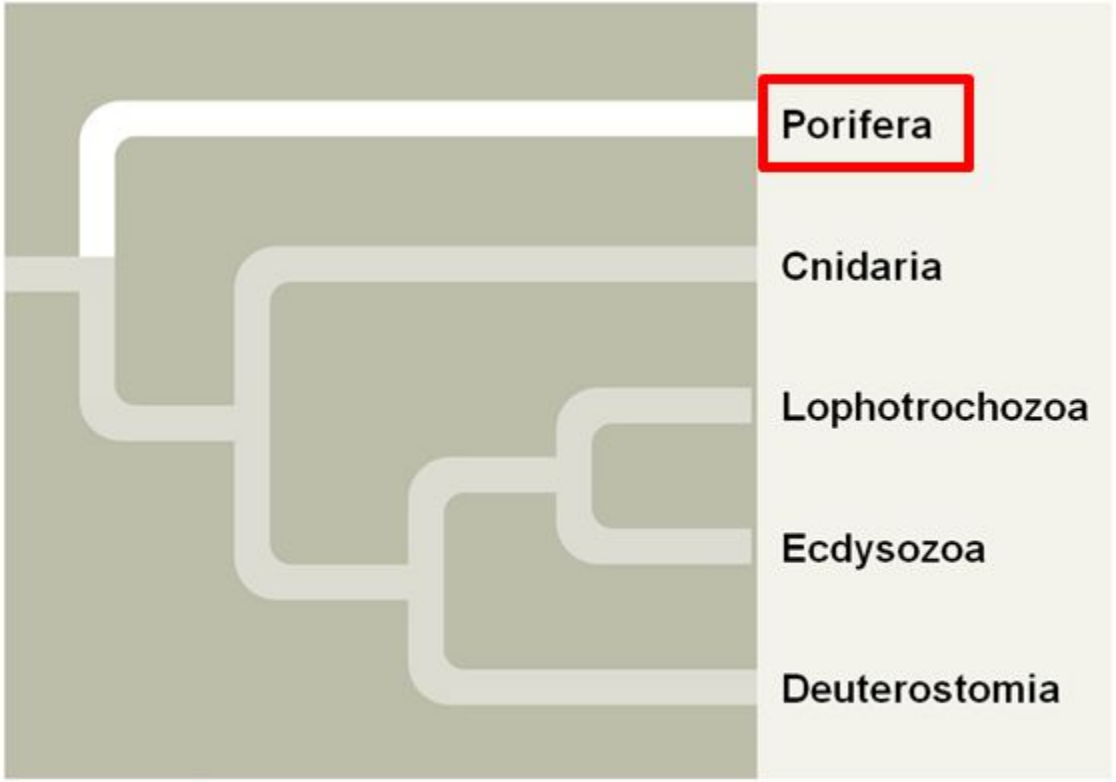
The Invertebrates

- **Invertebrates** are animals that lack a backbone
- Account for >95% of known animal species
- Invertebrates are morphologically diverse and occupy almost every habitat on Earth



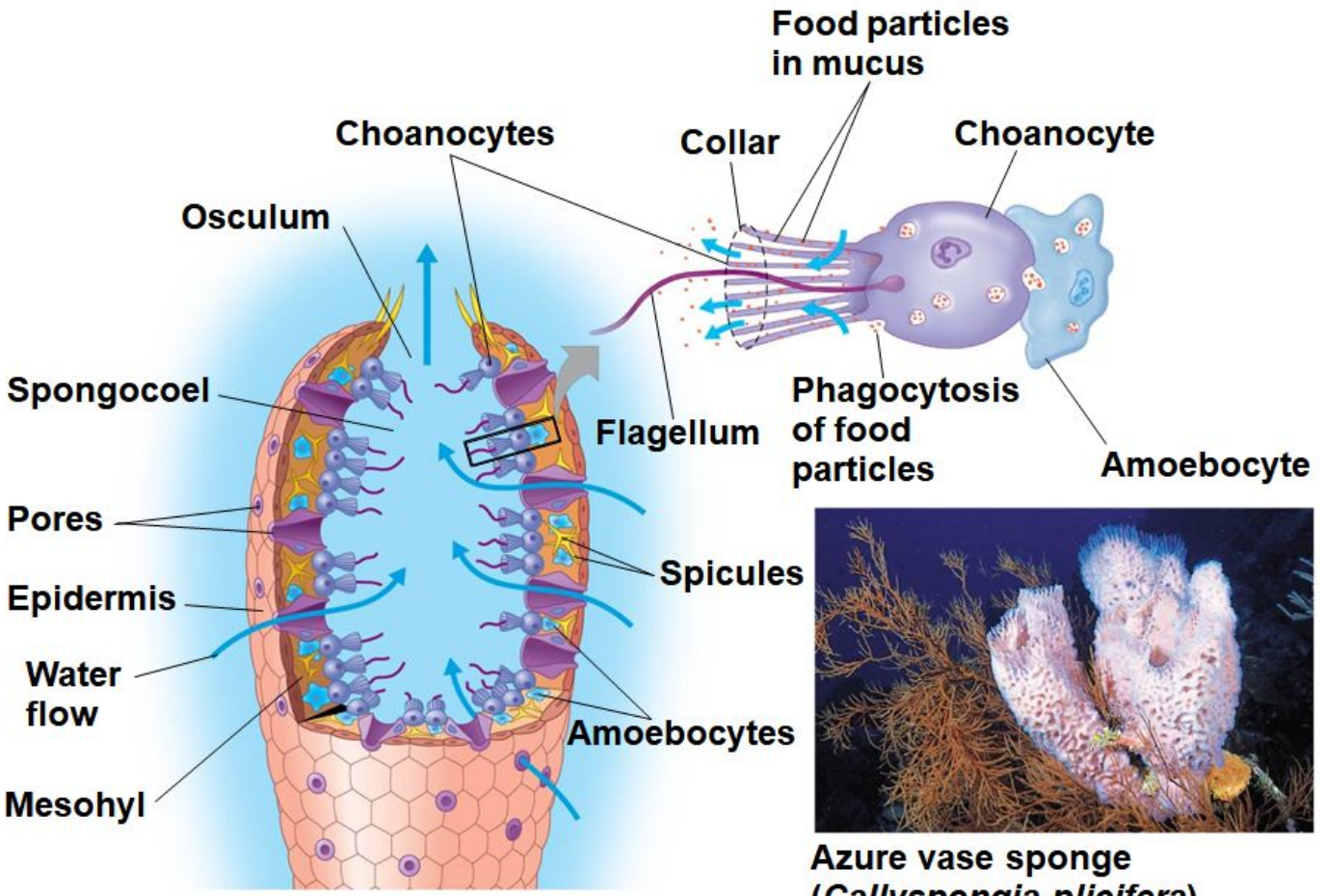
Concept 33.1: Sponges are basal animals that lack tissues

- Animals in the phylum Porifera are known informally as sponges
- They are sedentary and live in SW or FW (i think sea water and fresh water is what that means)



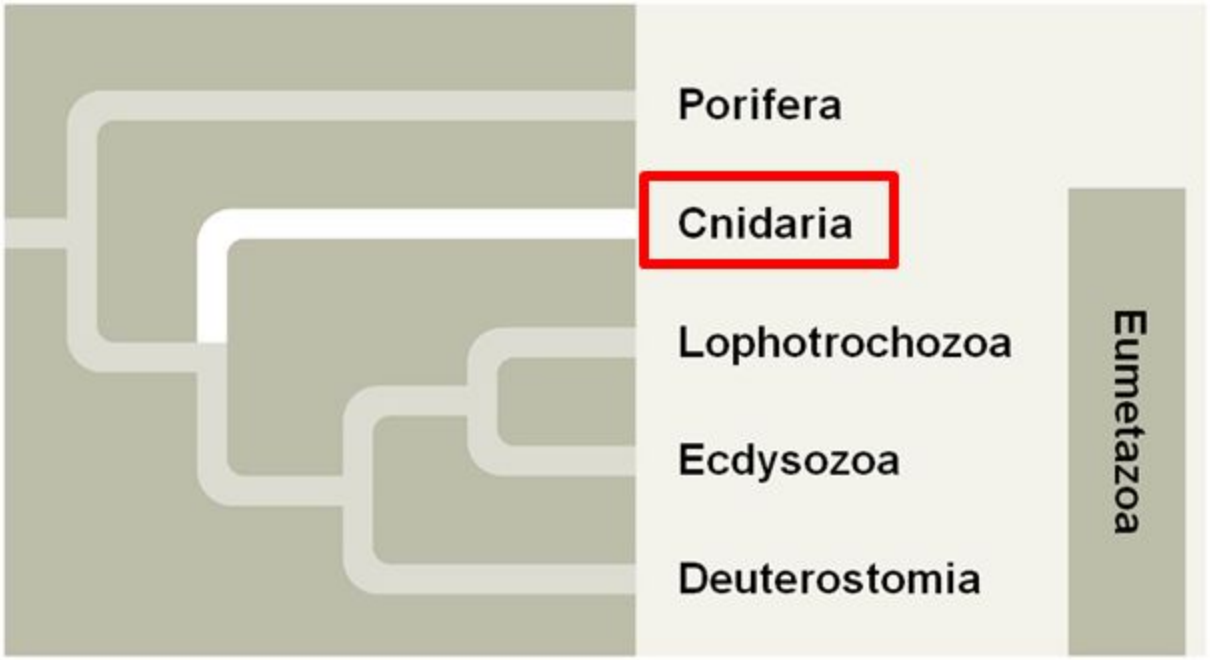
- Sponges are **filter feeders**, capturing food particles suspended in the water that passes through their body
- Water is drawn through pores into a cavity called the **spongocoel** and out through an opening called the **osculum**
- Sponges lack true tissues
- Sponges have several different cell types
  - **Choanocytes**, flagellated collar cells, generate a water current through the sponge and ingest suspended food
  - Sponges consist of a gelatinous noncellular **mesohyl** layer between two cell layers
  - **Amoebocytes** are totipotent cells found in the mesohyl that play roles in digestion and create skeletal fibers

- Most sponges are **hermaphrodites**: Each individual functions as <u>both male and female</u>
- Most exhibit sequential hermaphroditism: They function first as <u>one sex and then as the other</u>



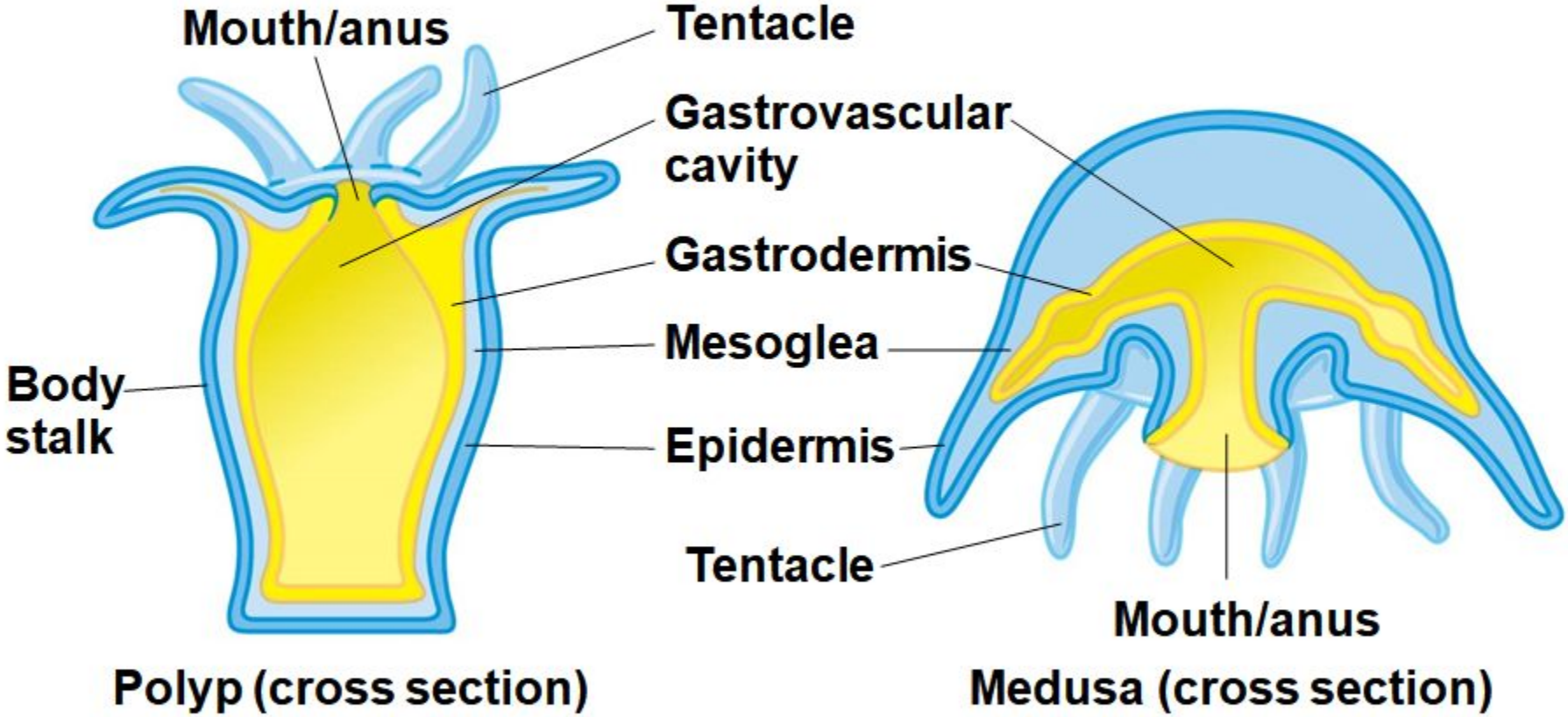
Concept 33.2: Cnidarians are an ancient phylum of eumetazoans

- All animals except sponges and a few other groups belong to the clade Eumetazoa, animals with true tissues
- Phylum Cnidaria is one of the oldest groups in this clade



- Cnidarians have diversified into a wide range of both sessile & motile forms including jellies, corals, hydras
- They have a simple diploblastic, radial body plan
- The basic body plan of a cnidarian is a sac with a central digestive compartment, the **gastrovascular cavity**
- A single opening functions as mouth and anus
- There are two variations on the body plan: the sessile polyp and motile medusa

1. A sessile **polyp** adheres to the substrate by the aboral end of its body
2. A motile **medusa** has a bell-shaped body with a bell-shaped body with its mouth on the underside



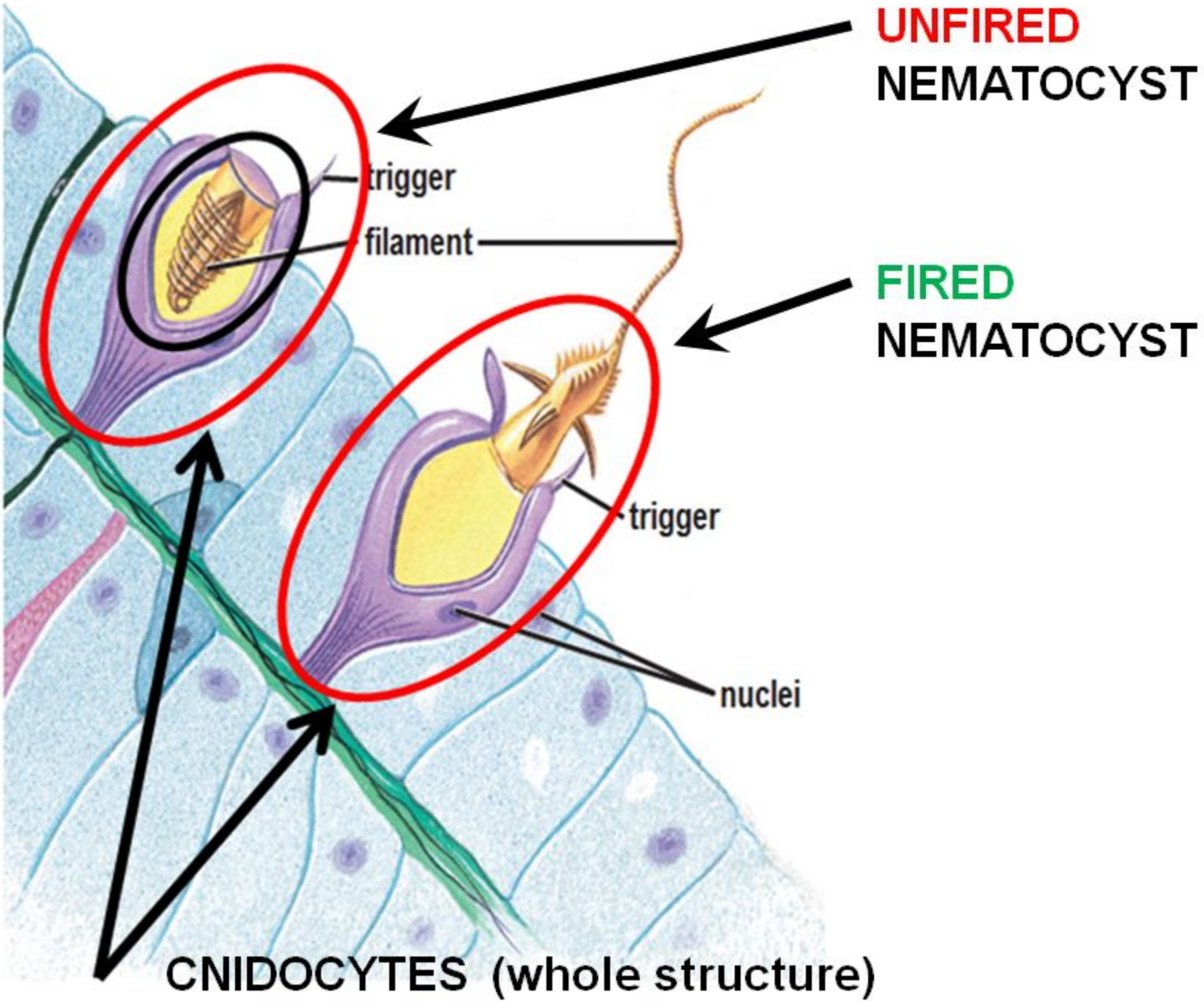
Polyp (cross section)

Medusa (cross section)

SESSILE
(attached to substrate)

MOTILE
(free floating)

- Cnidarians are carnivores that use tentacles to capture prey
- The tentacles are armed with **cnidocytes**, unique cells that function in defense and capture of prey
- **Nematocysts** are specialized organelles within cnidocytes that eject a stinging thread
- The gastrovascular cavity of cnidarians acts as a hydrostatic skeleton against which contractile fibers can work to cause movement
- Movements are coordinated by a non-centralized nerve net
- Phylum Cnidaria diverged into two major clades, Medusozoa and Anthozoa, early in its evolutionary history


UNFIRED
NEMATOCYST
trigger
filament
FIRED
NEMATOCYST
trigger
nuclei
CNIDOCYTES (whole structure)

Medusozoans

- Include all cnidarians that produce a medusa
  - Scyphozoans (jellies); Cubozoans (box jellies) which are highly toxic; Hydrozoans
- Most hydrozoans alternate between polyp and medusa forms

Anthozoans

- Includes the corals and sea anemones
- Anthozoans occur ***only*** as polyps
- Corals often form symbioses with algae and secrete a hard **exoskeleton** (external skeleton)
- Each generation grows on the skeletal remains of the previous generation

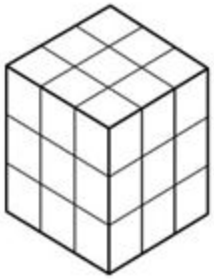
Concept 33.3: Lophotrochozoans have the widest range of animal body forms

- Bilaterian animals have bilateral symmetry and triploblastic development
- Most have a coelom & digestive tract with 2 openings
- The clade Bilateria contains Lophotrochozoa (flatworms), Ecdysozoa, and Deuterostomia

Flatworms

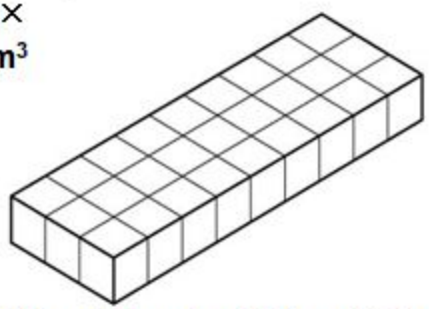
- Free-living members of phylum Platyhelminthes live in in marine, freshwater, and damp terrestrial habitats
- Many flatworms are parasites (flukes and tapeworms)
- Unlike most triploblastic animals, flatworms are acoelomates (animals that lack a body cavity)
- Flatworms have a gastrovascular cavity with one opening
- The excretory apparatus consists of **protonephridia**, networks of ciliated tubules
- Flatworms have a dorsoventrally flattened body shape that places all cells close to water in the surrounding environment or in their gut

MAKE CONNECTIONS: Maximizing Surface Area



possible application (what reordering a cubes makes the most SA)

SA: 6 (3 cm × 3 cm) = 54 cm^2
V: 3 cm × 3 cm × 3 cm = 27 cm^3

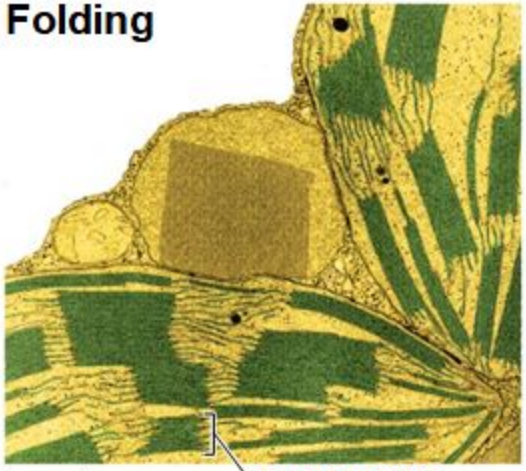


SA: 2 (3 cm × 1 cm) + 2 (9 cm × 1 cm) + 2 (3 cm × 9 cm) = 78 cm^2
V: 1 cm × 3 cm × 9 cm = 27 cm^3

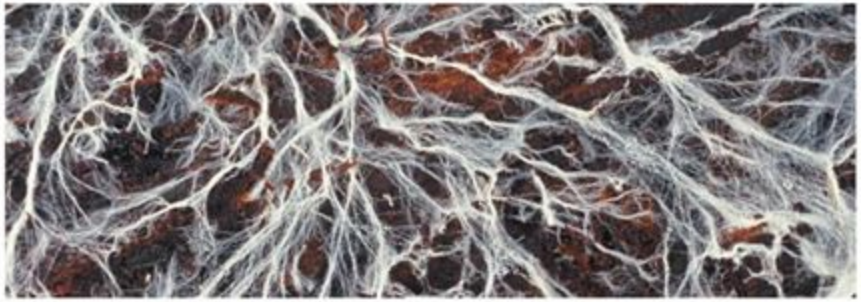
Diagrams comparing surface area (SA) for two different shapes with the same volume (V)

Flattening

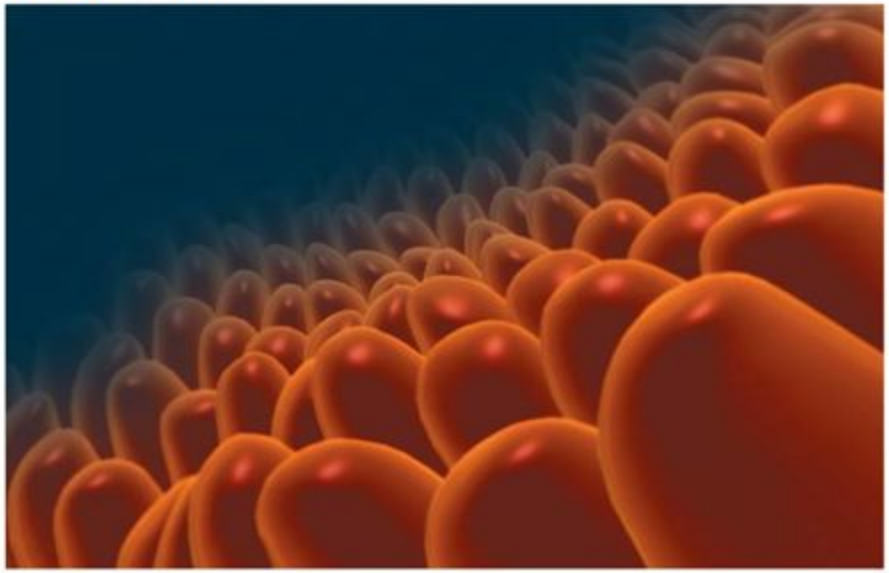
Folding



Branching

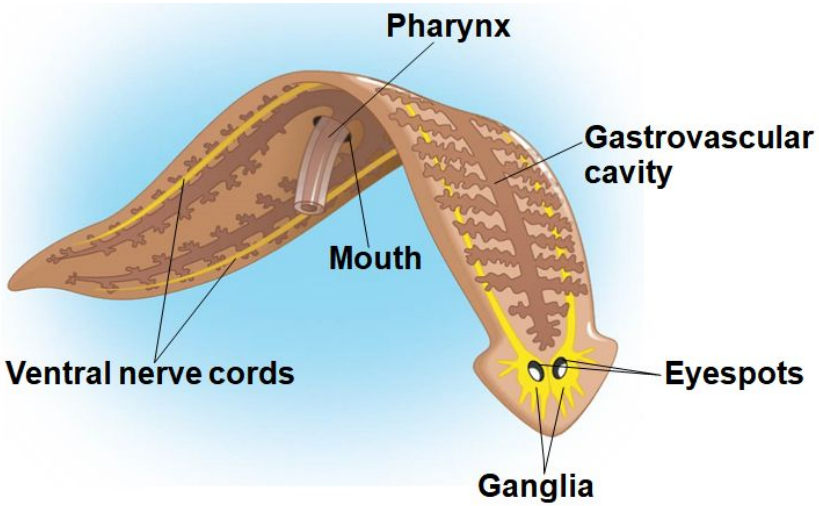


Projections



Free-Living Species

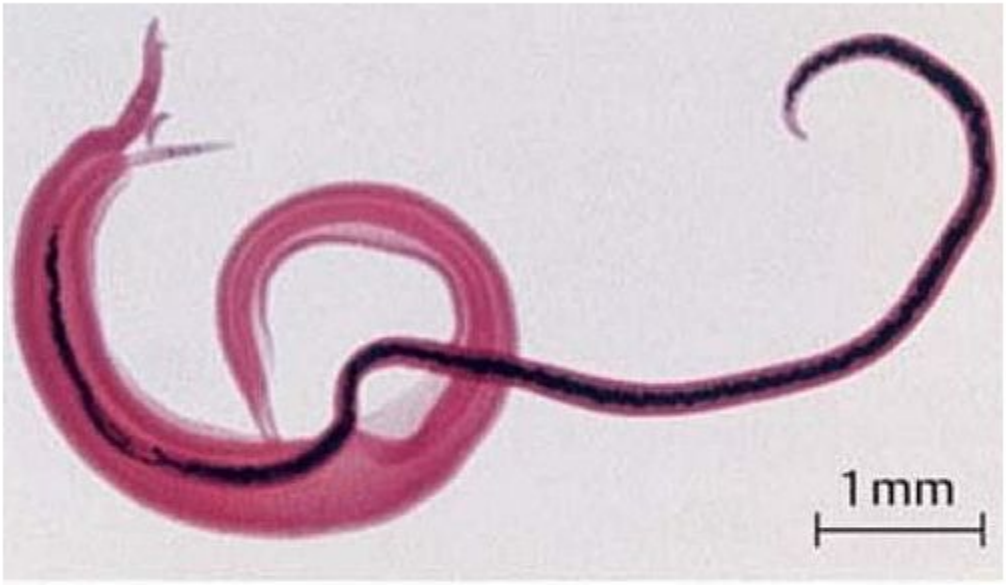
- The best-known flatworms are **planarians**
- Planarians live in FW and prey on smaller animals
- Planarians have light-sensitive eyespots & nerve nets
- The planarian nervous system is more complex and centralized than the nerve nets of cnidarians
- Planarians are hermaphrodites and can reproduce sexually, or asexually through fission



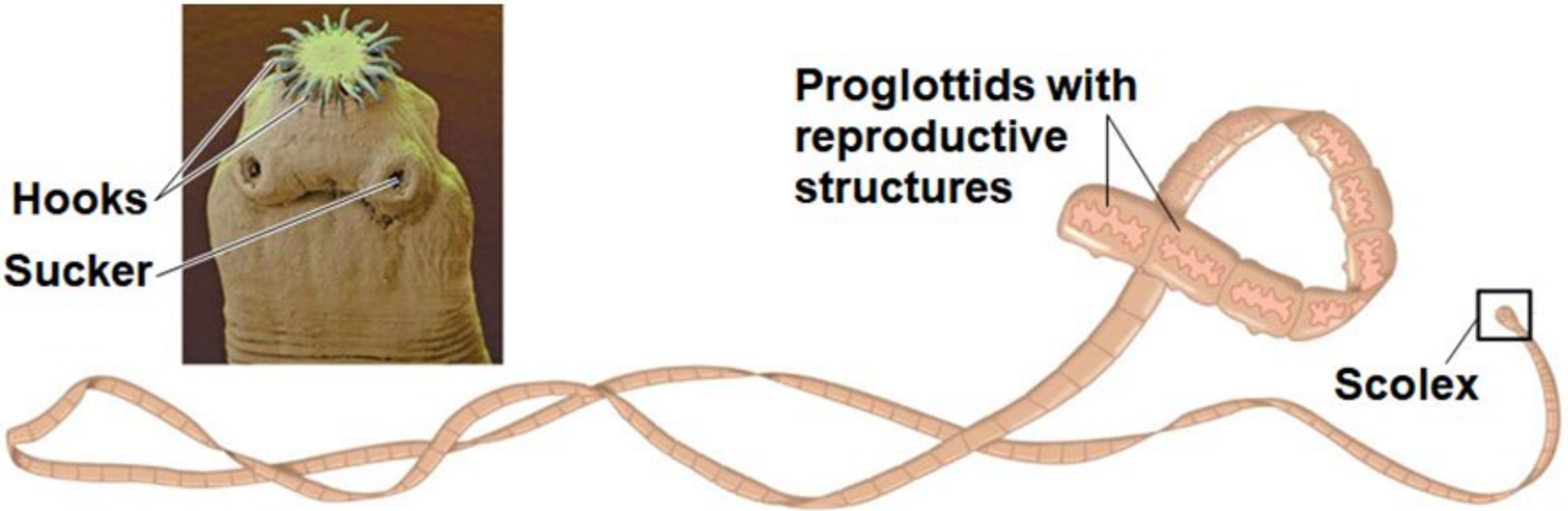
Parasitic Species: Trematodes and Tapeworms

- **Trematodes** that parasitize humans spend part of their lives in snail hosts; blood fluke (*Schistosoma mansoni)*
- They produce surface proteins and release molecules that manipulate the host's immune system
- **Tapeworms** are parasites of vertebrates; absorb nutrients from the host's intestine
- The scolex contains suckers and hooks for attaching to the host's intestine and absorb nutrients
- Fertilized eggs, produced by sexual reproduction, leave the host's body in feces

Blood Flukes (*Schistosoma mansoni*)



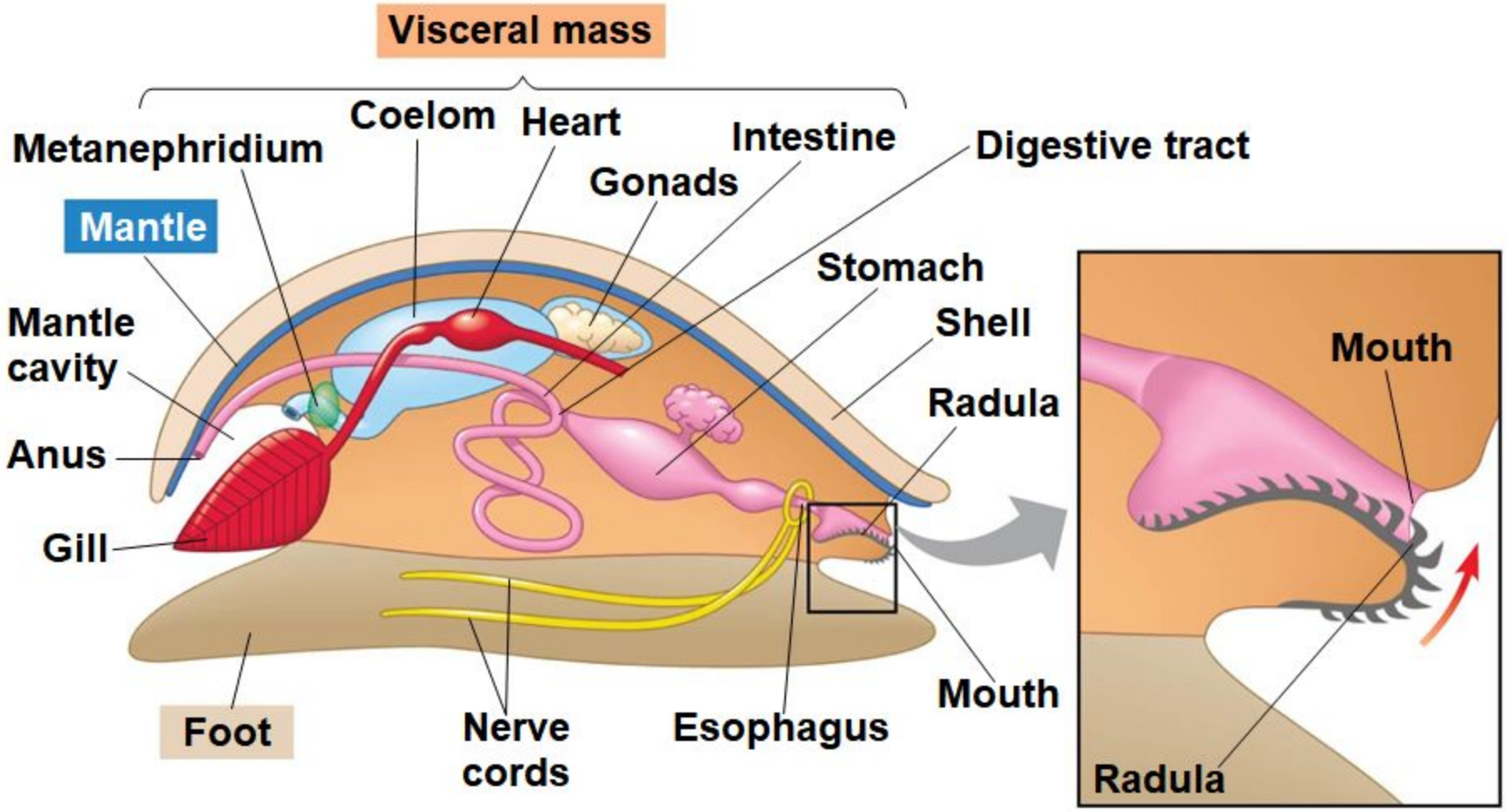
Tapeworms



Molluscs

- Phylum Mollusca includes snails and slugs, oysters and clams, and octopuses and squids
- Most molluscs are marine, though some inhabit fresh water and some snails and slugs are terrestrial
- Molluscs are soft-bodied animals, but most are protected by a calcium carbonate shell
- All mollusc have similar body plans with 3 main parts
  - Muscular **foot**
  - **Visceral mass**
  - **Mantle**
- Many molluscs also have a water-filled **mantle cavity** and feed using a straplike **radula**

Figure 33.16


Visceral mass
Coelom
Heart
Intestine
Digestive tract
Metanephridium
Gonads
Mantle
Stomach
Mantle cavity
Shell
Mouth
Radula
Anus
Gill
Mouth
Foot
Nerve cords
Esophagus
Radula

- Most molluscs have separate sexes with gonads located in the visceral mass, but many snails are hermaphrodites
- The life cycle of many molluscs includes a ciliated larval stage called a trochophore
- Four of the major classes of molluscs are
  1. Polyplacophora (chitons)
  2. Gastropoda (snails and slugs)
  3. Bivalvia (clams, oysters, and other bivalves)
  4. Cephalopoda (squids, octopuses, cuttlefish, and chambered nautiluses)

1. Chitons

- Chitons are oval-shaped marine animals encased in an armor of eight dorsal plates
- They use their foot like a suction cup to grip rock, and their radula to scrape algae off the rock surface

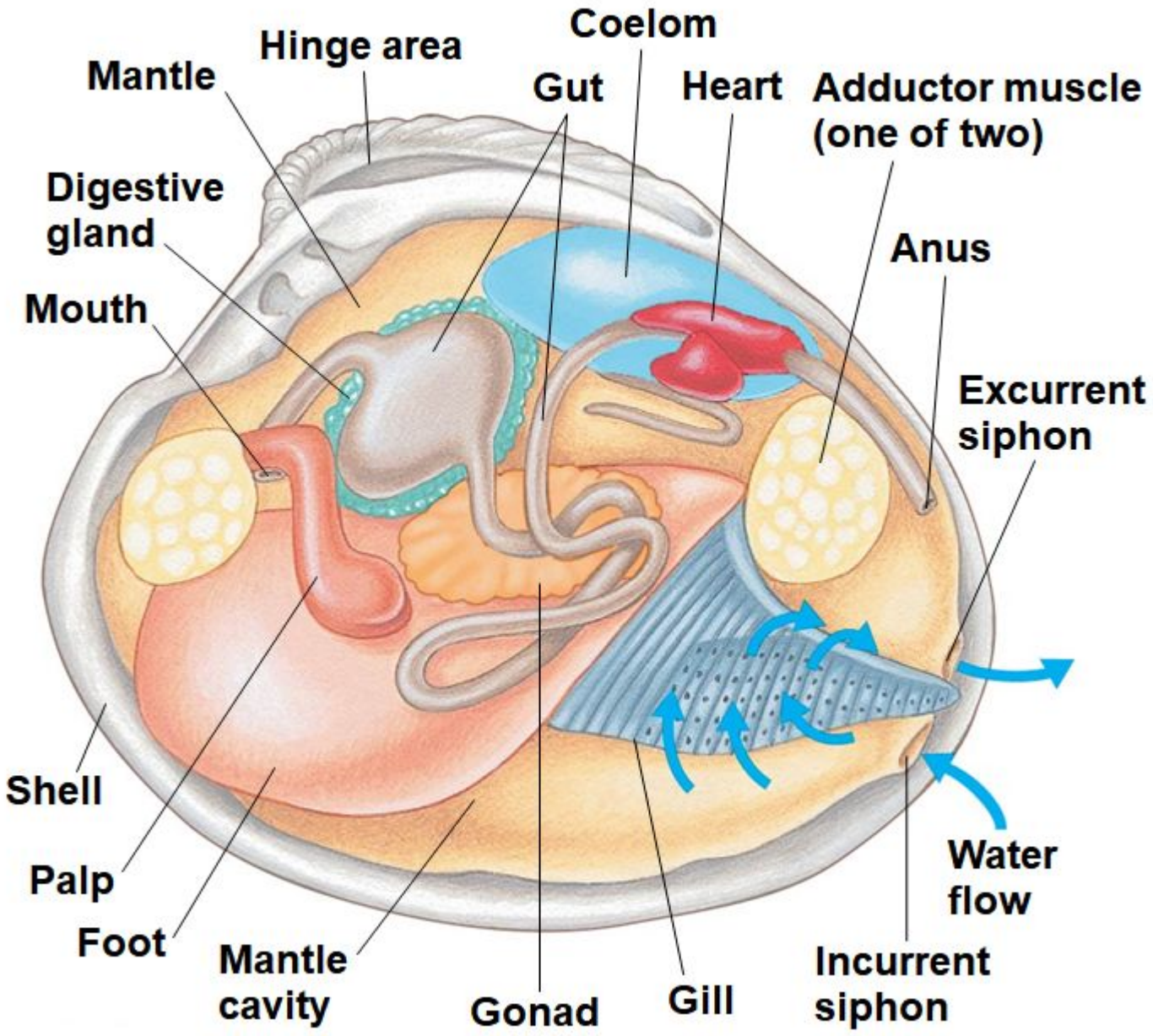
2. Gastropods

- About ¾ of all extant molluscs species are gastropods
- Most are marine, but there are many freshwater and terrestrial species
- Gastropods move slowly by a rippling motion of the foot or by cilia
- Most gastropods have a single, spiraled shell that functions in protection from predation & dehydration
- Most are herbivores, but some species use modified radula to feed on prey

3. Bivalves

- Bivalves are aquatic and include many species of clams, oysters, mussels, and scallops
- Shell is two halves held together by adductor muscles
- Some bivalves have eyes and sensory tentacles along the edge of their mantle
- The mantle cavity of a bivalve contains gills that are used for feeding as well as gas exchange
- Most species are sedentary, but some have limited motility

Figure 33.20


Coelom
Hinge area
Mantle
Gut
Heart
Adductor muscle
(one of two)
Digestive
gland
Anus
Mouth
Excurrent
siphon
Shell
Water
flow
Palp
Foot
Mantle
cavity
Gonad
Gill
Incurrent
siphon

4. Cephalopods

- Cephalopods are active marine predators with beak-like jaws surrounded by tentacles
- Some immobilize prey with poison in their saliva
- The foot is modified into a muscular excurrent siphon and part of the tentacles
- The shell is reduced and internal or missing in most species, except the chambered nautiluses
- Cephalopods have a closed circulatory system, well-developed sense organs, and a complex brain
- EX: squid, octopus, and nautilus

Annelids

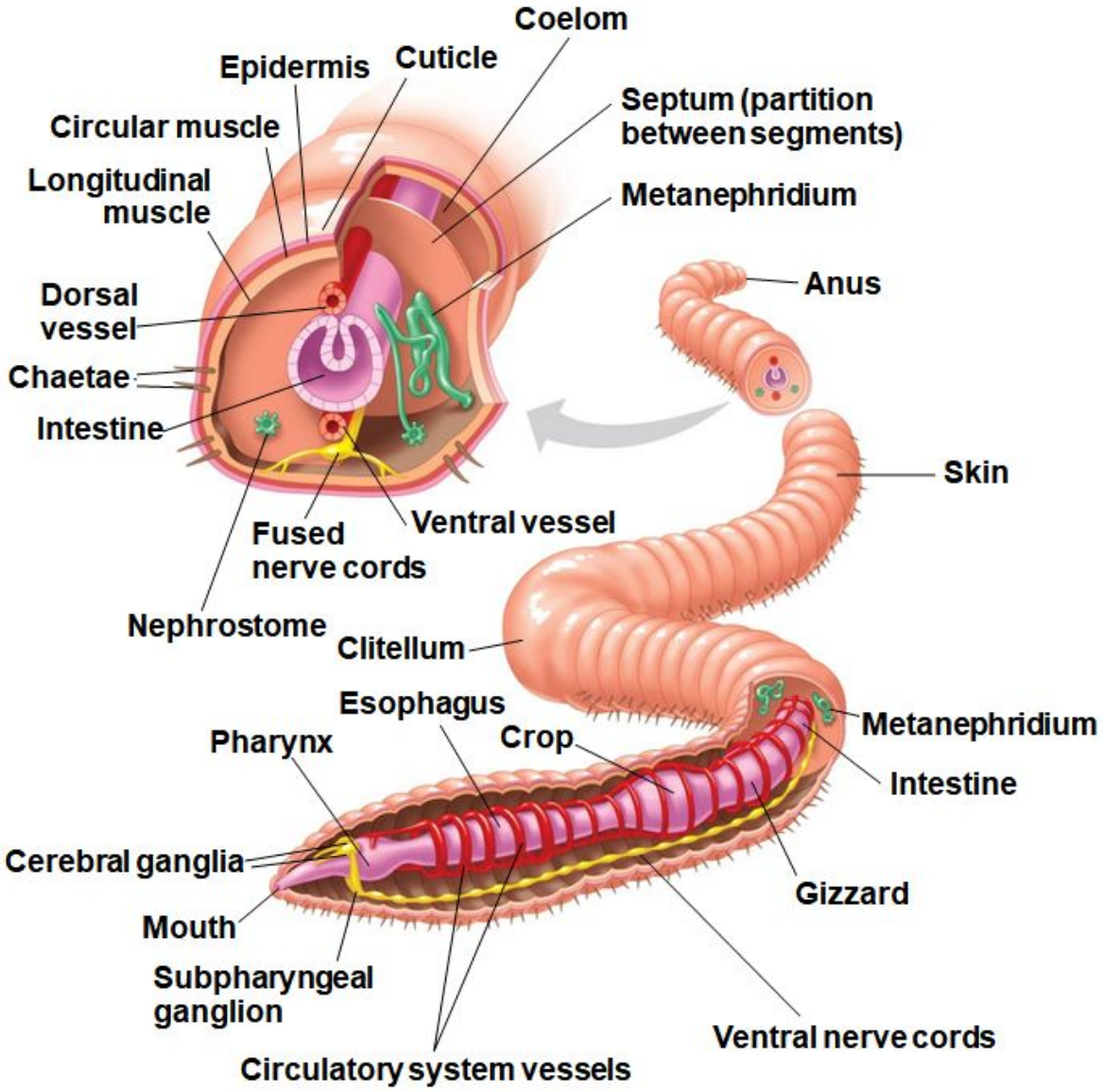
- Annelids are coelomates with bodies composed of a series of fused rings
- The phylum Annelida was traditionally divided into three clades
  1. Polychaetes
  2. Oligochaetes (earthworms)
  3. Hirudinea (leeches)

1. Polychaetes

- Primarily live in the ocean
- Some have tubes from which they project feathery gills used for gas exchange and to filter the water for food

2. Earthworms

- Earthworms eat through soil, extracting nutrients as the soil moves through the alimentary canal
- Earthworms are hermaphrodites but cross-fertilize
- Some reproduce asexually by fragmentation

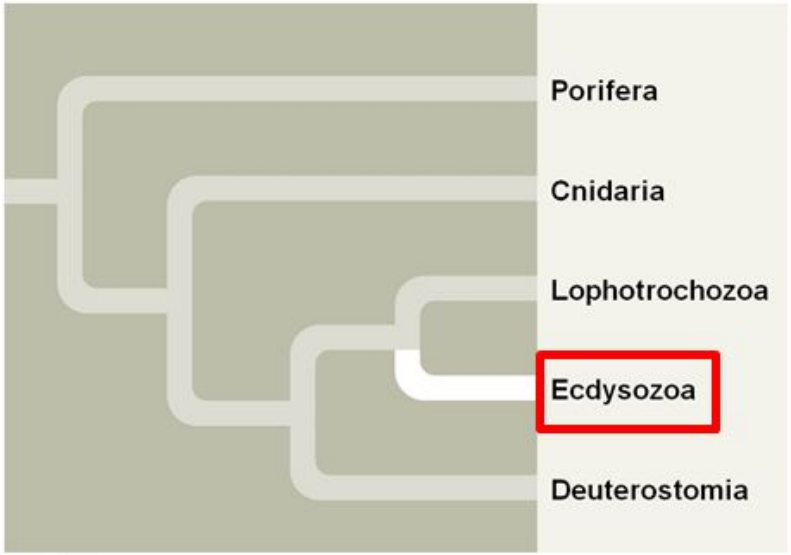


3. Leeches

- Most species of leeches live in fresh water; some are marine or terrestrial
- Leeches include predators of invertebrates and parasites that suck blood
- Some parasitic leeches slit the skin of their host and secrete an anesthetic to prevent detection
- They secrete another chemical called hirudin to prevent blood from coagulating

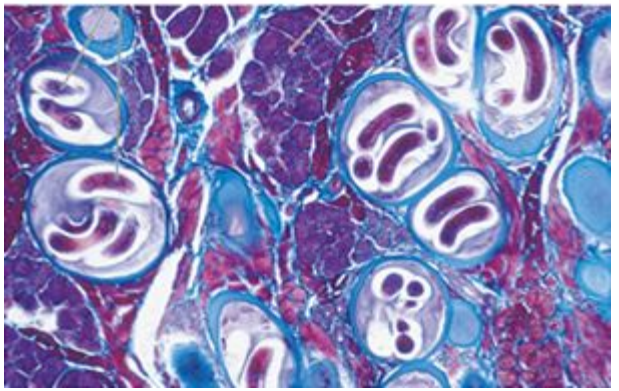
Concept 33.4: Ecdysozoans are the most species-rich animal group

- Ecdysozoans are covered by a tough coat called a **cuticle**
- The cuticle is shed or **molted** through a process called ecdysis
- The two largest phyla are nematodes and arthropods



Nematodes

- Nematodes, or roundworms, are found in most aquatic habitats, in the soil, in moist tissues of plants, and in body fluids and tissues of animals
- They have an alimentary canal, but lack a circulatory system
- Body wall muscles are all longitudinal, and their contraction produces a thrashing motion
- *Trichinella spiralis* is a parasite that can be acquired by humans from undercooked pork



Arthropods

- Zoologists estimate that there are about a billion arthropods living on Earth
- More than 1 million species have been described, and 2 of 3 every known species of animals are arthropods
- Members of the phylum Arthropoda are found in nearly all habitats of the biosphere
- The **arthropod** body plan consists of a segmented body, hard exoskeleton, and jointed appendages
- This body plan dates to the Cambrian explosion (535-525 MYA)
- Early arthropods show little variation from segment to segment

General Characteristics of Arthropods

- The appendages of some living arthropods are modified for functions such as walking, feeding, sensory reception, reproduction, and defense
- These modified appendages are jointed and come in pairs
- The body of an arthropod is completely covered by the cuticle, an exoskeleton made of layers of protein and the polysaccharide chitin
- When an arthropod grows, it molts its exoskeleton

- Evolution of the exoskeleton in early arthropods enabled them to be among the first animals to colonize land
  - Its relative impermeability to water helped prevent desiccation
  - Its strength provided support without reliance on the buoyancy of water
- Arthropods have eyes, olfactory receptors, and antennae that function in touch and smell
- Arthropods have an **open circulatory system** in which hemolymph is circulated into the spaces surrounding the tissues and organs
- A variety of organs specialized for gas exchange have evolved in arthropods

- Morphological and molecular evidence suggests that living arthropods consist of three major lineages that diverged early in the phylum's evolution

1. **Chelicerates** (sea spiders, horseshoe crabs, scorpions, ticks, mites, and spiders)
2. **Myriapods** (centipedes and millipedes)
3. **Pancrustaceans** (lobsters and other crustaceans, as well as insects and their relatives)

1. Chelicerates

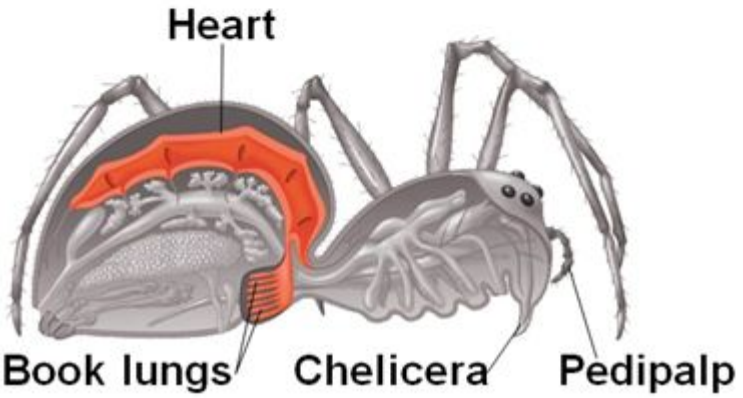
- Chelicerates, clade Chelicerata, are named for clawlike feeding appendages called **chilicerae**
- The earliest chelicerates were **eurpyterids** (water scorpions)
- Most marine chelicerates (including eurypterids) are extinct, but some species survive today, including horseshoe crabs

- Most modern chelicerates are **arachnids**, which include spiders, scorpions, ticks, and mites
- Arachnids have six pairs of appendages: the chelicerae, the pedipalps, and four pairs of walking legs
- Gas exchange in spiders occurs in respiratory organs called **book lungs**
- Many spiders produce silk, a liquid protein, from specialized abdominal glands


Scorpion

Dust mite


Web-building spider



2. Myriapods

- Clade Myriapoda includes millipedes & centipedes
- All living myriapods are terrestrial
- They have a pair of antennae and three pairs of appendages modified as mouthparts
- Millipedes eat decaying leaves and plant matter
- Millipedes have many legs, with two pairs/segment

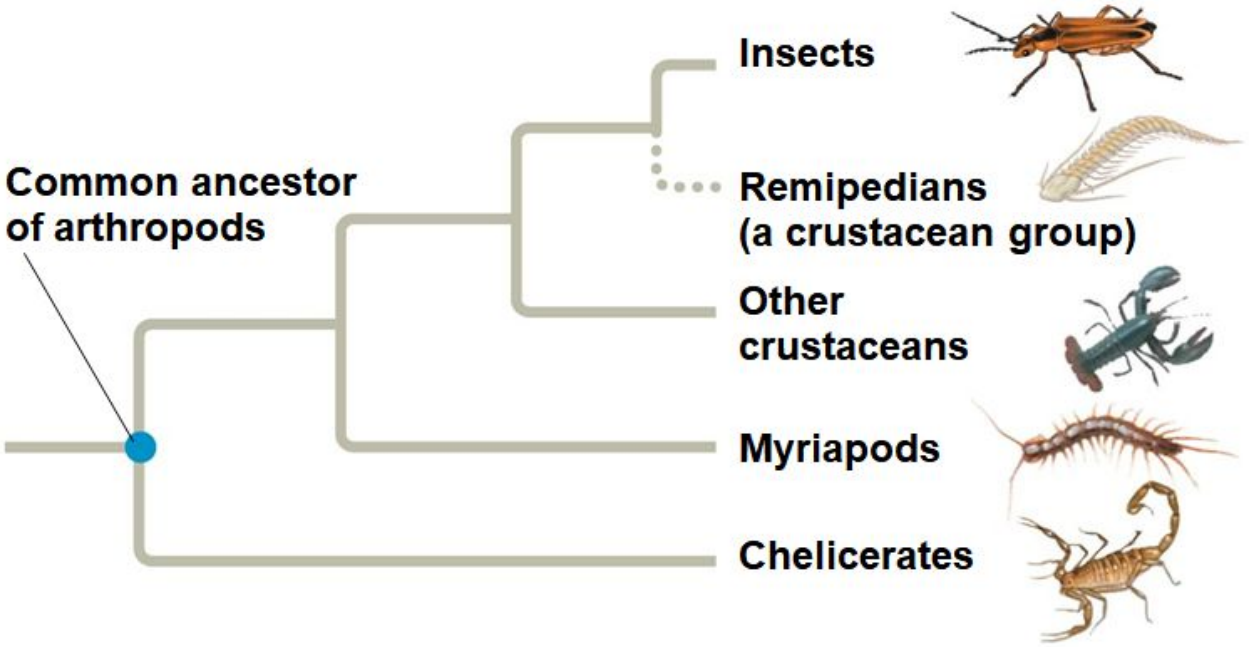
(a) Millipede

- Centipedes are carnivores
- Centipedes have one pair of legs per trunk segment
- Poison claws on the foremost trunk segment paralyze prey and aid in defense

(b) Centipede

3. Pancrustaceans

- Recent evidence indicates that terrestrial insects are more closely related to crustaceans than myriapods
- Some lineages of crustaceans are more closely related to insects than other crustaceans
- Together, insects and crustaceans form the clade Pancrustacea



Crustaceans

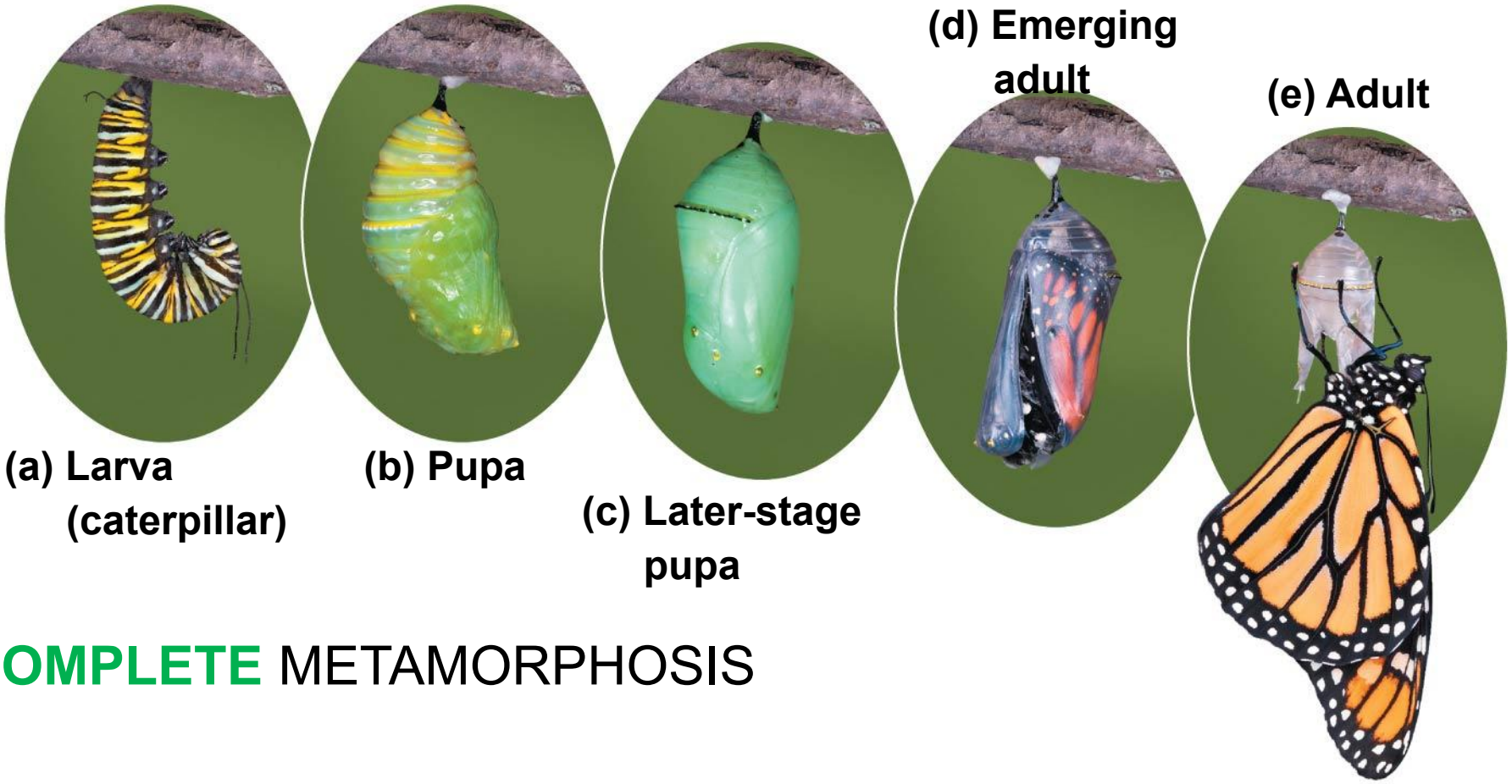
- Crustaceans (crabs, lobsters, shrimps, barnacles, and others) live in marine, freshwater, and terrestrial environments
- Many crustaceans have very specialized appendages
- Small crustaceans exchange gases through the cuticle; larger crustaceans have gills
- Most crustaceans have separate males and females
- Isopods are one of the largest groups of crustaceans and include pill bugs, a well-known group of terrestrial isopods
- Decapods are all relatively large crustaceans and include lobsters, crabs, crawfish, and shrimp

Insects

- Hexapoda is an enormous clade including insects and their relatives
- Insects live in almost every terrestrial habitat and in fresh water; flying insects fill the air; they are rare in marine habitats
- Insects diversified rapidly following the evolution of flight 359-252 MYA
- An animal that can fly can escape predators, find food, and disperse to new habitats much faster than organisms that can only crawl
- Insects evolved flight without sacrificing a pair of walking legs because wings are an extension of the cuticle

- Many insects undergo metamorphosis during their development
- In **incomplete metamorphosis**, the young, called nymphs, resemble adults but are smaller and go through a series of molts until they reach full size
- After the final molt, the wings develop and the insect becomes sexually mature
- Insects with **complete metamorphosis** have larval stages known by such names as maggot, grub, or caterpillar
- The larval stage looks very different from the adult stage
- Metamorphosis from larva to adult occurs during a pupal stage

egg larva (feeding stage) **pupa** (non-feeding stage) adult



COMPLETE METAMORPHOSIS

INCOMPLETE METAMORPHOSIS

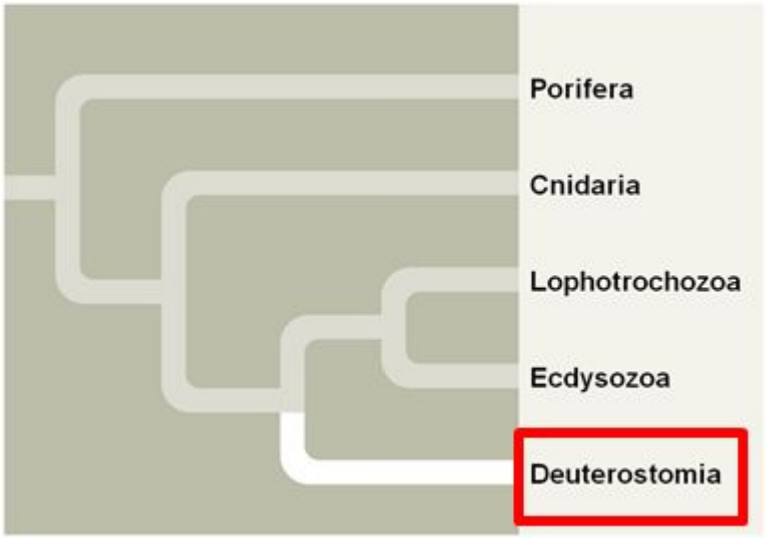
egg nymph (feeding stage, resembles adult) adult

EX: grasshoppers and crickets

- Most insects have separate males and females and reproduce sexually
- Individuals find and recognize members of their own species by bright colors, sound, or odors
- Fertilization is generally internal
- In some species copulation occurs; in others, the male deposits a sperm packet that the female picks up
- Eggs are generally laid on a food source
- Insects are classified into more than 30 orders
- Some insects are beneficial as pollinators, while others are harmful as carriers of diseases or pests of crops

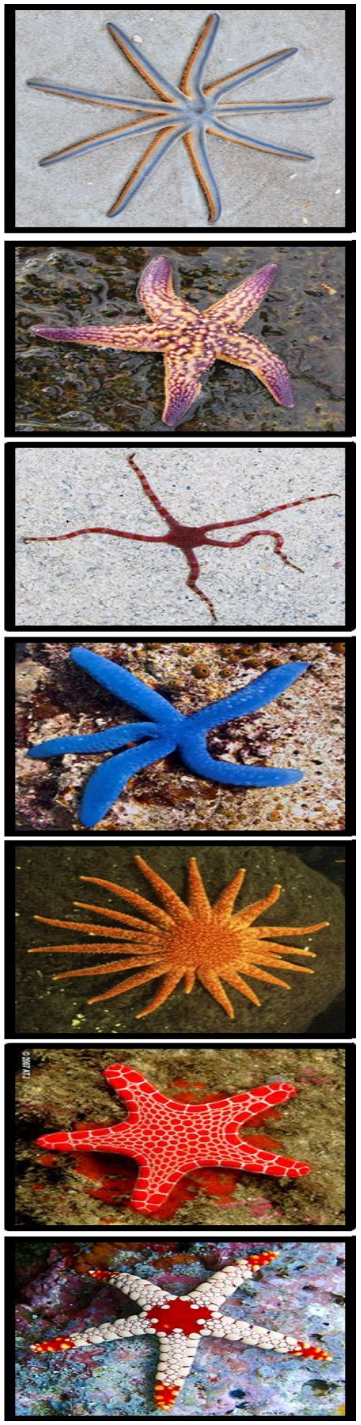
Concept 33.5: Echinoderms and chordates are deuterostomes

- Echinoderms (phylum Echinodermata) include sea stars and sea urchins
- Vertebrates (animals that have a backbone) are members of phylum Chordata
- Echinoderms and chordates constitute the clade Deuterostomia



Echinoderms

- Sea stars and most other **echinoderms** are slow-moving or sessile marine animals
- A thin epidermis covers an endoskeleton of hard calcareous plates
- Echinoderms have a unique **water vascular system**, a network of hydraulic canals branching into **tube feet** for locomotion and feeding
- Males and females are usually separate; sexual reproduction is external



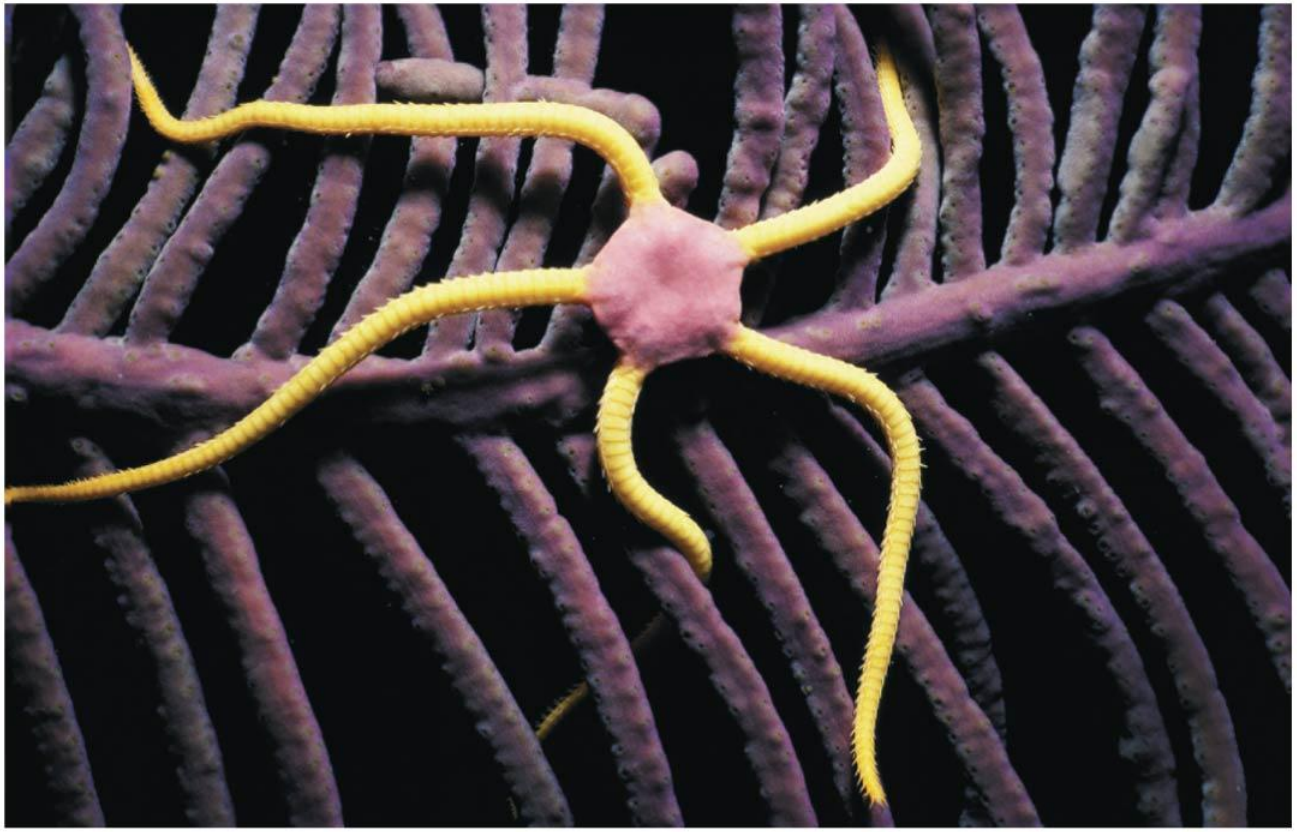
- Most adult echinoderms appear to have radial symmetry with multiples of five
- Their symmetry is not truly radial; the opening of the water vascular system is is not central
- Echinoderm larvae have bilateral symmetry
- Living echinoderms are divided into five clades
  1. Asteroidea (sea stars and sea daisies)
  2. Ophiuroidea (brittle stars)
  3. Echinoidea (sea urchins and sand dollars)
  4. Crinoidea (sea lilies and feather stars)
  5. Holothuroidea (sea cucumbers)

1. *Asteroidea: Sea Stars and Sea Daisies*

- Sea stars have several arms radiating from a central disk; can also can regrow lost arms
- Each arm bears tube feet, which grip a substrate
- Sea stars feed on bivalves by prying them open with their tube feet, everting their stomach, and digesting their prey externally with digestive enzymes
- Sea daisies are a group of armless species in the clade Asteroidea; only three species are known
- Sea daisies live on submerged wood and absorb nutrients through a membrane that surrounds their body

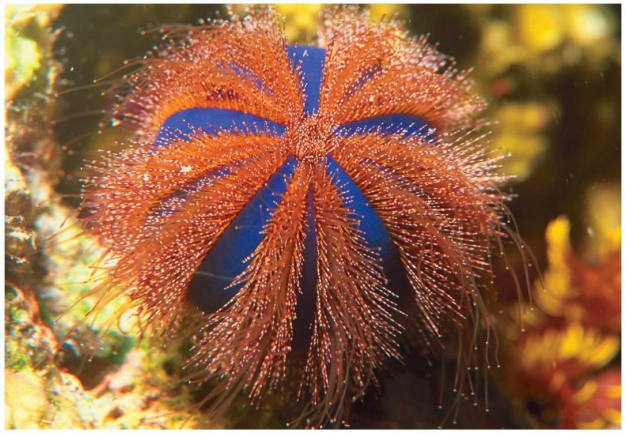
2. *Ophiuroidea: Brittle Stars*

- Brittle stars have a distinct central disk and long, flexible arms that they use for movement
- Some species are suspension feeders, while others are predators or scavengers



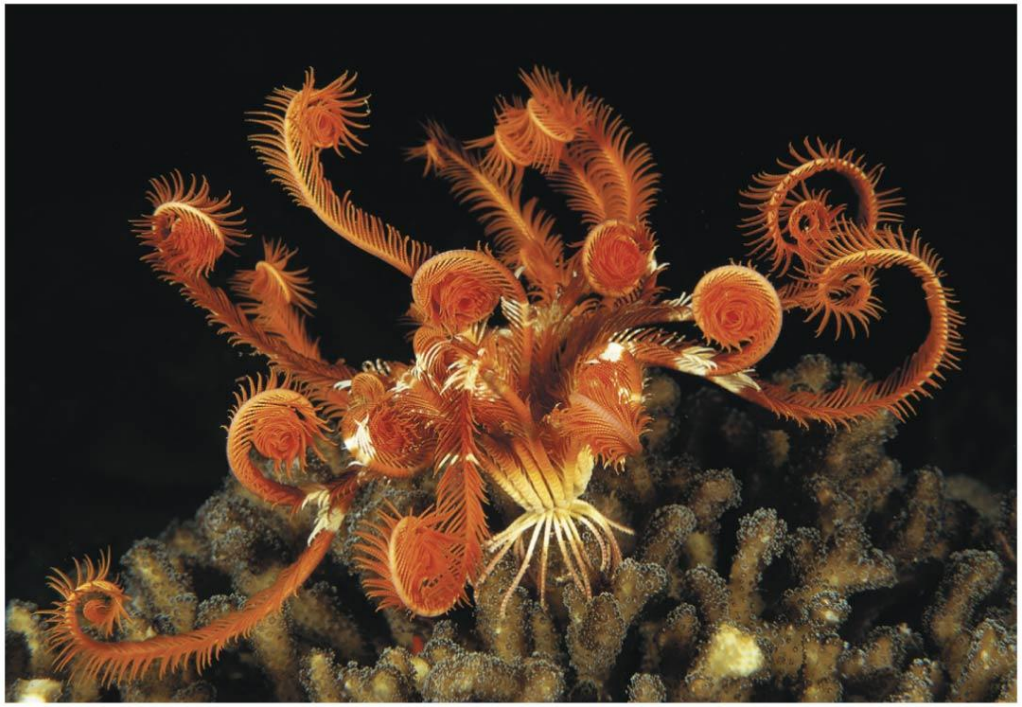
3. *Echinoidea: Sea Urchins and Sand Dollars*

- Sea urchins and sand dollars have no arms but have five rows of tube feet
- Sea urchins also use their spines for locomotion and protection
- Sea urchins feed on seaweed using a jaw-like structure on their underside
- Sea urchins are roughly symmetrical; sand dollars flat disks



4. *Crinoidea: Sea Lilies and Feather Stars*

- Sea lilies live attached to the substrate by a stalk
- Feather stars can crawl using long, flexible arms
- Both use their arms in suspension feeding
- Crinoidea have changed little over the course of evolution



5. *Holothuroidea: Sea Cucumbers*

- Sea cucumbers lack spines, have a very reduced endoskeleton, and do not look much like other echinoderms
- Sea cucumbers have five rows of tube feet; some of these are developed as feeding tentacles

Chordates

- Phylum Chordata consists of two basal groups of ***invertebrates*** as well as ***vertebrates***
- Chordates are bilaterally symmetrical coelomates with segmented bodies
- Chordates did not evolve from echinoderms, but have evolved separately from them for at least 500 MYA