CHAPTER 10

The Animal Diversity

B.T.Anh

Overview

- The animal kingdom
  - Extends far beyond humans and other animals we may encounter

- Animal are multicellular, heterotrophic eukaryotes with tissues that develop from embryonic layers
- Several characteristics of animals
  - Sufficiently define the group

Nutritional Mode

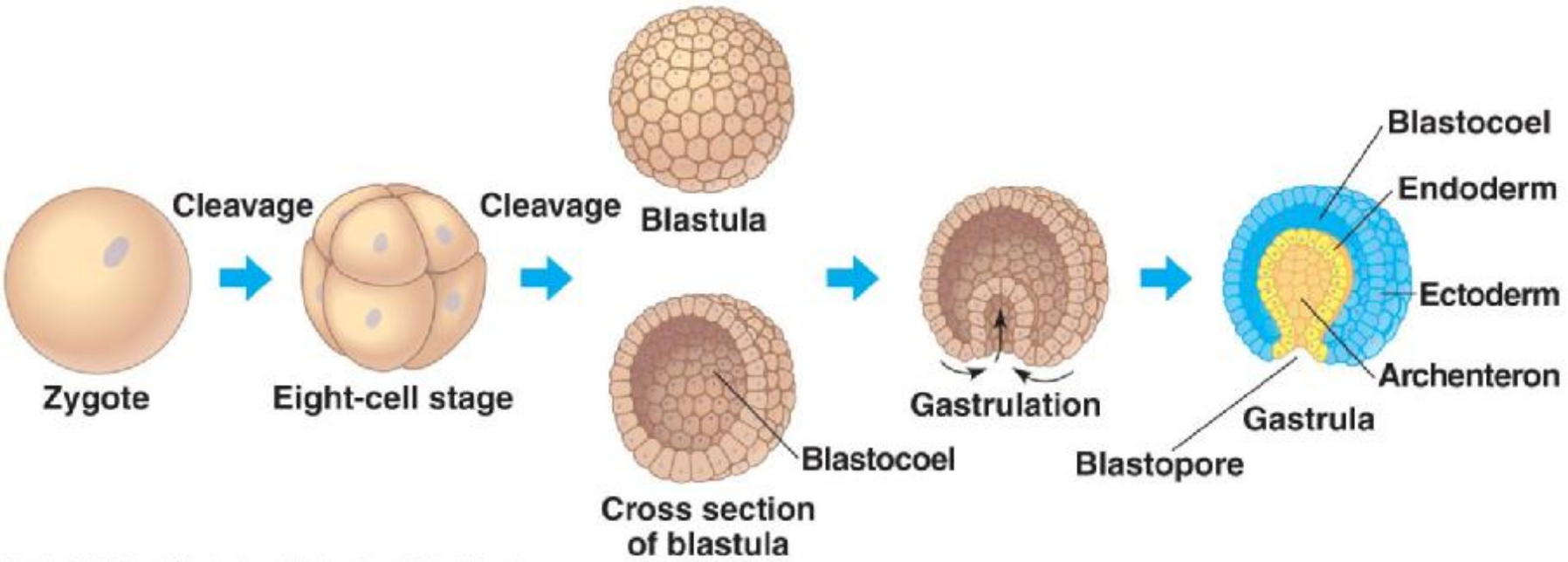
- Animals are heterotrophs
  - That ingest their food

Cell Structure and Specialization

- Animals are multicellular eukaryotes
- Their cells lack cell walls
- Their bodies are held together
  - By structural proteins such as collagen
- Nervous tissue and muscle tissue
  - Are unique to animals

Reproduction and Development

- Most animals reproduce sexually
  - With the diploid stage usually dominating the life cycle
- After a sperm fertilizes an egg
  - The zygote undergoes cleavage, leading to the formation of a blastula
- The blastula undergoes gastrulation
  - Resulting in the formation of embryonic tissue layers and a gastrula

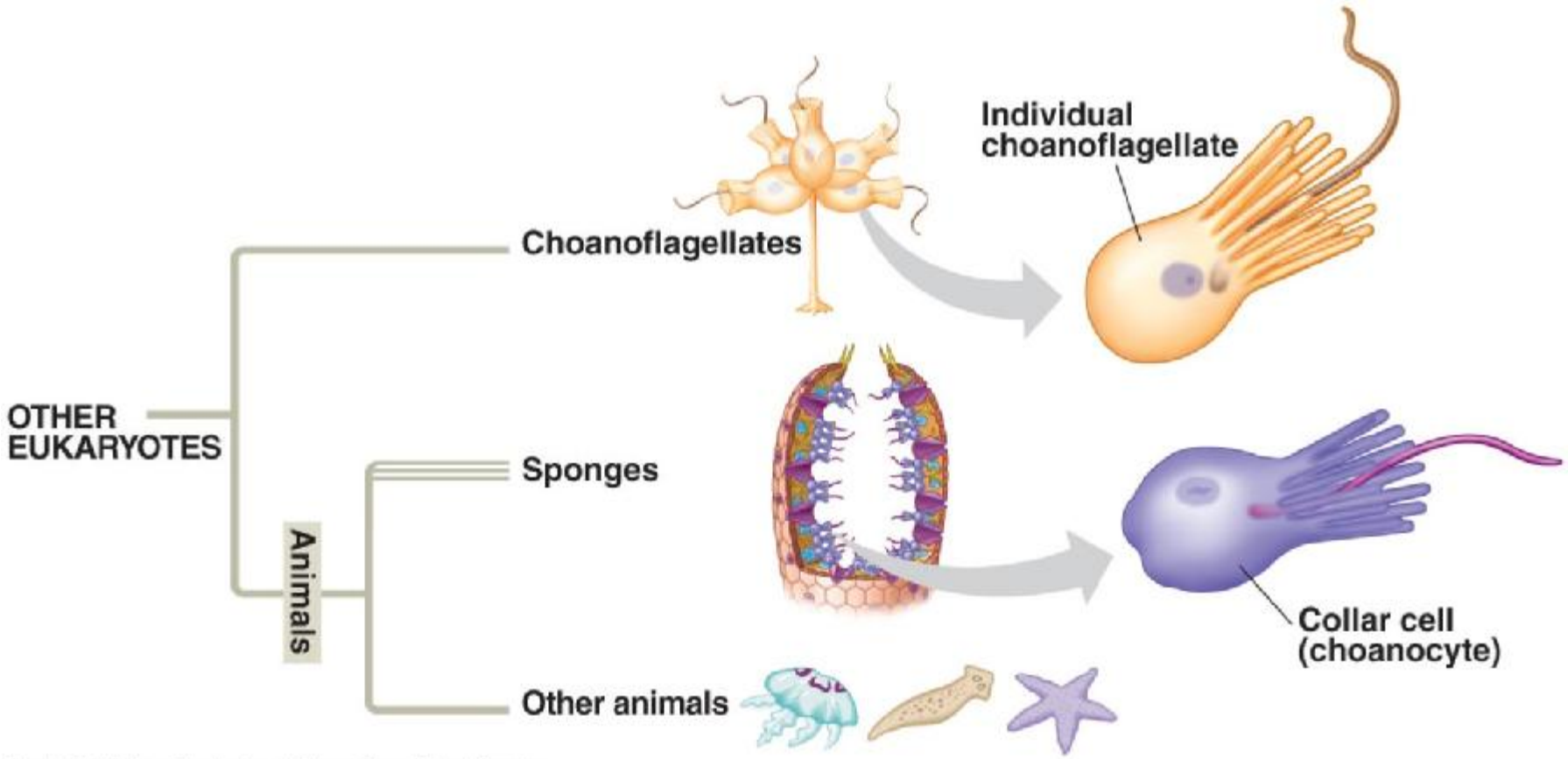


- All animals, and only animals
  - Have *Hox* genes that regulate the development of body form
- Although the *Hox* family of genes has been highly conserved
  - It can produce a wide diversity of animal morphology

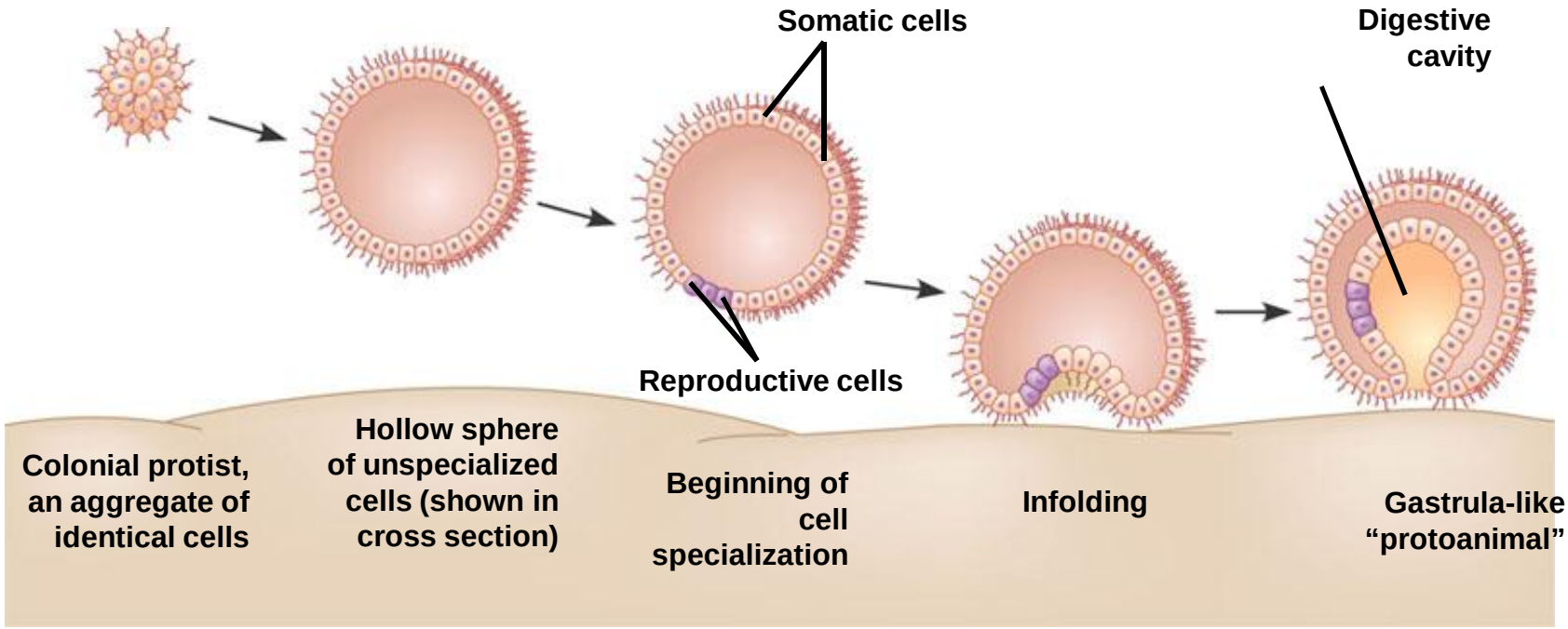
The history of animals

- The history of animals may span more than a billion years
- The animal kingdom includes not only great diversity of living species
  - But the even greater diversity of extinct ones as well

- The common ancestor of living animals
  - May have lived 1.2 billion–800 million years ago
  - May have resembled modern choanoflagellates, protists that are the closest living relatives of animals



- Animals probably evolved from a colonial protist that lived in the Precambrian seas

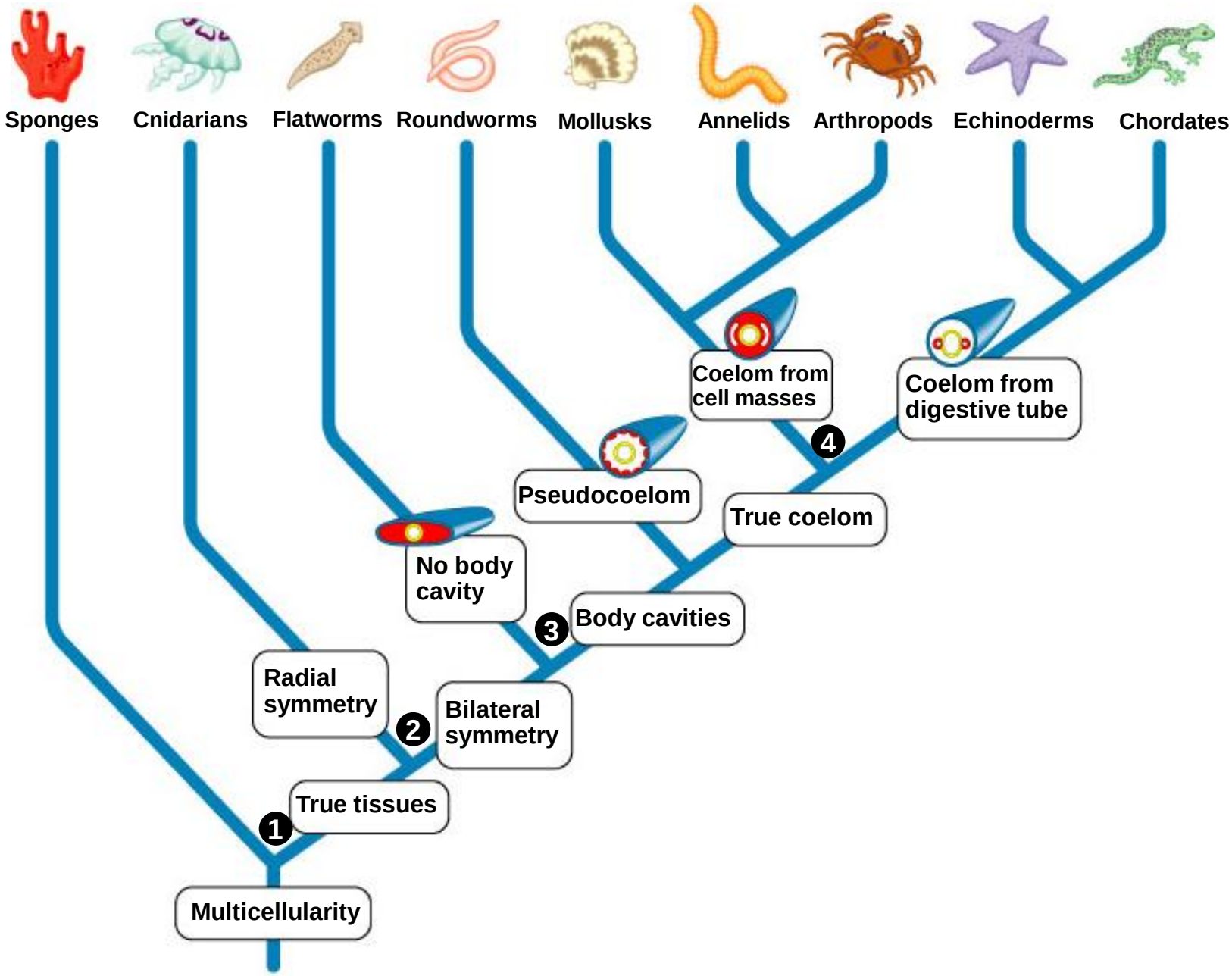


- At the beginning of the Cambrian period, 545 million years ago, animals underwent a rapid diversification

Animal Phylogeny

- To reconstruct the evolutionary history of animal phyla, researchers must depend on clues from comparative anatomy and embryology

- Four key evolutionary branch points have been hypothesized:
  - Tissue
  - Symmetry
  - Body cavity
  - Coelom

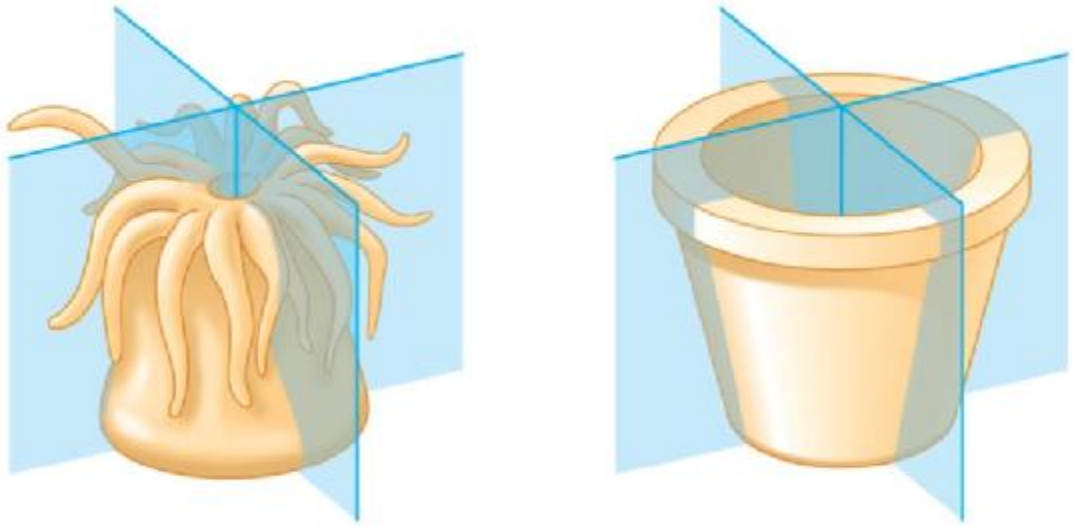

Sponges
Cnidarians
Flatworms
Roundworms
Mollusks
Annelids
Arthropods
Echinoderms
Chordates
Coelom from cell masses
Coelom from digestive tube
4
Pseudocoelom
True coelom
No body cavity
3
Body cavities
Radial symmetry
2
Bilateral symmetry
True tissues
1
Multicellularity

Tissues

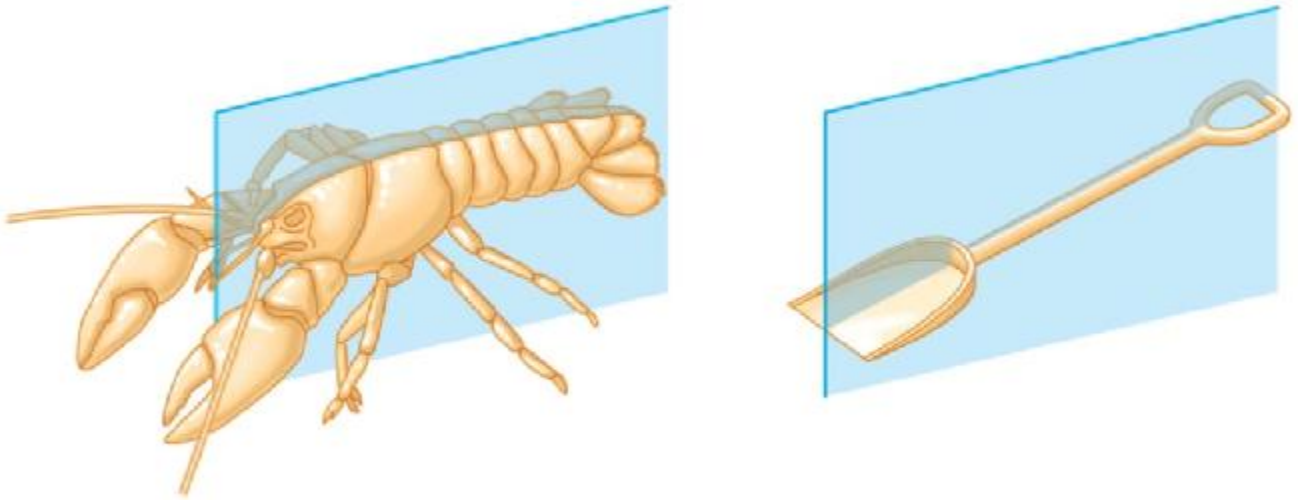
- Animal body plans
  - Also vary according to the organization of the animal's tissues
- Tissues
  - Are collections of specialized cells isolated from other tissues by membranous layers

Symmetry

- Animals can be categorized
  - According to the symmetry of their bodies, or lack of it
- Some animals have radial symmetry
  - Like in a flower pot
- Some animals exhibit bilateral symmetry
  - Or two-sided symmetry

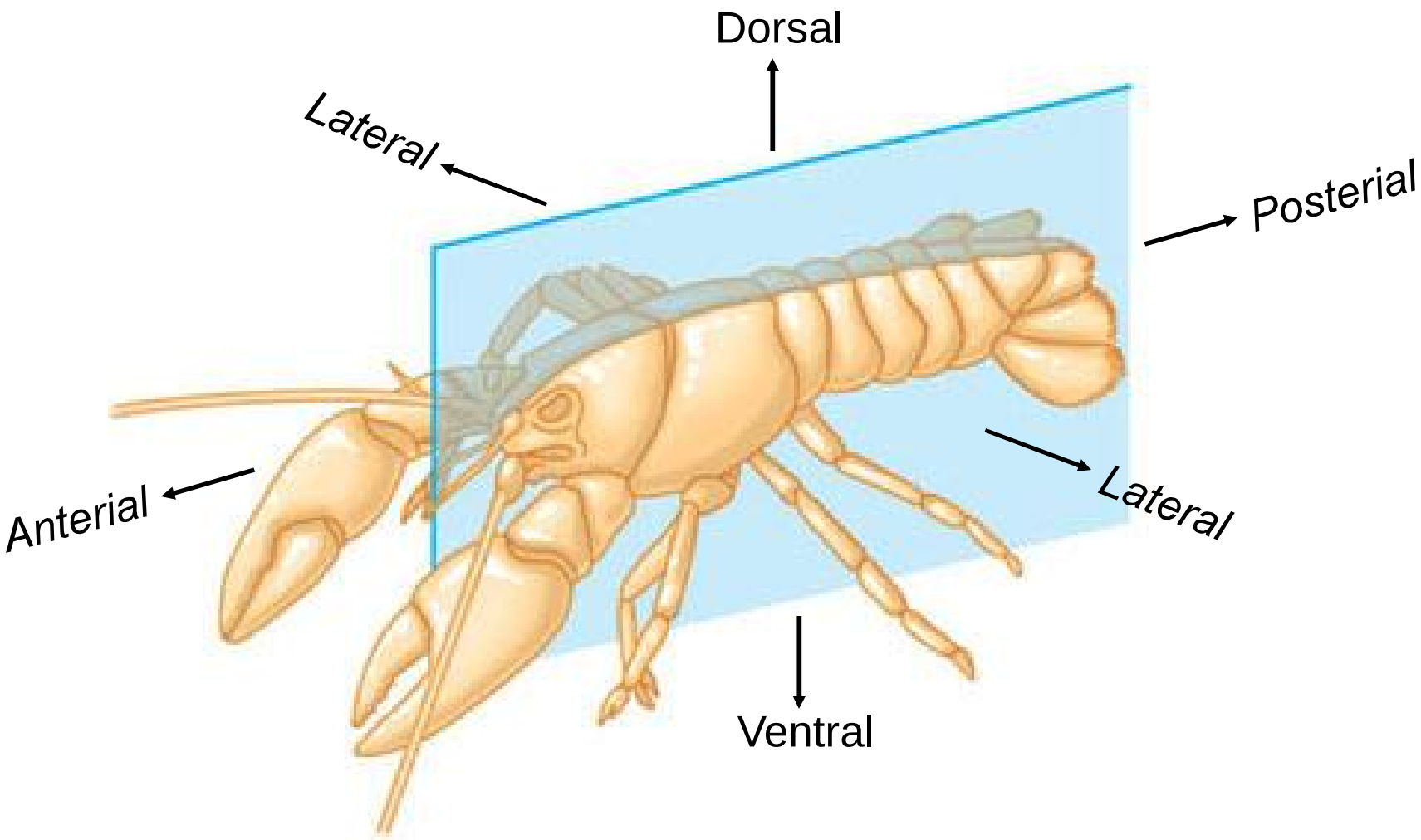


(a) Radial symmetry



(b) Bilateral symmetry

- Bilaterally symmetrical animals have
  - A dorsal (top) side and a ventral (bottom) side
  - A right and left side
  - Anterior (head) and posterior (tail) ends
  - Cephalization, the development of a head

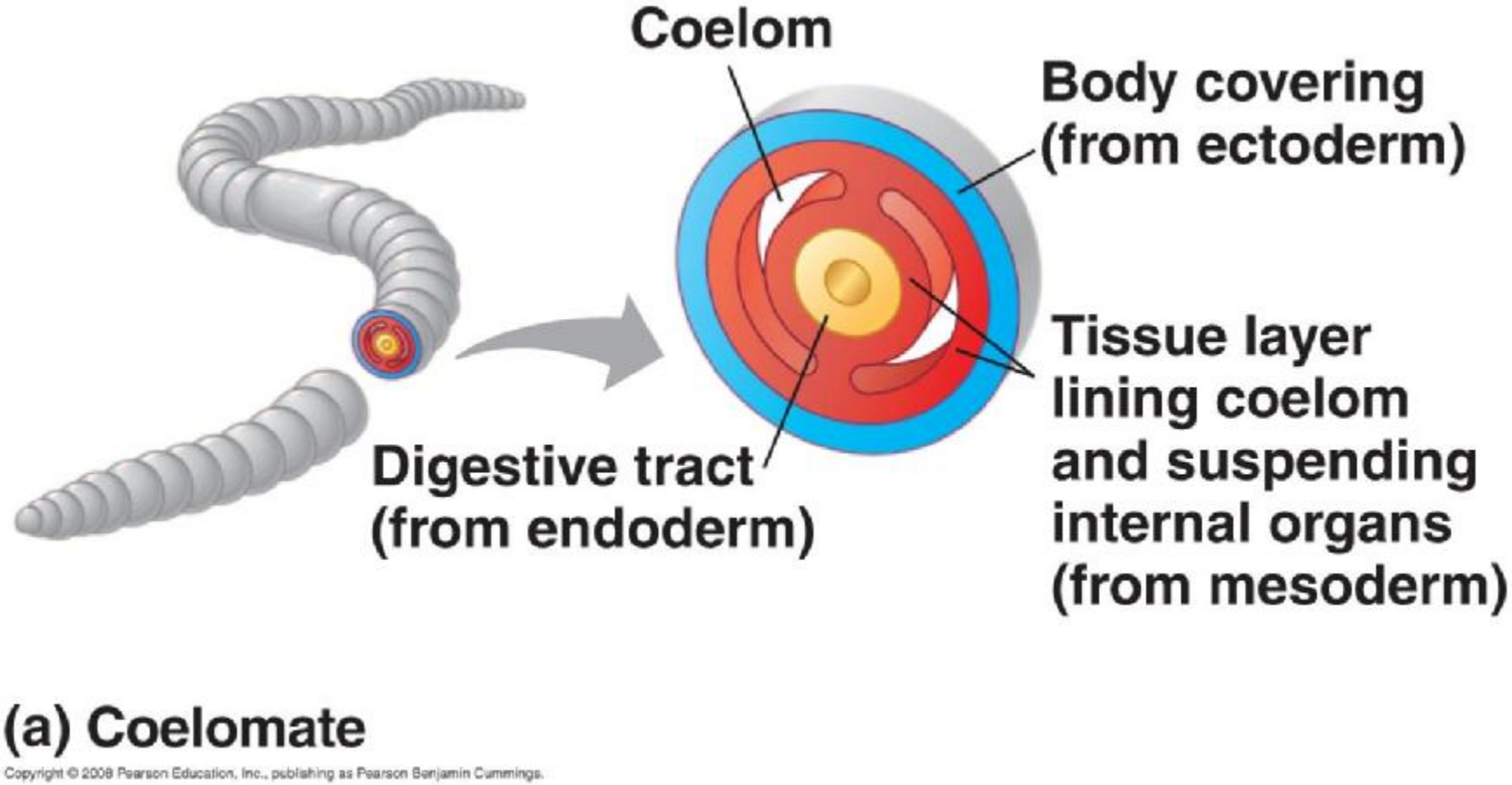

Dorsal
Lateral
Posterial
Anterial
Lateral
Ventral

- Animal embryos
  - Form germ layers, embryonic tissues, including ectoderm, endoderm, and mesoderm
- Diploblastic animals
  - Have two germ layers
- Triploblastic animals
  - Have three germ layers

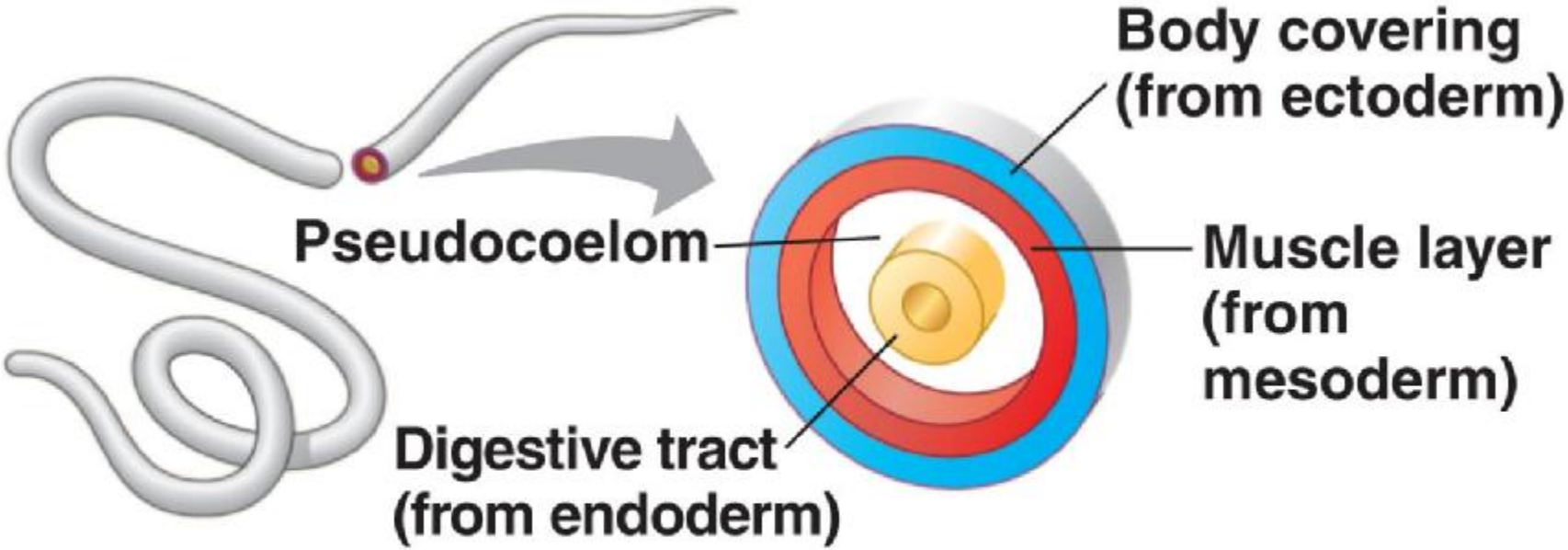
Body Cavities

- In triploblastic animals
  - A body cavity may be present or absent

- A true body cavity
  - Is called a coelom and is derived from mesoderm

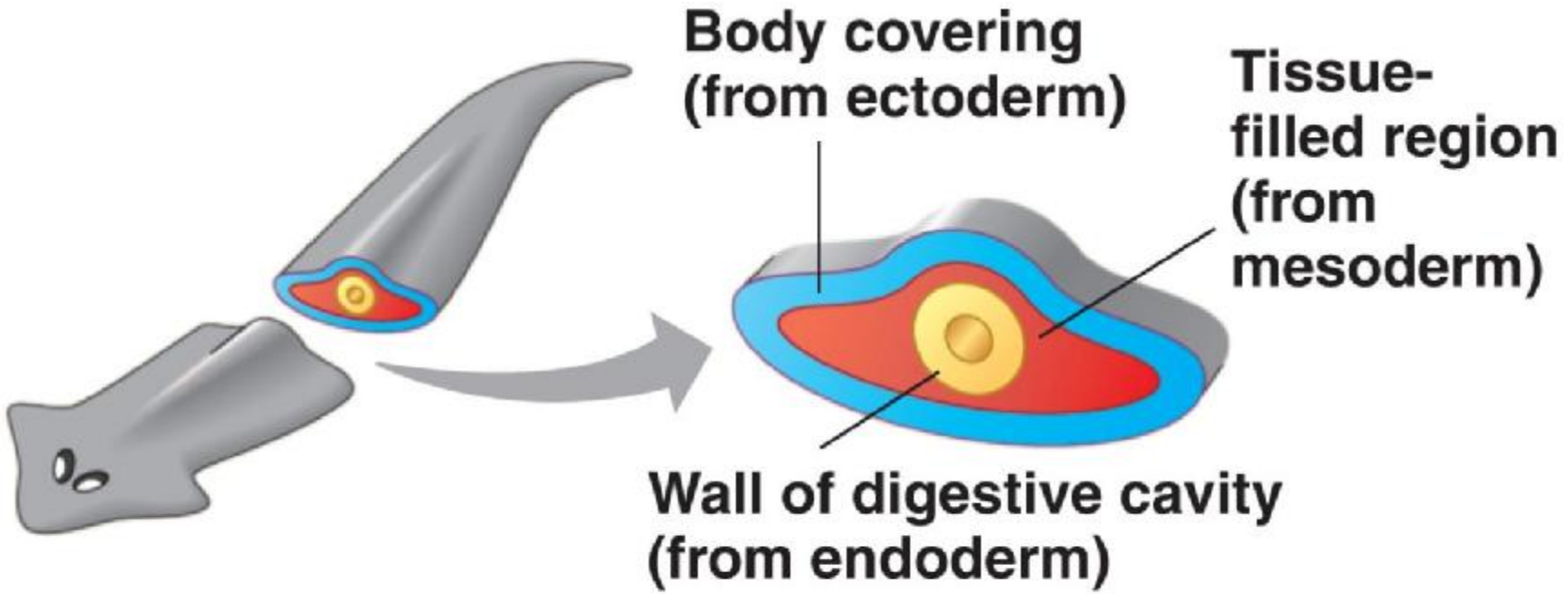


- A pseudocoelom
  - Is a body cavity derived from the blastocoel, rather than from mesoderm



(b) Pseudocoelomate

- Organisms without body cavities
  - Are considered acoelomates



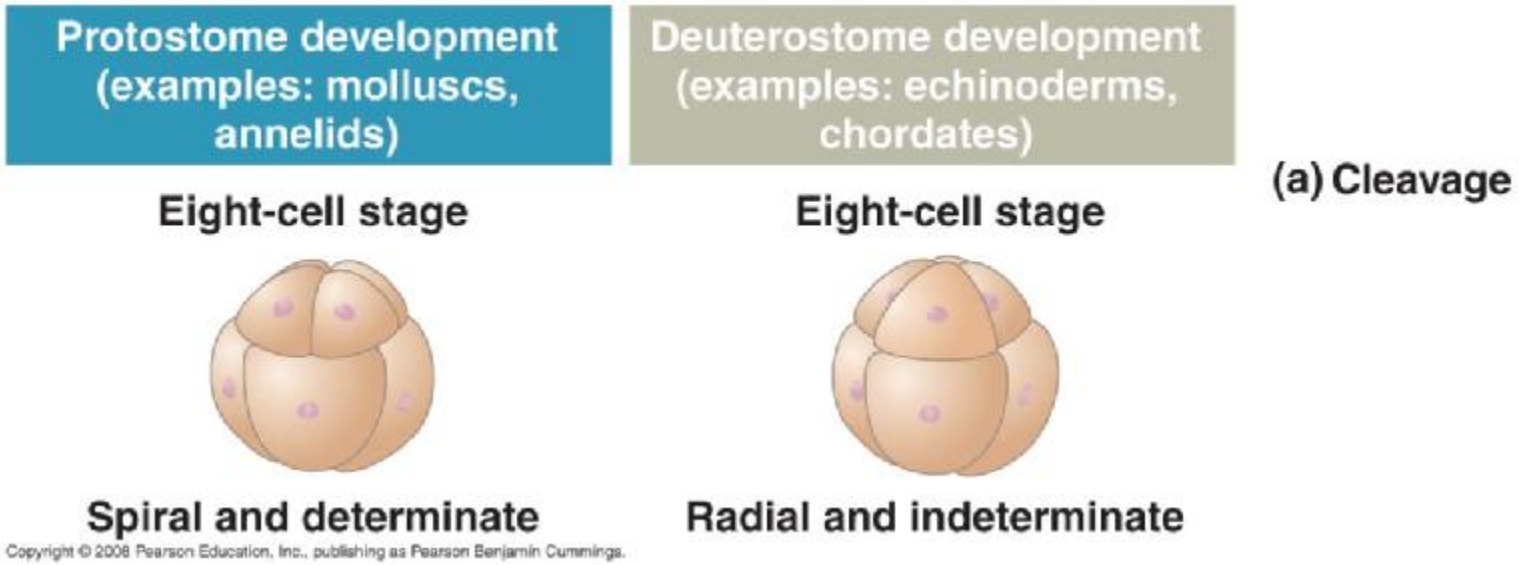
(c) Acoelomate

Protostome and Deuterostome Development

- Based on certain features seen in early development
  - Many animals can be categorized as having one of two developmental modes: protostome development or deuterostome development

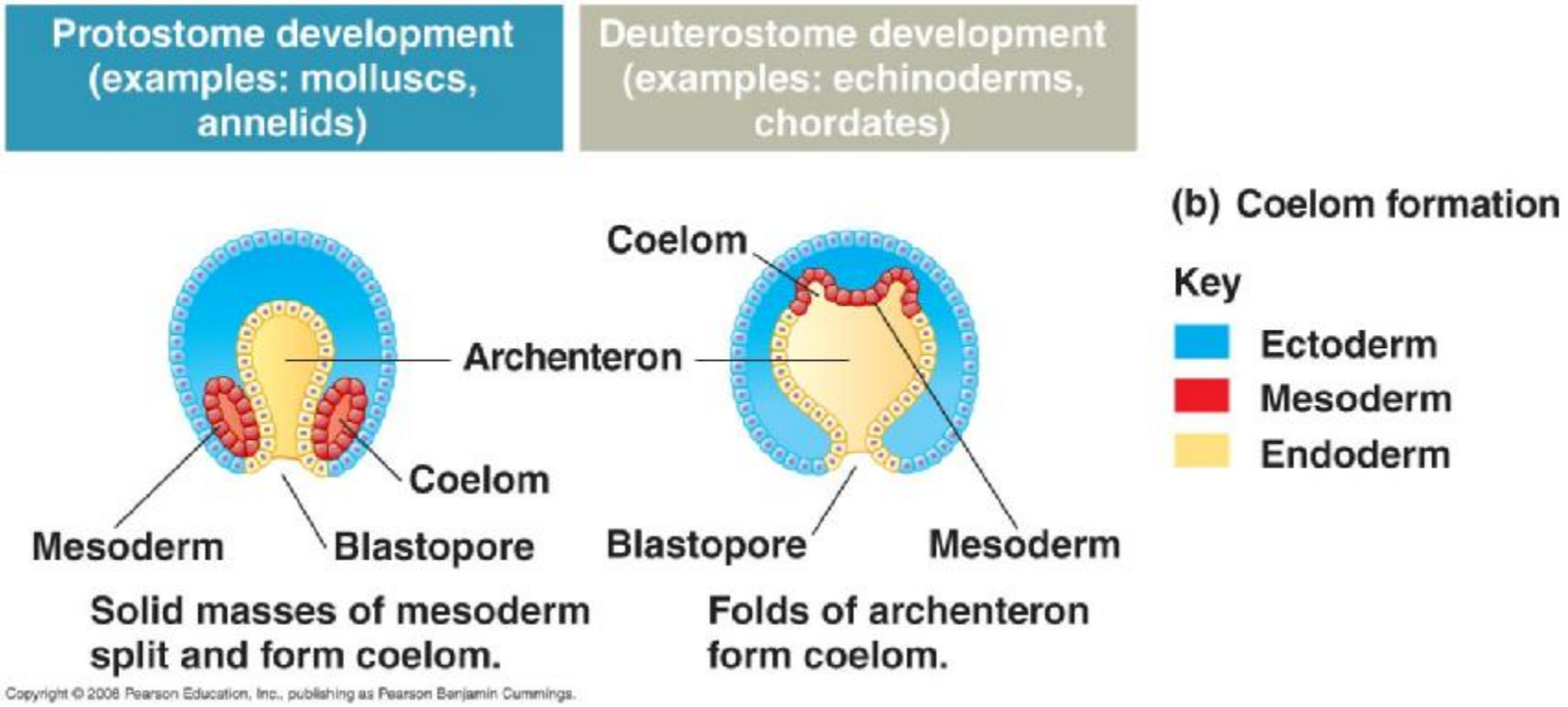
Cleavage

- In protostome development
  - Cleavage is spiral and determinate
- In deuterostome development
  - Cleavage is radial and indeterminate



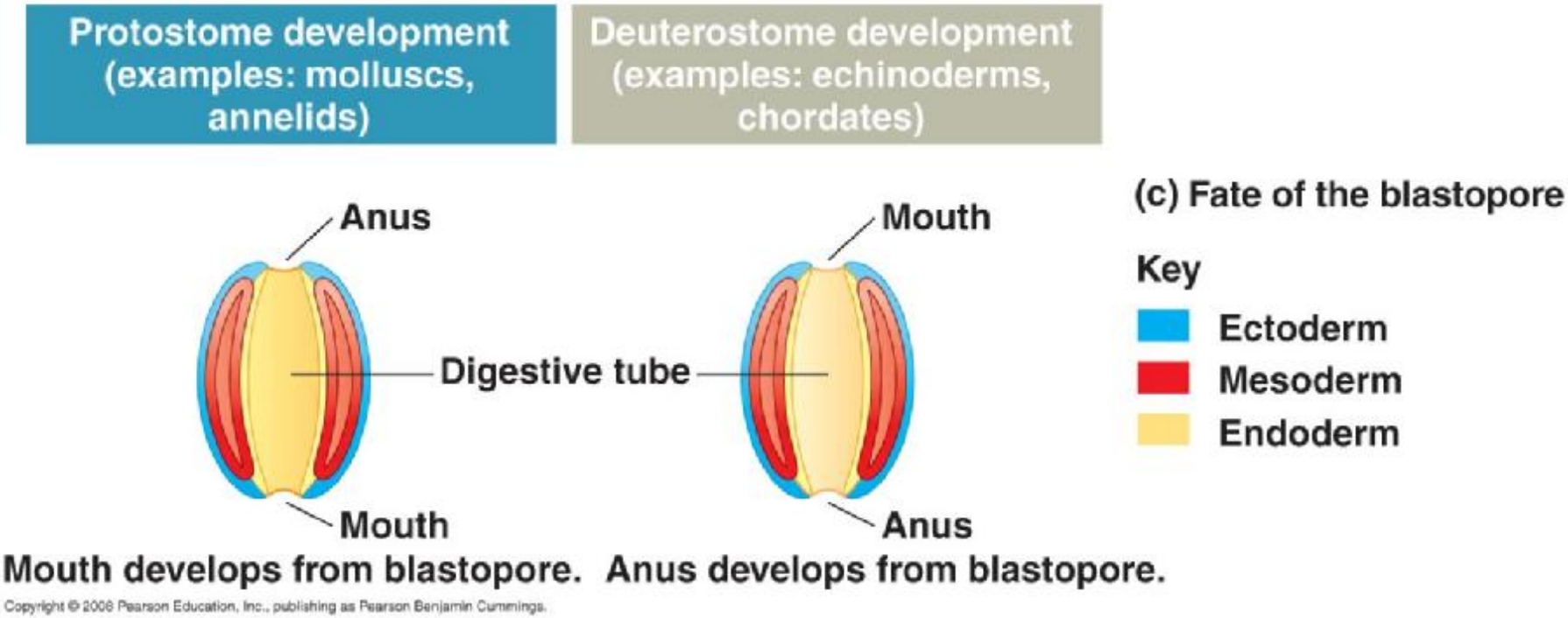
Coelom Formation

- In protostome development
  - The splitting of the initially solid masses of mesoderm to form the coelomic cavity is called schizocoelous development
- In deuterostome development
  - Formation of the body cavity is described as enterocoelous development



Fate of the Blastopore

- In protostome development
  - The blastopore becomes the mouth
- In deuterostome development
  - The blastopore becomes the anus



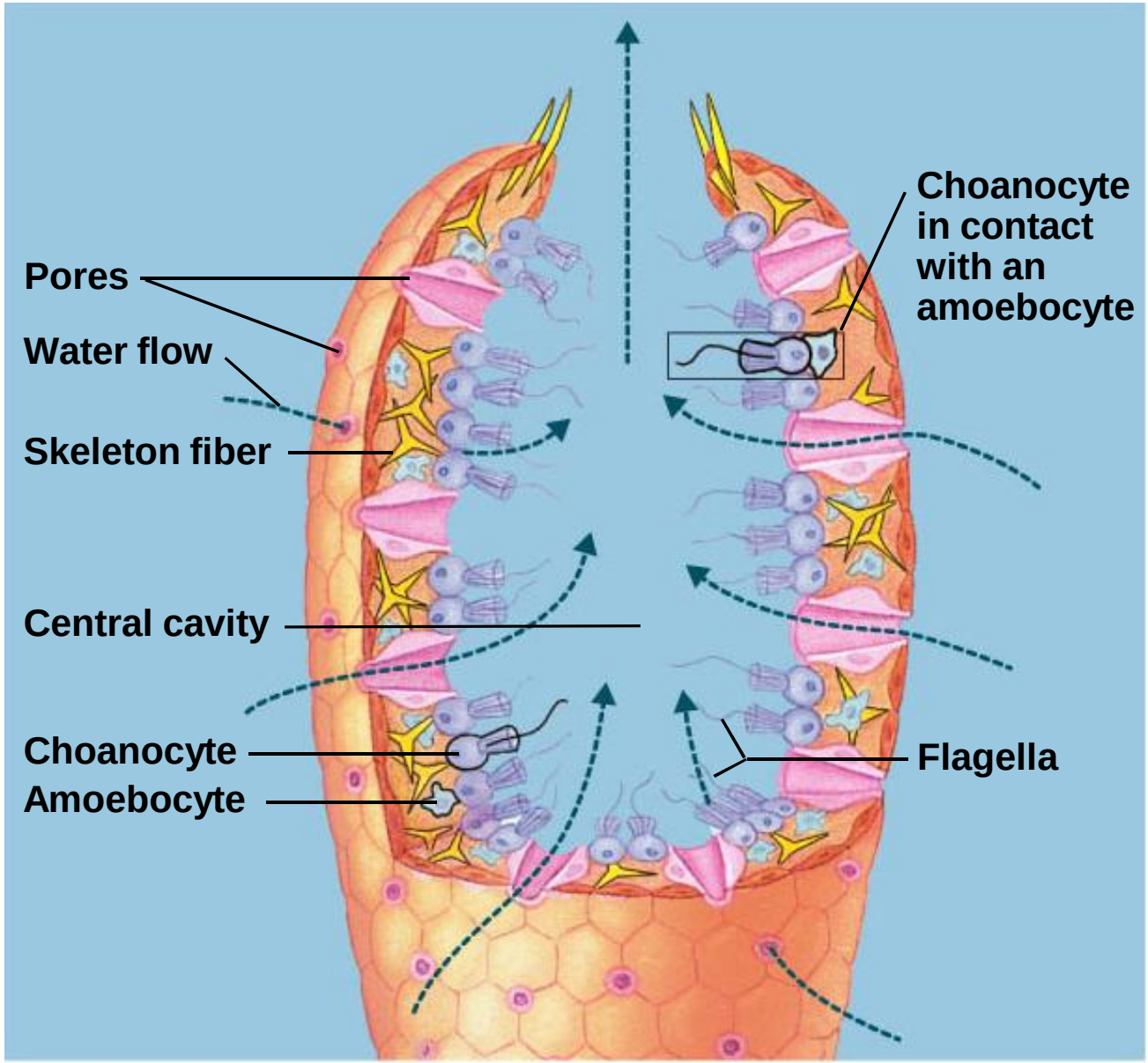
MAJOR INVERTEBRATE PHYLA

- Invertebrates
  - Are animals without backbones
  - Represent 95% of the animal kingdom

Sponges

- Phylum Porifera
  - Includes sessile animals once believed to be plants
  - Lack true tissues

- The body of a sponge
  - Resembles a sac perforated with holes
  - Draws water into a central cavity, where food is collected

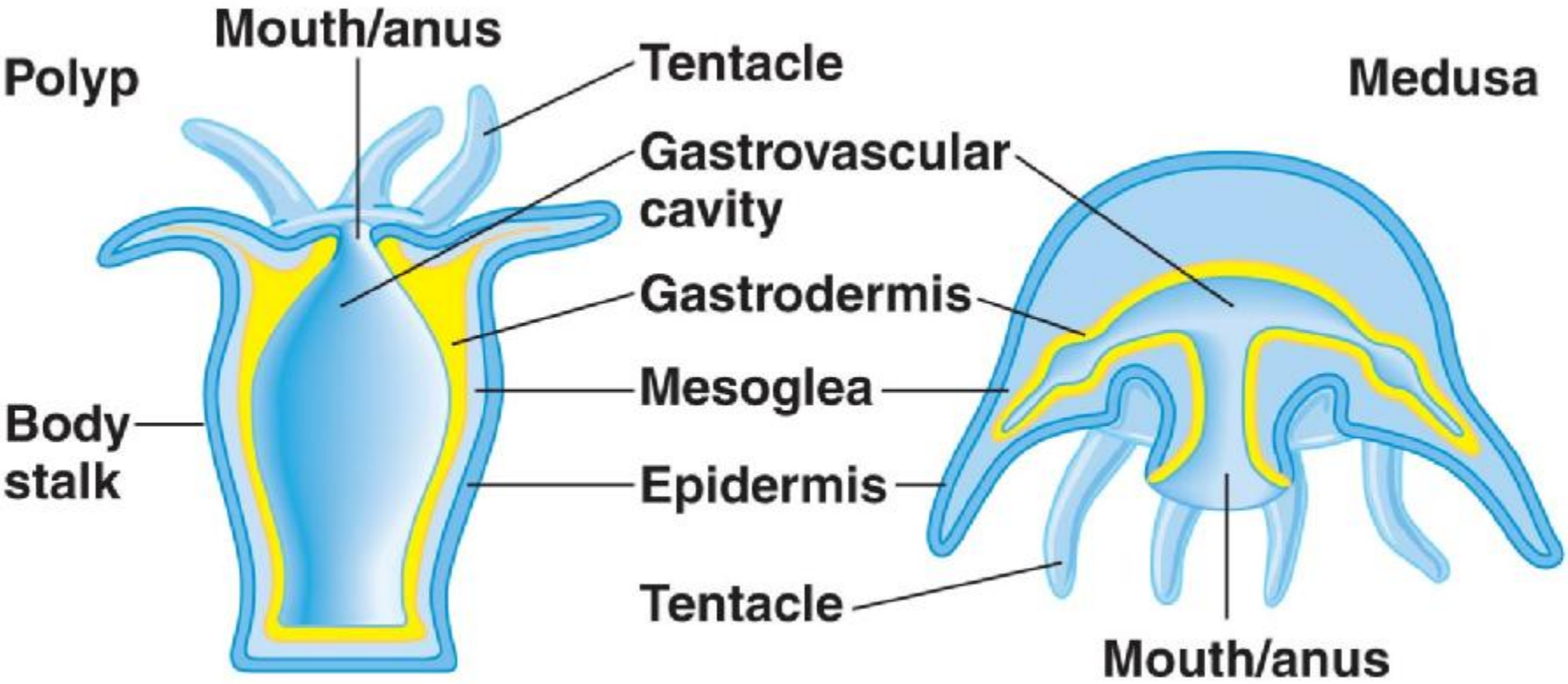

Pores
Water flow
Skeleton fiber
Central cavity
Choanocyte
Amoebocyte
Choanocyte in contact with an amoebocyte
Flagella

Phylum Cnidaria

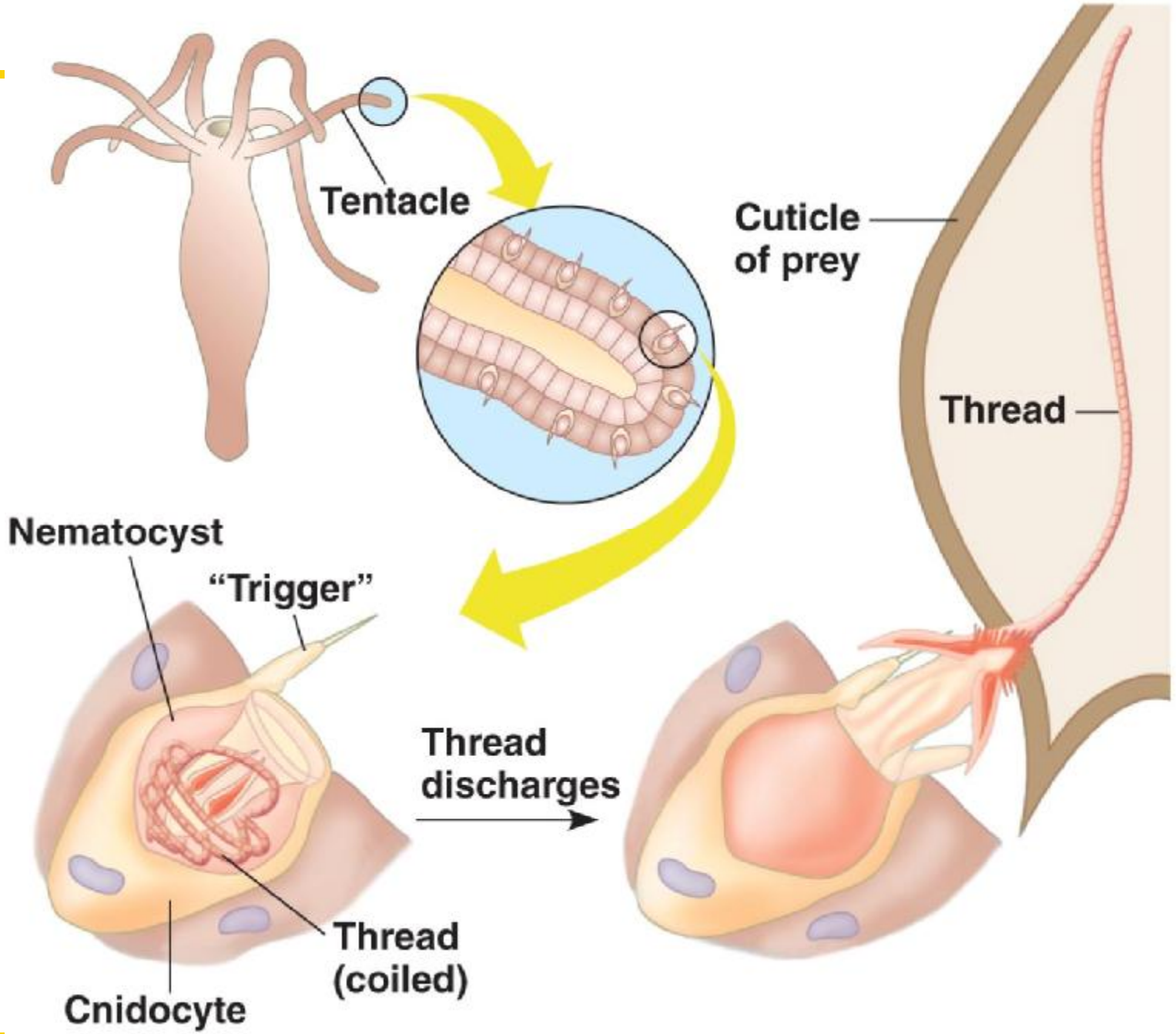
- All animals except sponges
  - Belong to the clade Eumetazoa, the animals with true tissues
- Phylum Cnidaria
  - Is one of the oldest groups in this clade
- Cnidarians have radial symmetry, a gastrovascular cavity, and cnidocytes

- Cnidarians
  - Have diversified into a wide range of both sessile and floating forms including jellies, corals, and hydras
  - But still exhibit a relatively 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 both mouth and anus
- There are two variations on this body plan
  - The sessile polyp and the floating medusa



- Cnidarians are carnivores
  - That use tentacles to capture prey
- The tentacles are armed with cnidocytes
  - Unique cells that function in defense and the capture of prey

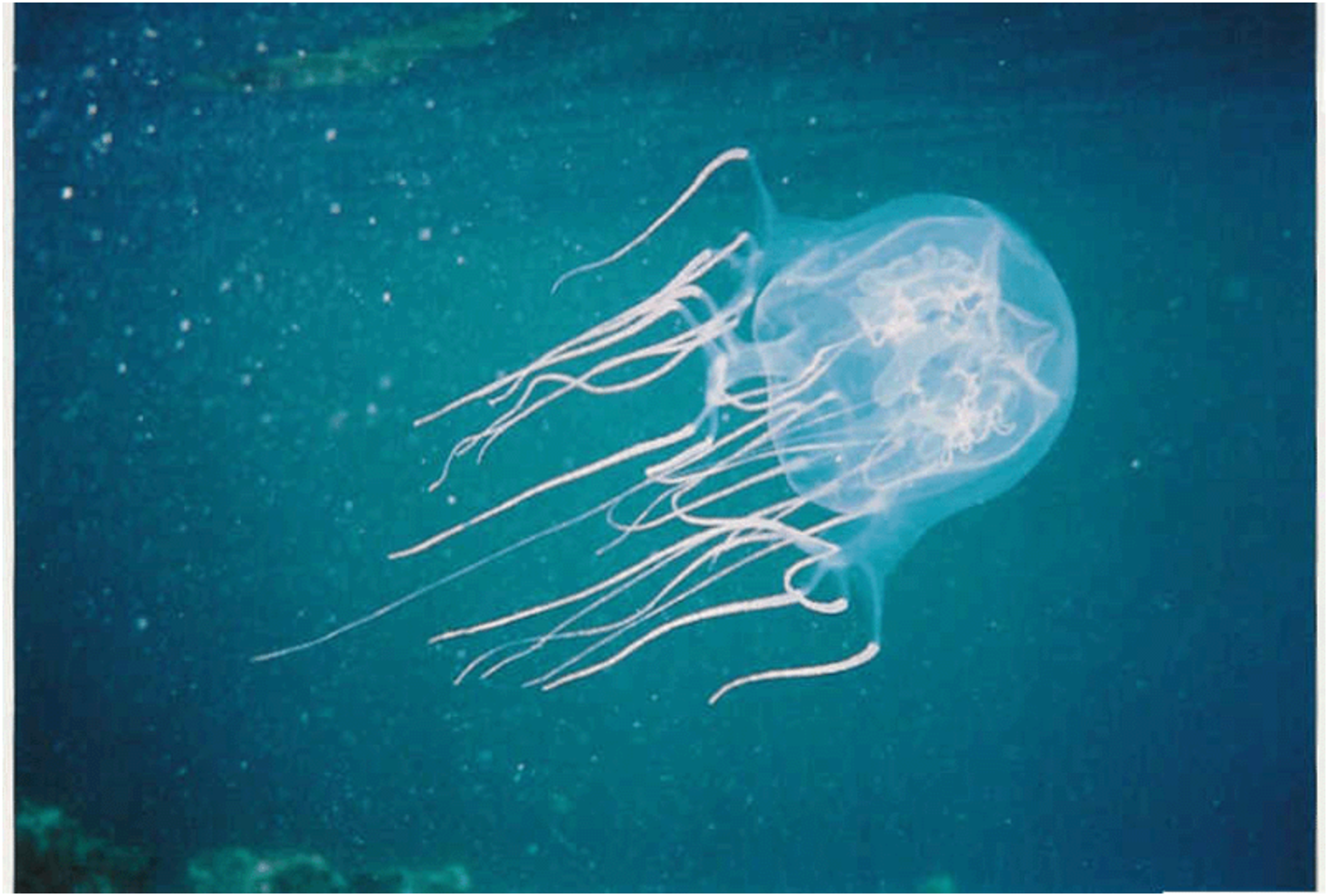


- The phylum Cnidaria is divided into four major classes:
  - Hydrozoa: Hydras, *Obelia*
  - Scyphozoa: jellyfish
  - Cubozoa: sea wasps
  - Anthozoa: sea anemones, corals

Hydra (class Hydrozoa)

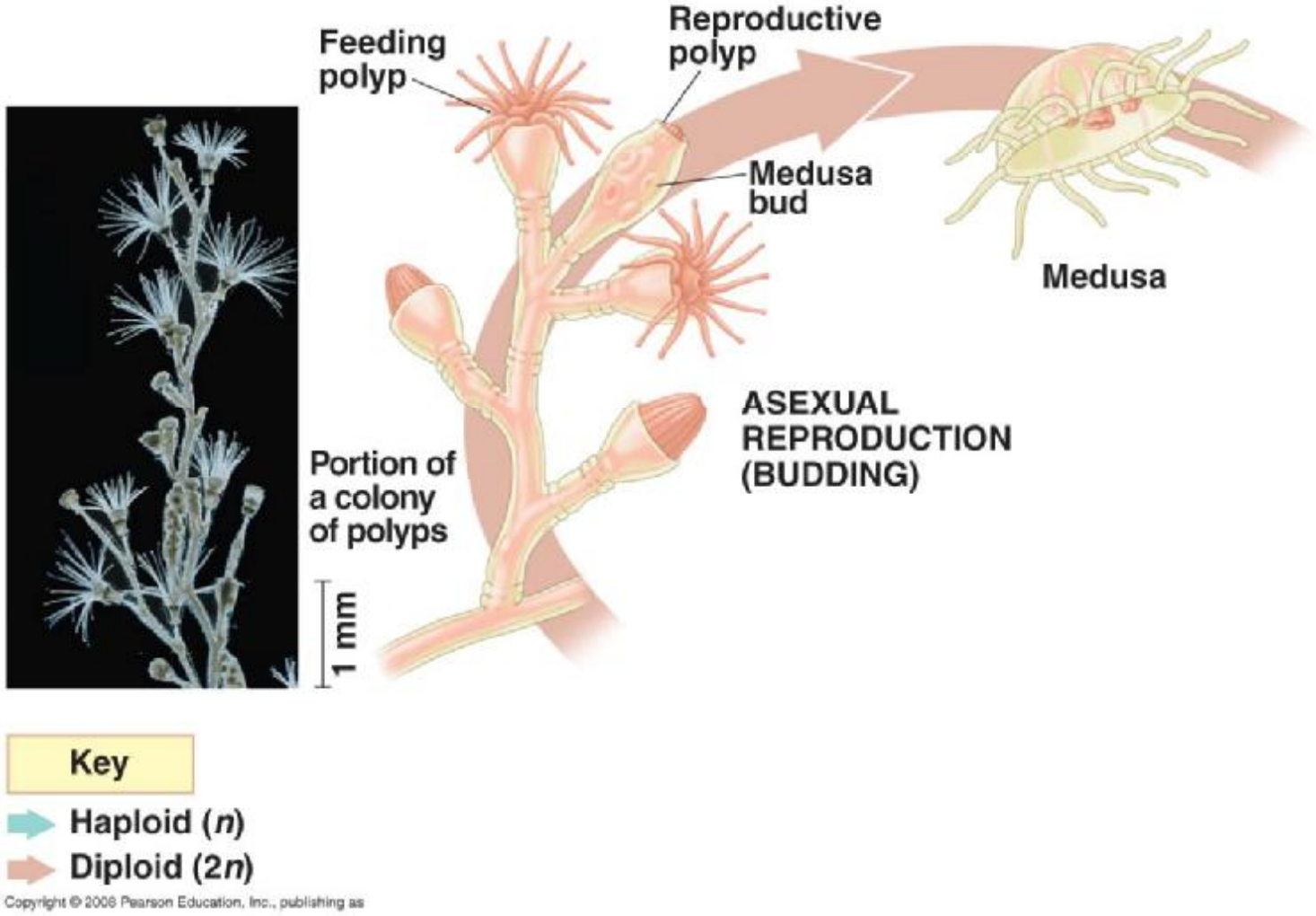
Jellyfish (class Scyphozoa)

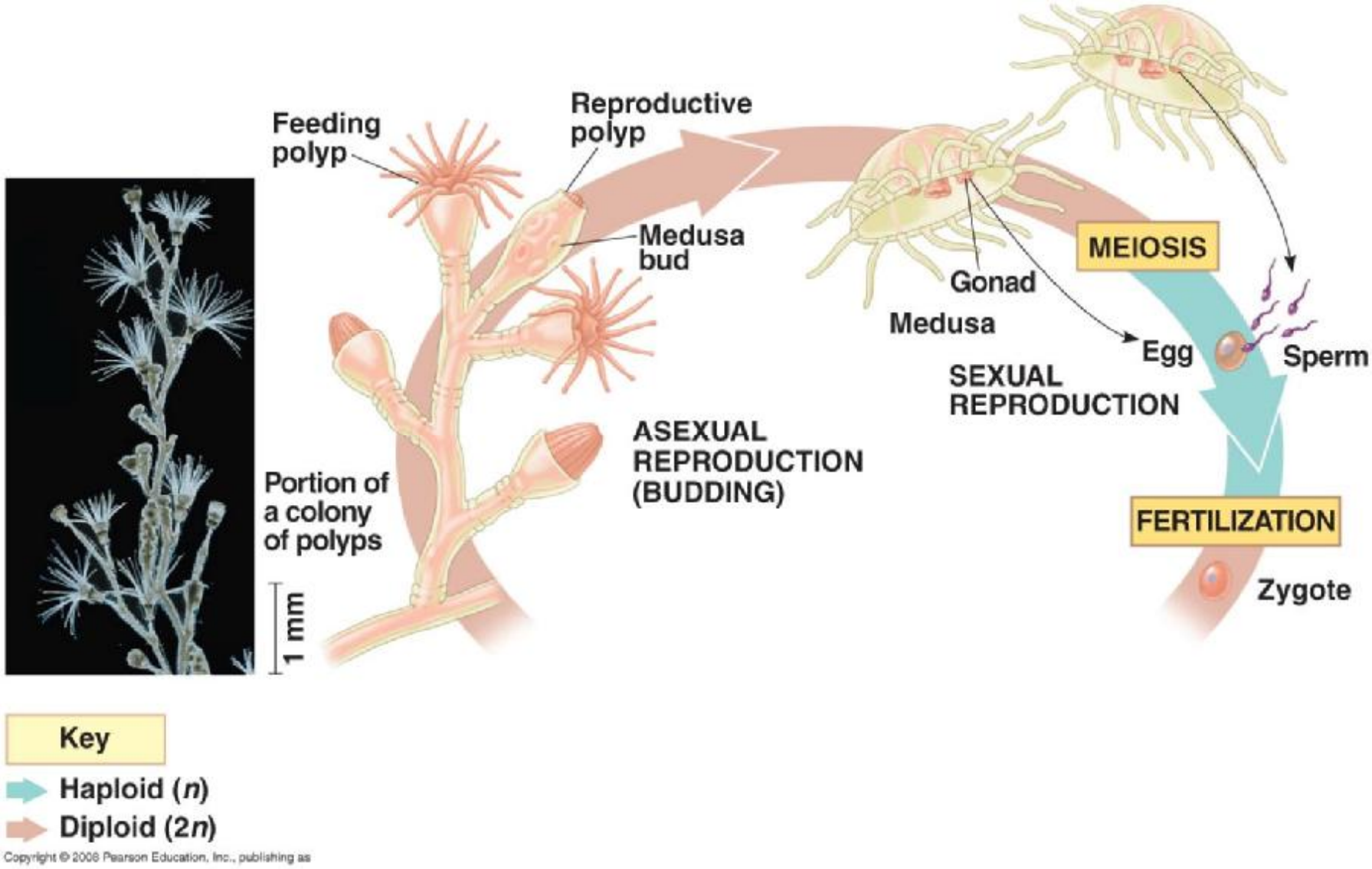
Sea wasp (class Cubozoa)

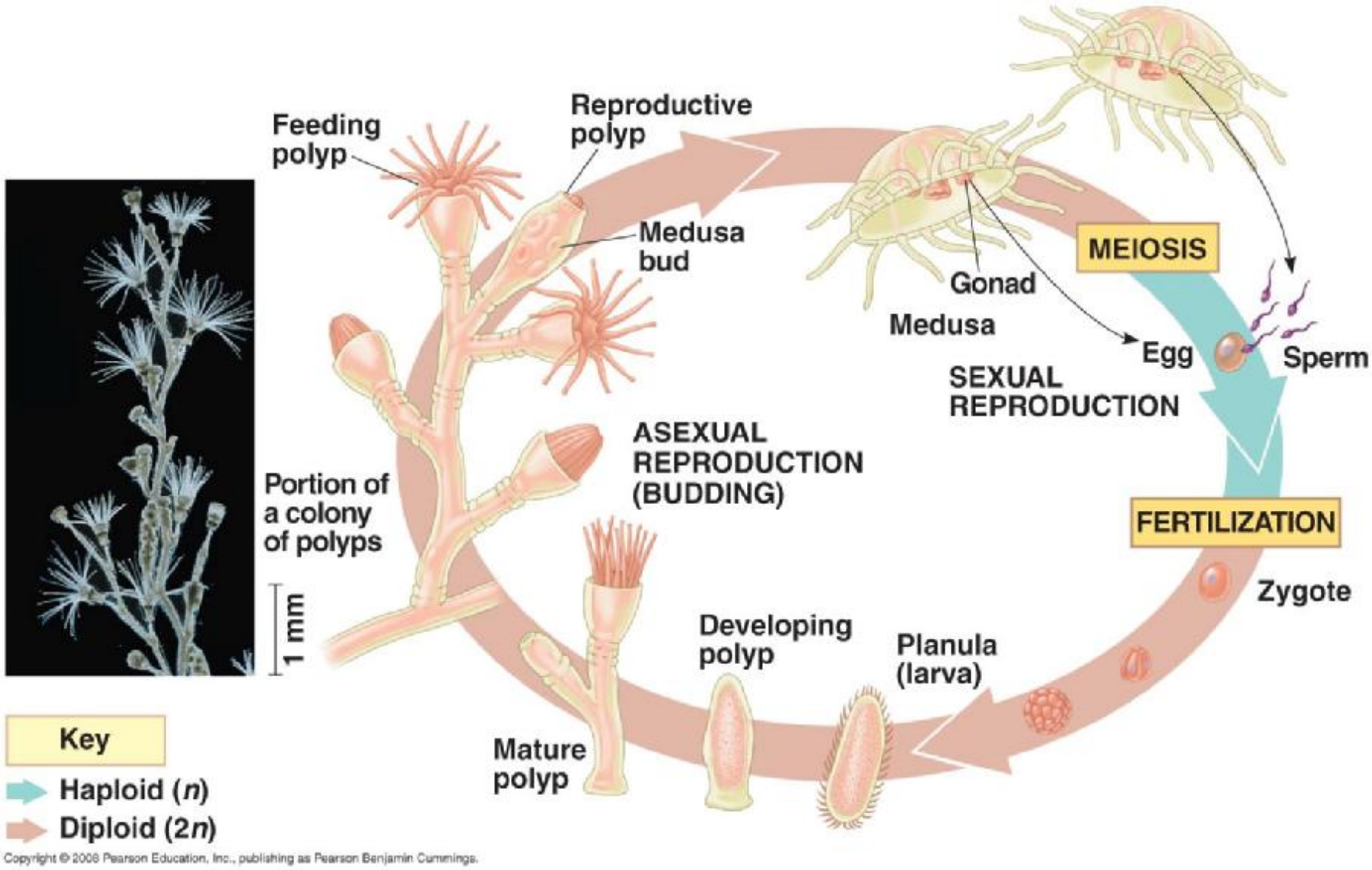


Sea anemone (class Anthozoa)

- Most hydrozoans
  - Alternate between polyp and medusa forms







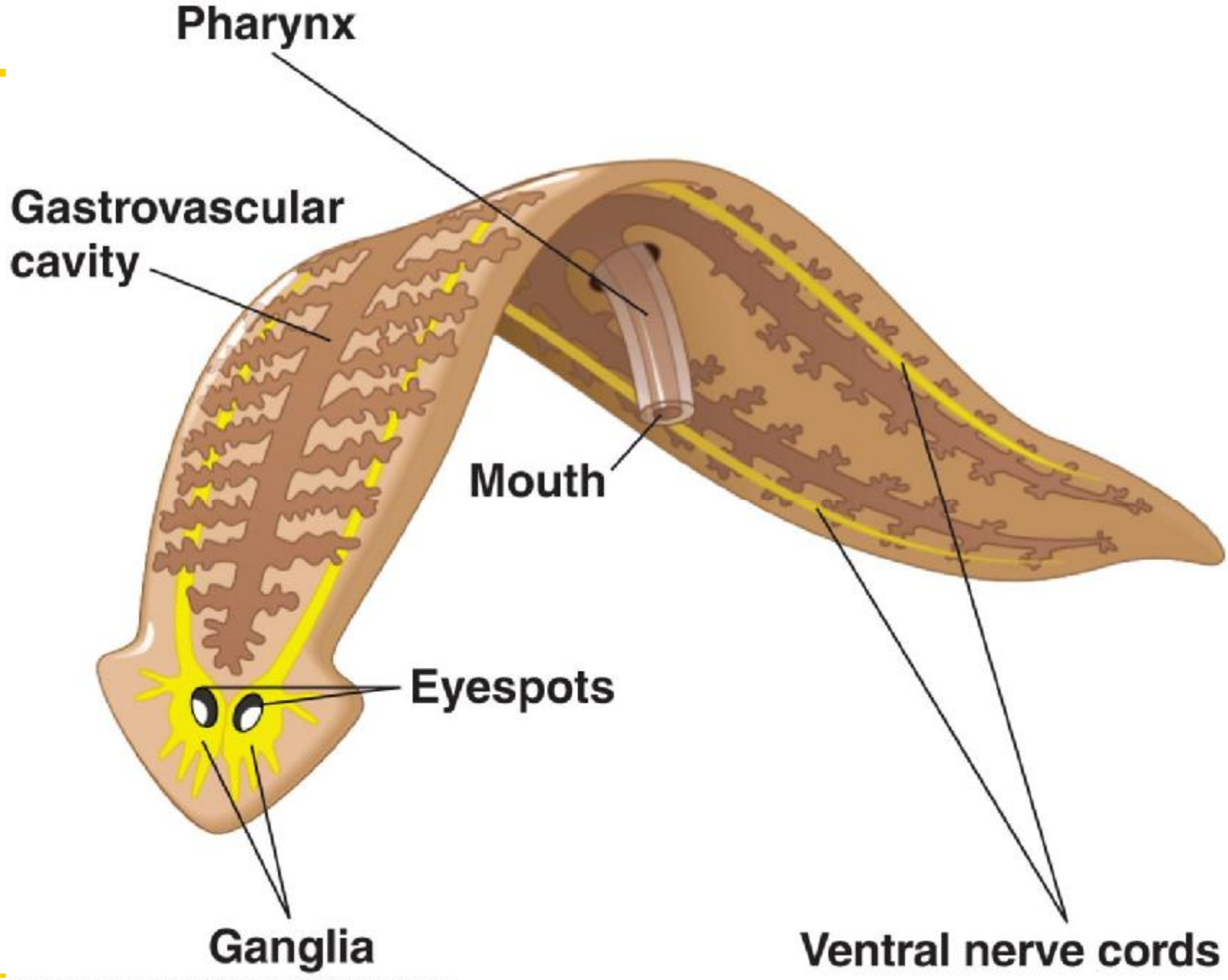
Phylum Platyhelminthes

- Members of phylum Platyhelminthes
  - Live in marine, freshwater, and damp terrestrial habitats
  - Are flattened dorsoventrally and have a gastrovascular cavity
- Although flatworms undergo triploblastic development
  - They are acoelomates

- Flatworms are divided into four classes
  - Turbellaria: *Dugesia*
  - Monogenea
  - Trematoda: flukes (trematodes)
  - Cestoda: tapeworm

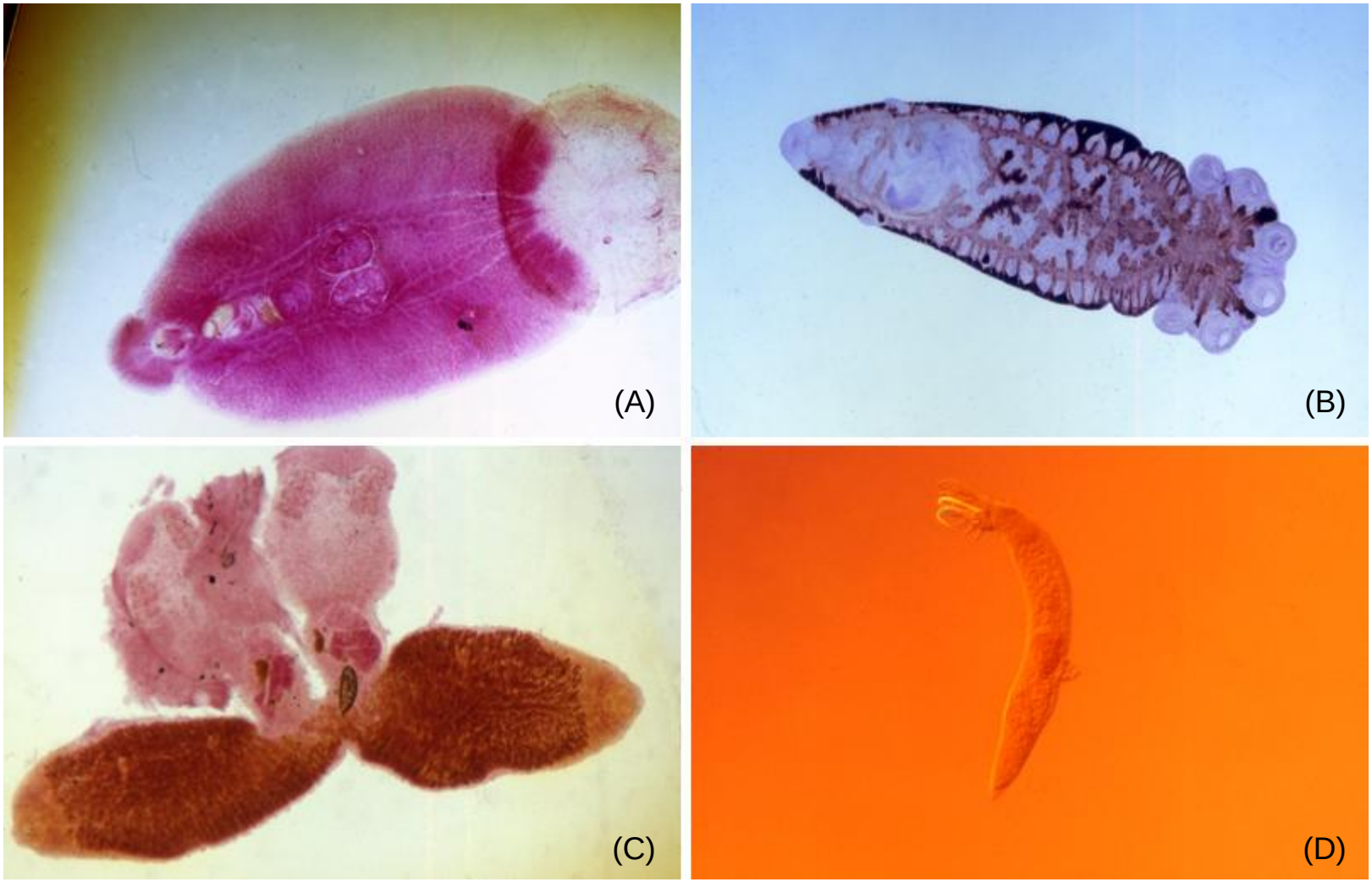
Turbellarian

- The best-known turbellarians, commonly called planarians
  - Have light-sensitive eyespots and centralized nerve nets



Monogeneans

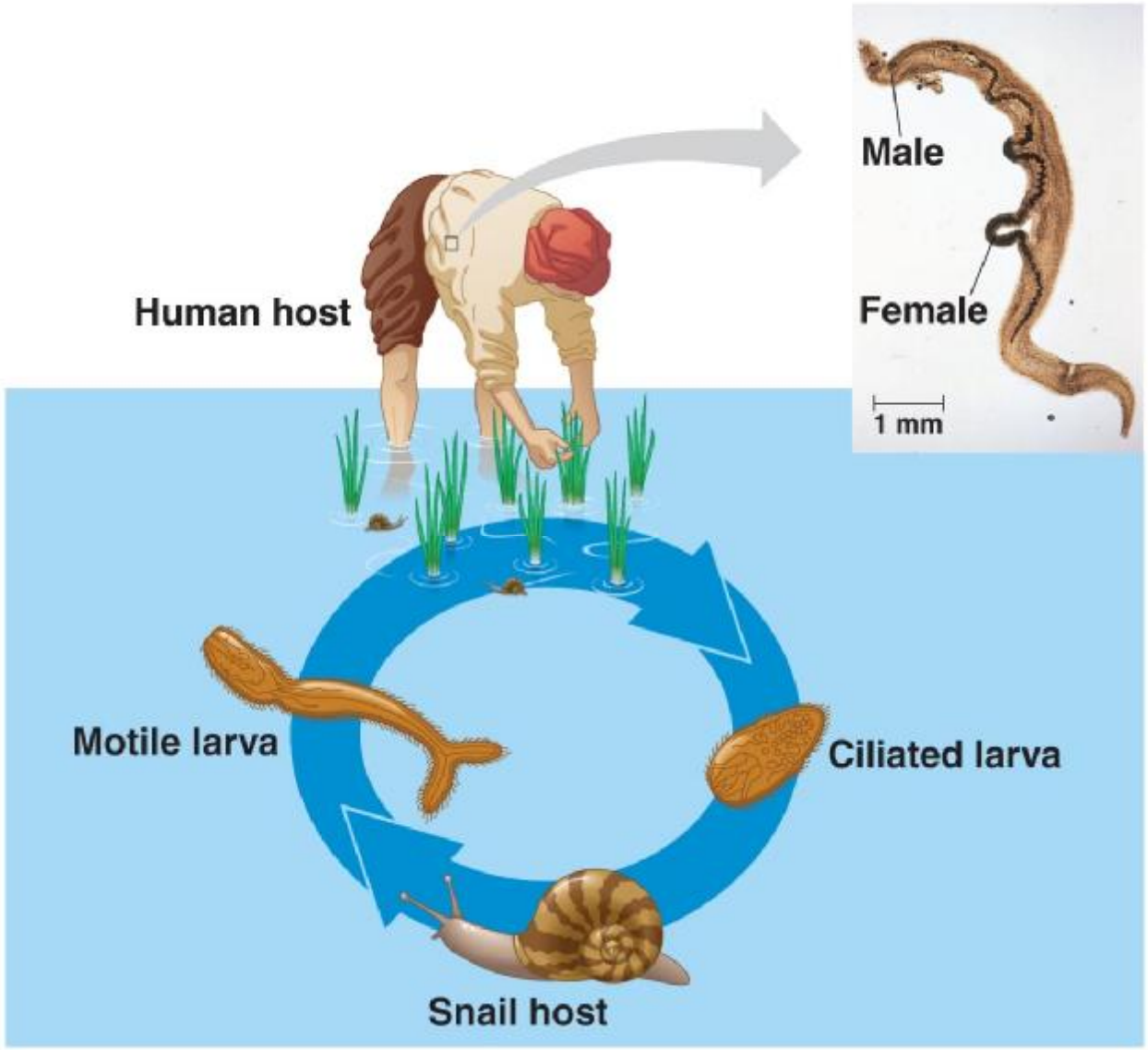
- Monogeneans
  - are usually ectoparasites on the skin and gills of fish.
  - The life cycle involves only one host, for the adult. New hosts are located and infected by free-living larvae.



(A) *Monopisthocotylea entobdellae* (B) *Polyopisthocotylea polystoma*
(C) *Gyrodactylus* sp., (D) *Diplozoon paradoxum*

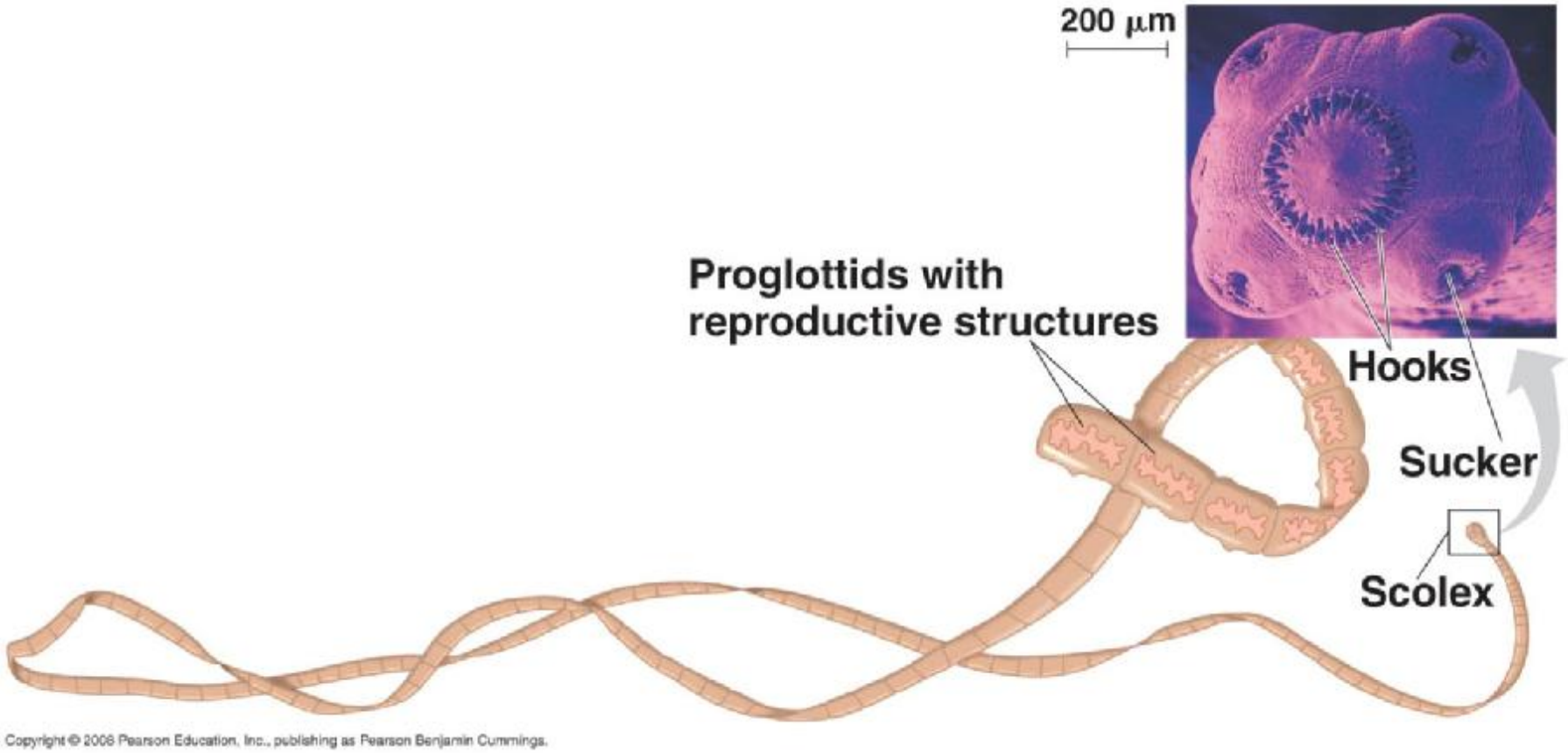
Trematode

- Trematodes
  - Live as parasites in or on other animals
  - Parasitize a wide range of hosts
- Trematodes that parasitize humans
  - Spend part of their lives in snail hosts



Tapeworm

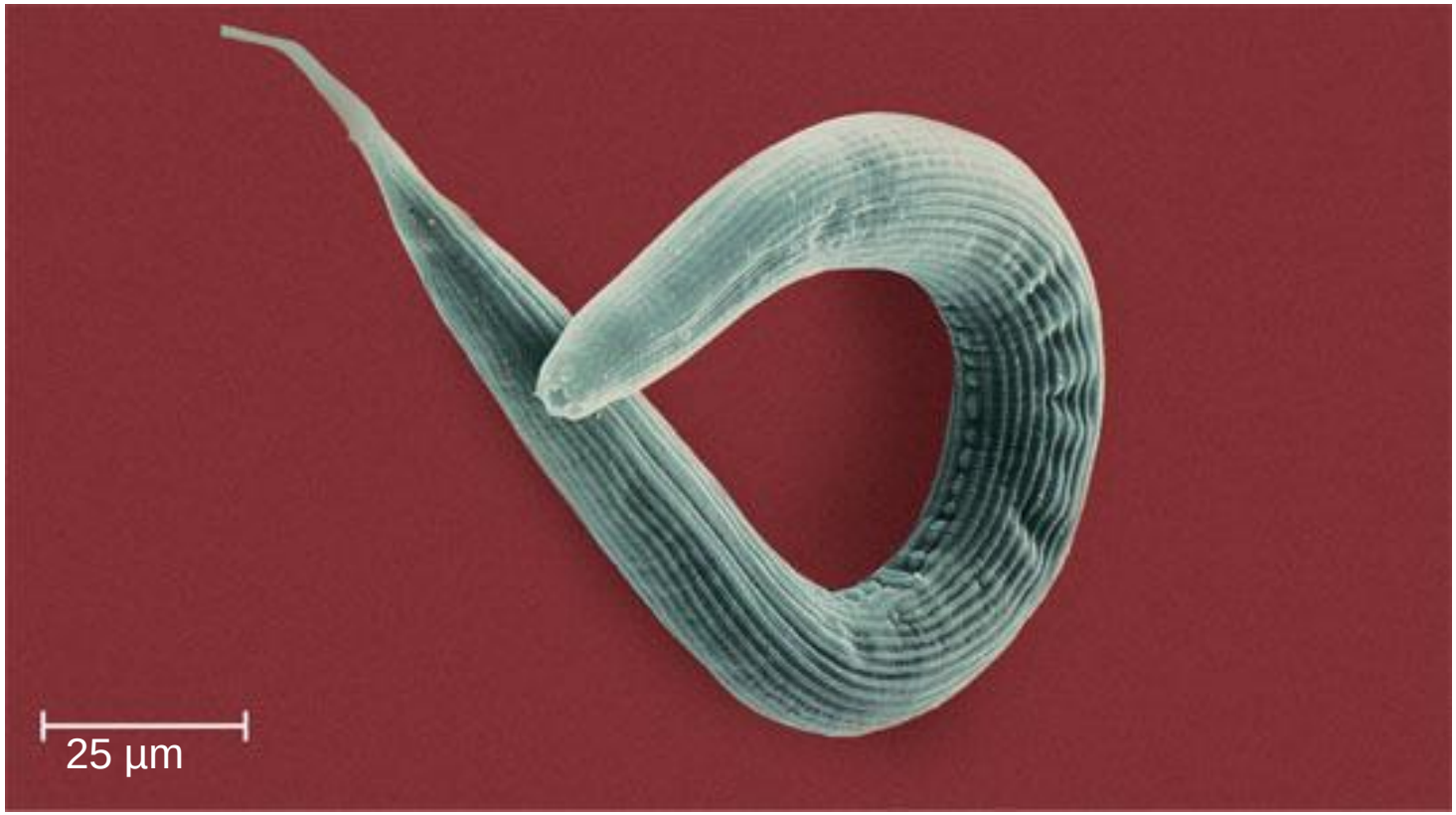
- Tapeworms
  - Are also parasitic and lack a digestive system



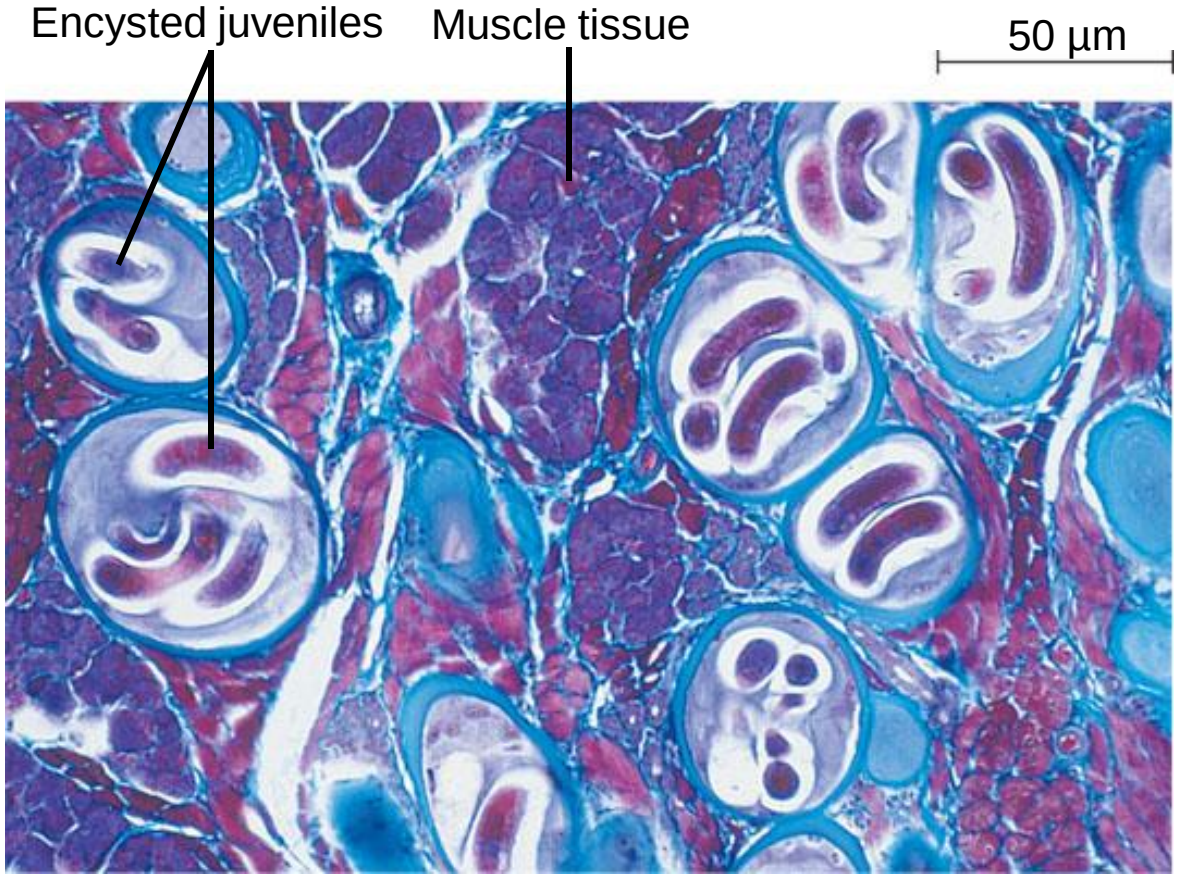
Phylum Nematoda

- Nematodes are nonsegmented pseudocoelomates covered by a tough cuticle
- Among the most widespread of all animals, nematodes, or roundworms
  - Are found in most aquatic habitats, in the soil, in moist tissues of plants, and in the body fluids and tissues of animals

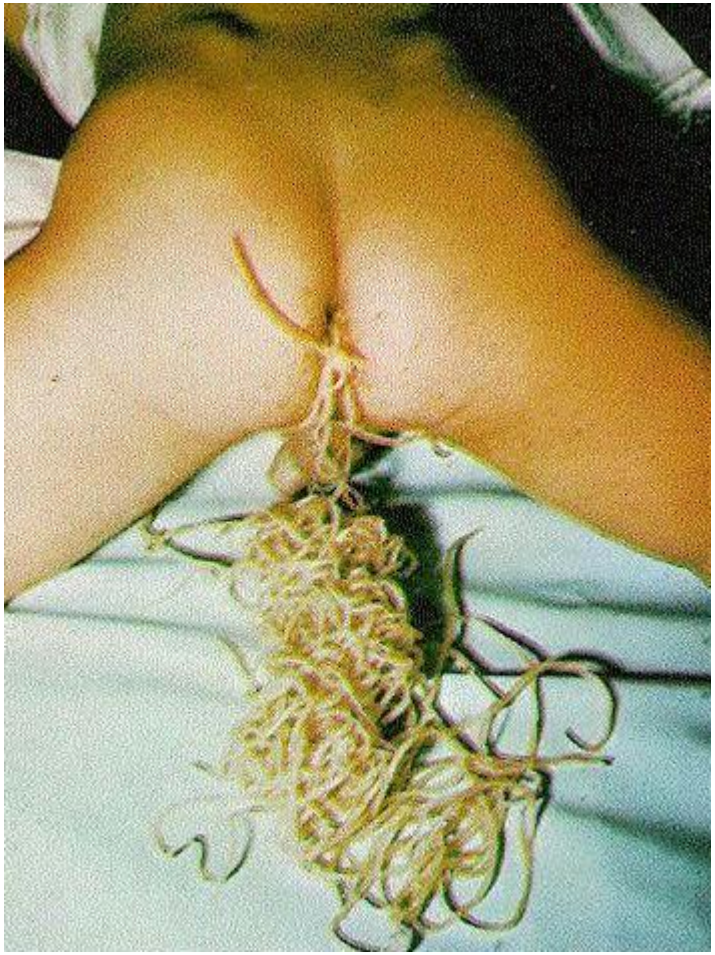
- The cylindrical bodies of nematodes
  - Are covered by a tough coat called a cuticle



- Some species of nematodes
  - Are important parasites of plants and animals



Ascaris lubricoides

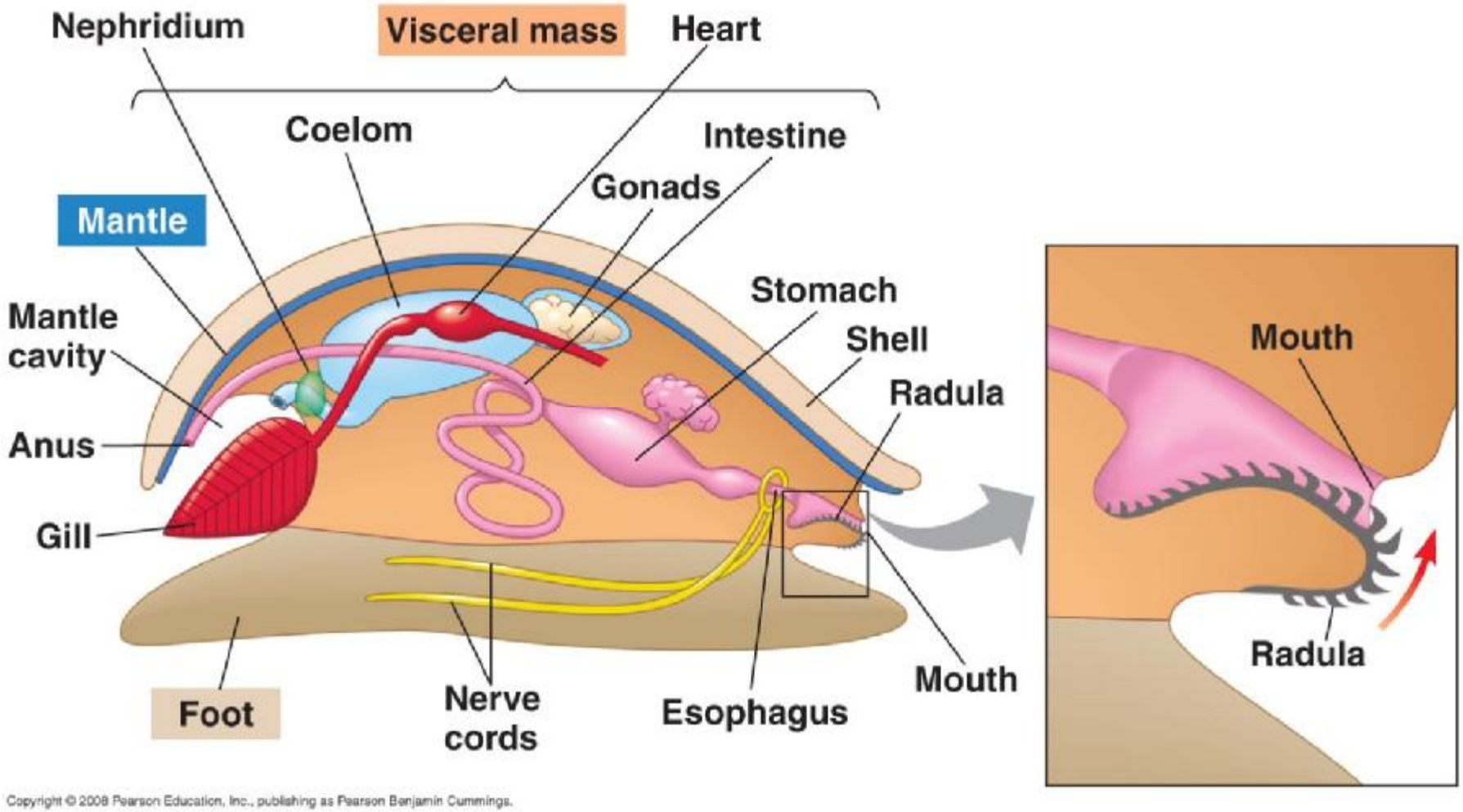


Elephanthiasis

Phylum Mollusca

- Phylum Mollusca
  - Includes snails and slugs, oysters and clams, and octopuses and squids
- Molluscs have a muscular foot, a visceral mass, and a mantle
- Most molluscs are marine
  - Though some inhabit fresh water and some are terrestrial
- Molluscs are soft-bodied animals
  - But most are protected by a hard shell

- All molluscs have a similar body plan with three main parts
  - A muscular foot
  - A visceral mass
  - A mantle



- Most molluscs have separate sexes
  - With gonads located in the visceral mass
- The life cycle of many molluscs
  - Includes a ciliated larval stage called a trochophore

- There are four major classes of molluscs
  - Polyplacophora: chitons
  - Gastropoda: snail, slugs
  - Bivalvia: clams, mussels, scallops, oysters
  - Cephalopoda: squids, octopuses, cuttle fish, chambered nautiluses

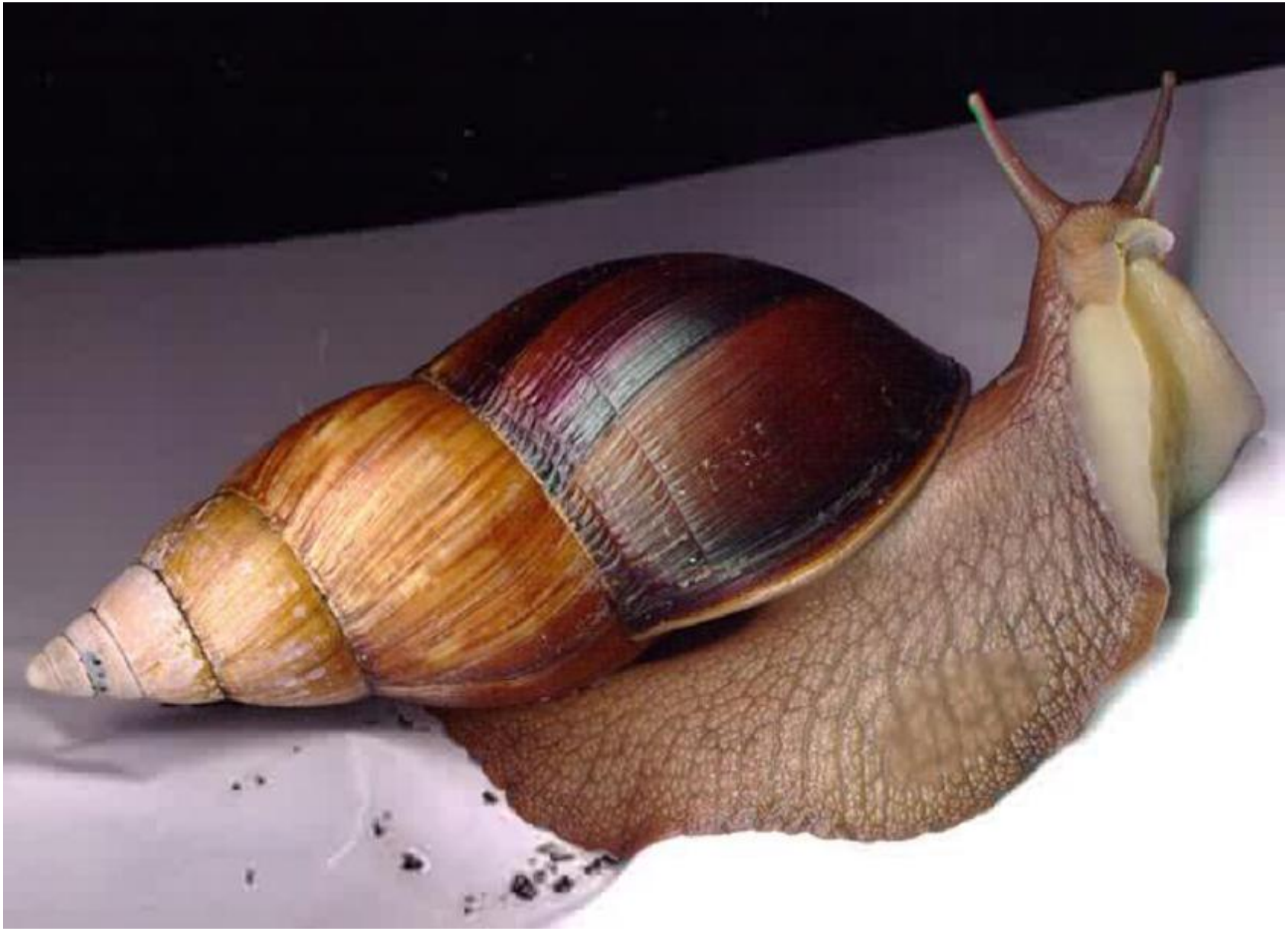
Chitons

- Class Polyplacophora is composed of the chitons
  - Oval-shaped marine animals encased in an armor of eight dorsal plates

Gastropods

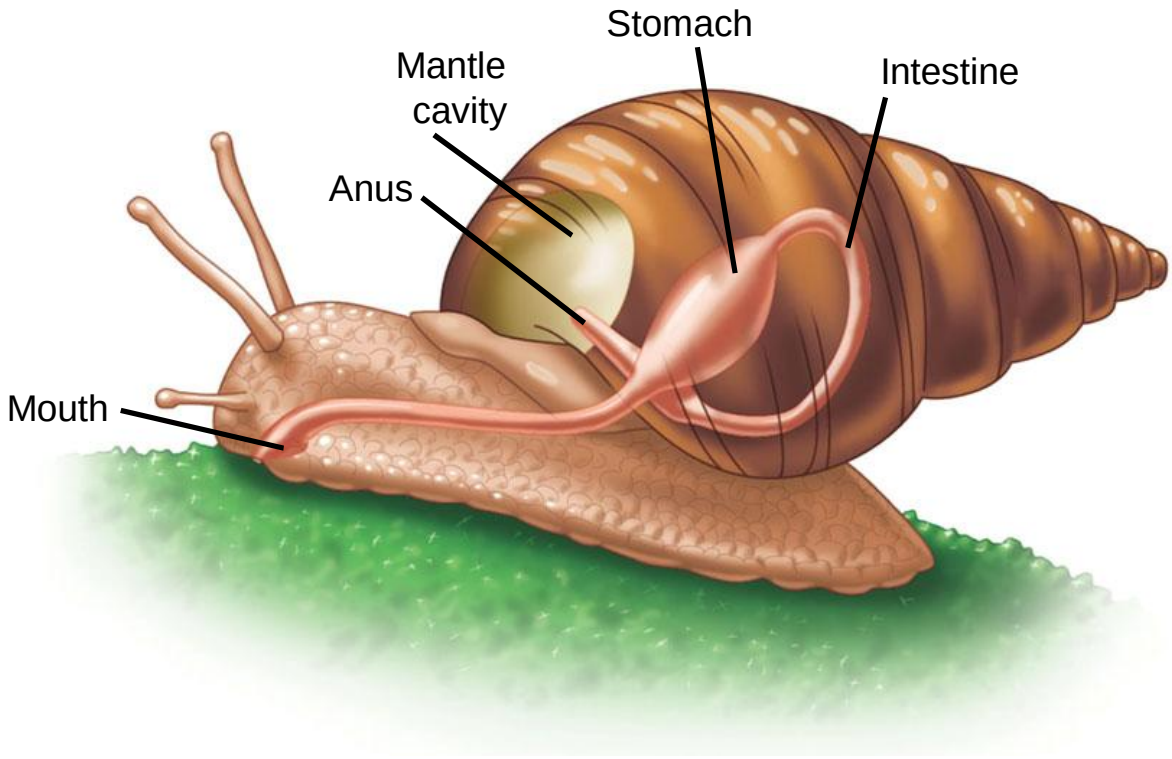
- About three-quarters of all living species of molluscs
  - Belong to class Gastropoda
- Most gastropods
  - Are marine, but there are also many freshwater and terrestrial species
  - Possess a single, spiraled shell
- Slugs lack a shell
  - Or have a reduced shell

A land snail



A sea slug

- The most distinctive characteristic of this class
  - Is a developmental process known as torsion, which causes the animal's anus and mantle to end up above its head



Bivalves

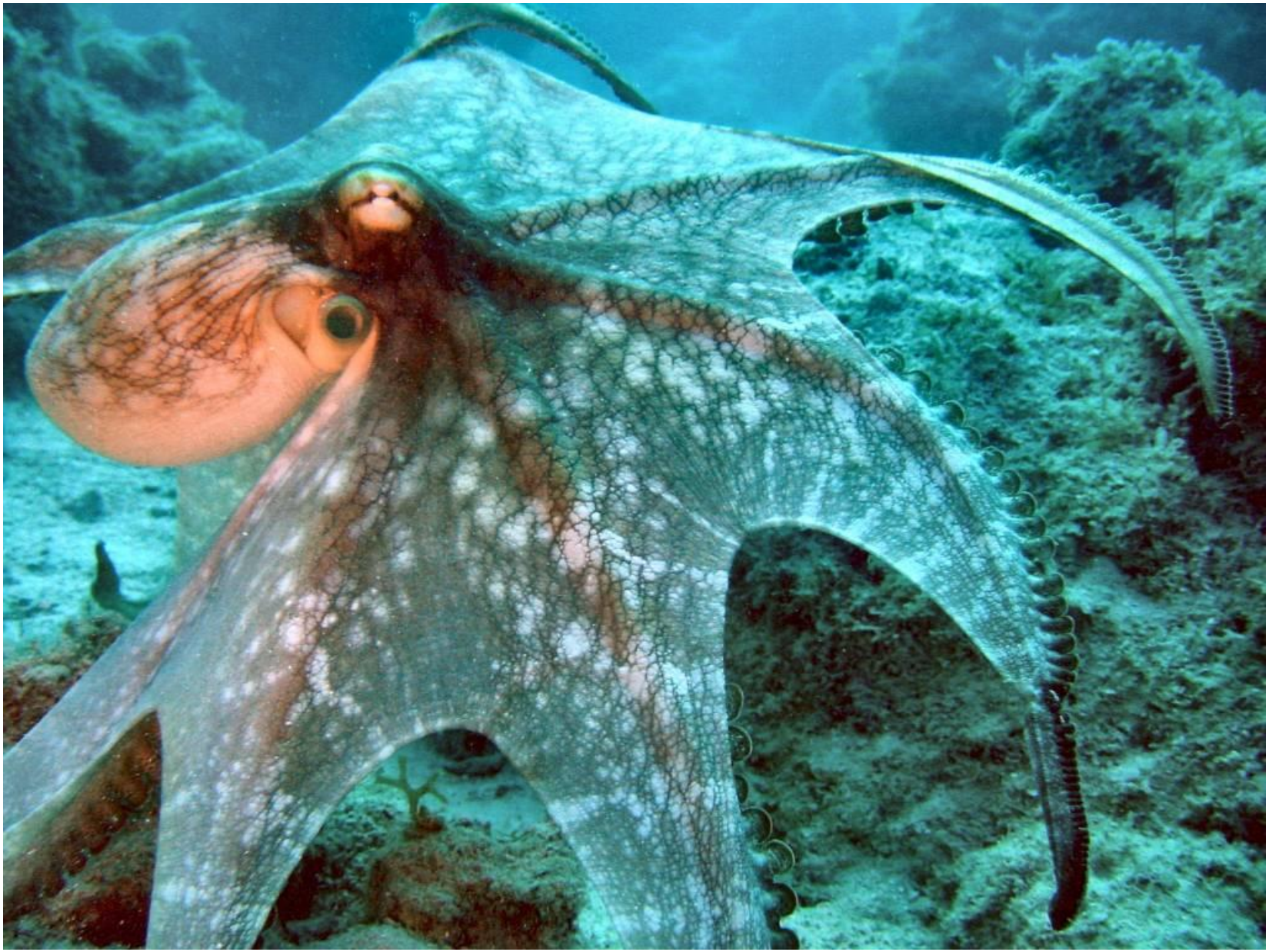
- Include many species of clams, oysters, mussels, and scallops
- Have a shell divided into two halves

Cephalopods

- Class Cephalopoda includes squids and octopuses
  - Carnivores with beak-like jaws surrounded by tentacles of their modified foot

- Most octopuses
  - Creep along the sea floor in search of prey
- Octopuses are considered among the most intelligent invertebrates

Octopus



- Squids use their siphon
  - To fire a jet of water, which allows them to swim very quickly
- Squids are speedy carnivores with beaklike jaws and well-developed eyes

Squid

- One small group of shelled cephalopods
  - The nautiluses, survives today
- Chambered nautiluses are the only living cephalopods with an external shell

Nautilus

A cuttlefish

Phylum Annelida

- Annelids
  - are segmented worms
  - Have bodies composed of a series of fused rings

- The phylum Annelida is divided into three classes:
  - Oligochaeta: earthworm
  - Polychaeta
  - Hirudinea: leeches

Oligochaetes

- Oligochaetes (class Oligochaeta)
  - Are named for their relatively sparse chaetae, or bristles made of chitin
  - Include the earthworms and a variety of aquatic species

- Earthworms eat their way through the soil, extracting nutrients as the soil moves through the alimentary canal
  - Which helps till the earth, making earthworms valuable to farmers

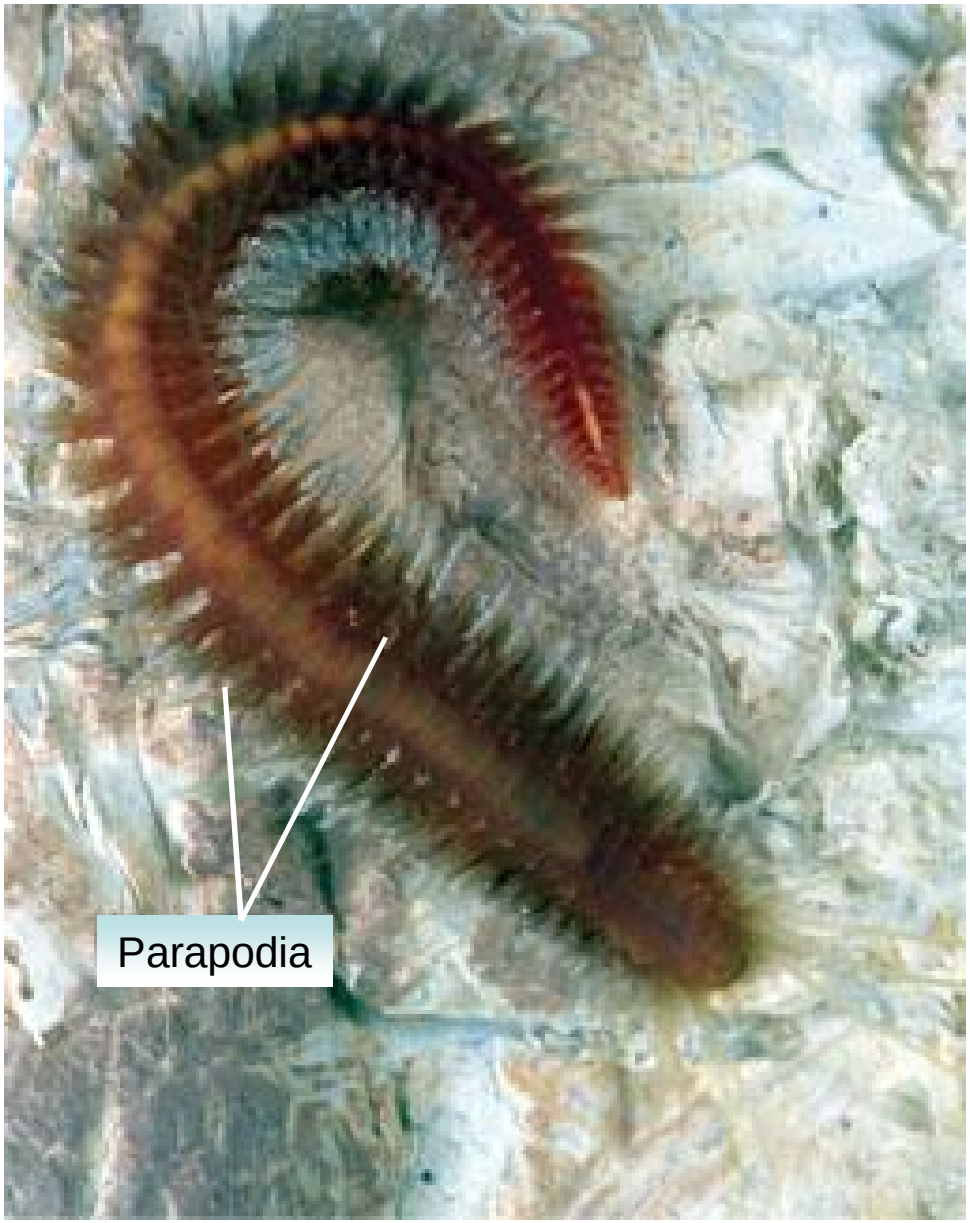
Giant Australian earthworm

Epidermis
Cuticle
Coelom
Septum (partition between segments)
Circular muscle
Longitudinal muscle
Metanephridium
Anus
Dorsal vessel
Chaetae
Intestine
Fused nerve cords
Ventral vessel
Nephrostome
Clitellum
Metanephridium
Esophagus
Crop
Pharynx
Intestine
Cerebral ganglia
Gizzard
Mouth
Subpharyngeal ganglion
Blood vessels
Ventral nerve cord with segmental ganglia

Polychaetes

- Members of class Polychaeta
  - Possess paddlelike parapodia that function as gills and aid in locomotion

Polychaetes



Christmas tree worm

Leeches

- Members of class Hirudinea
  - Are blood-sucking parasites, such as leeches

Phylum Arthropoda

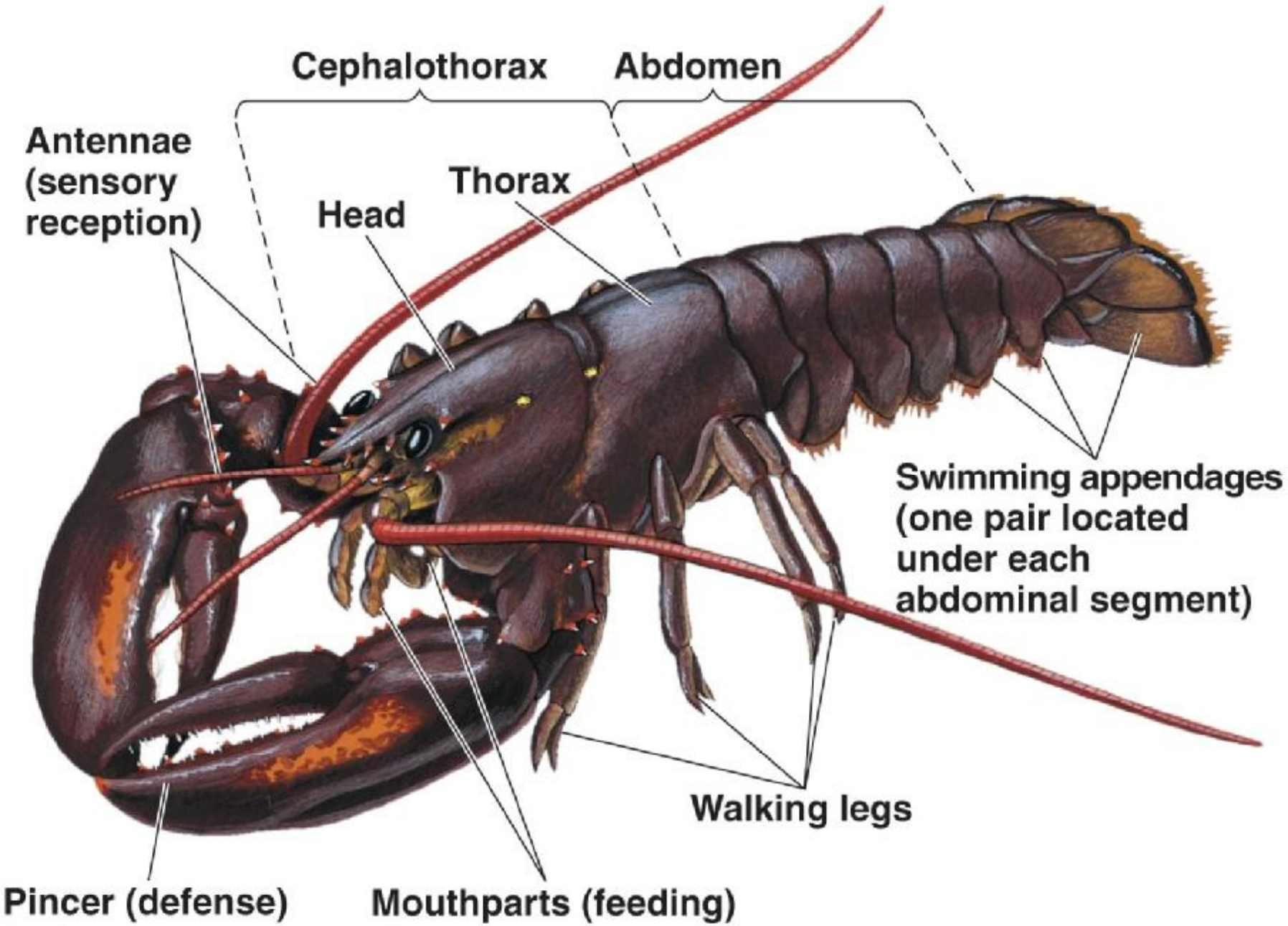
- Arthropods are segmented coelomates that have an exoskeleton and jointed appendages
- Two out of every three known species of animals are arthropods
- Members of the phylum Arthropoda
  - Are found in nearly all habitats of the biosphere

General Characteristics of Arthropods

- The diversity and success of arthropods
  - Are largely related to their segmentation, hard exoskeleton, and jointed appendages

- Early arthropods, such as trilobites
  - Showed little variation from segment to segment

- As arthropods evolved
  - The segments fused, and the appendages became more specialized
- The appendages of some living arthropods
  - Are modified for many different functions



- 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

- Arthropods have an open circulatory system
  - In which fluid called hemolymph is circulated into the spaces surrounding the tissues and organs
- A variety of organs specialized for gas exchange
  - Have evolved in arthropods

- Molecular evidence now suggests that living arthropods consist of four subphyla

Cheliceriforms

- Cheliceriforms, subphylum Cheliceriformes
  - Are named for clawlike feeding appendages called chelicerae
  - Include spiders, ticks, mites, scorpions, and horseshoe crabs

- Most of the marine cheliceriforms are extinct
  - But some species survive today, including the horseshoe crabs

- Most modern cheliceriforms are arachnids
  - A group that includes spiders, scorpions, ticks, and mites

(a) Scorpions

(b) Mites (colorized SEM).

(c) spiders

Myriapods

- Subphylum Myriapoda
  - Includes millipedes and centipedes

Millipedes, class Diplopoda

- Millipedes have a large number of legs
- Each trunk segment has two pairs of legs

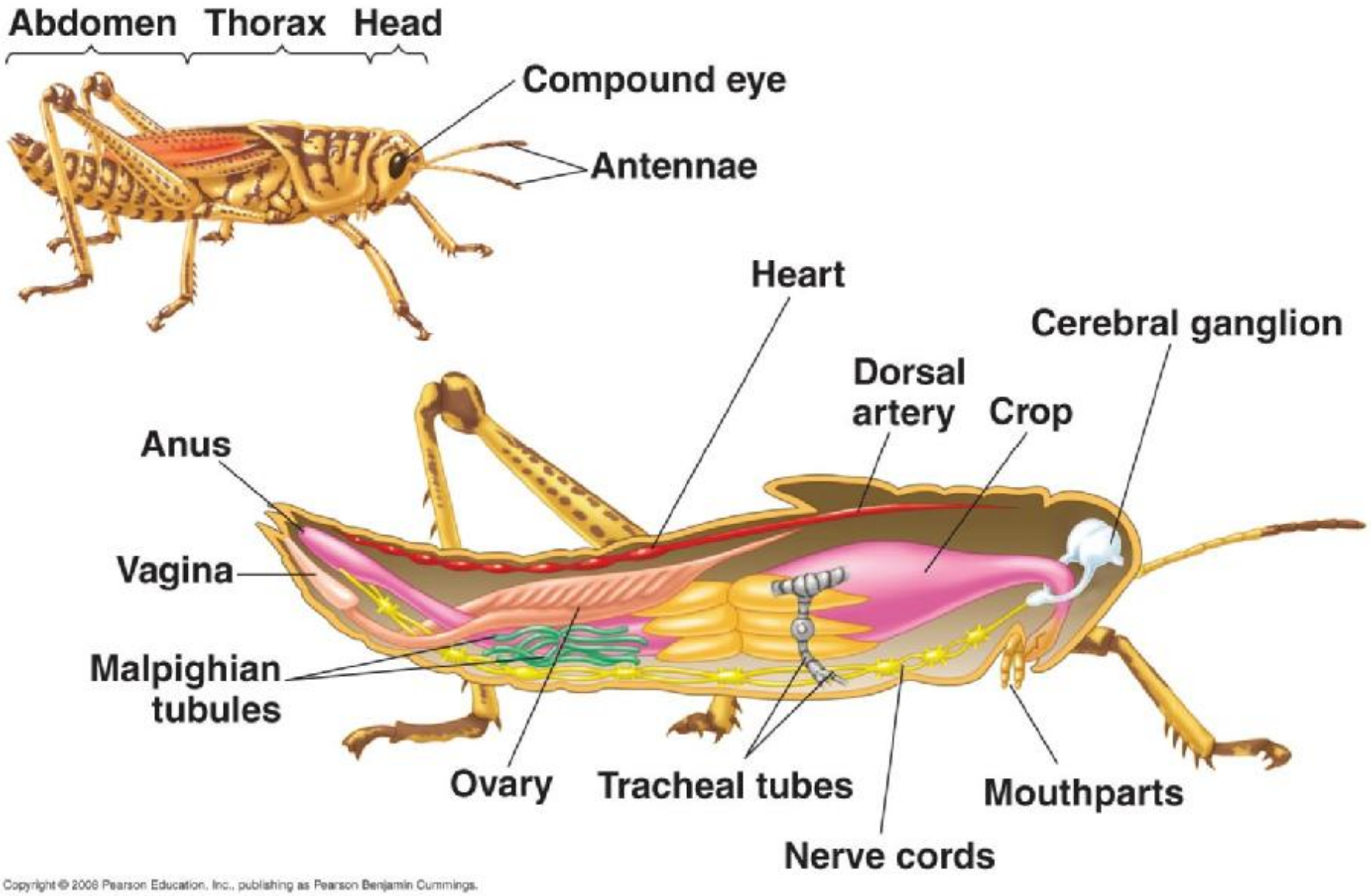
Centipedes, class Chilopoda

- Are carnivores with jaw-like mandibles
- Have one pair of legs per trunk segment

Insects

- Subphylum Hexapoda, insects and their relatives
  - Are more species-rich than all other forms of life combined
  - Live in almost every terrestrial habitat and in fresh water

The internal anatomy of an insect



- Flight is obviously one key to the great success of insects
- An animal that can fly
  - Can escape predators, find food, and disperse to new habitats much faster than organisms that can only crawl

- 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

- Insects with complete metamorphosis
  - Have larval stages specialized for eating and growing that are known by such names as maggot, grub, or caterpillar
- The larval stage
  - Looks entirely different from the adult stage

- Metamorphosis from the larval stage to the adult stage
  - Occurs during a pupal stage

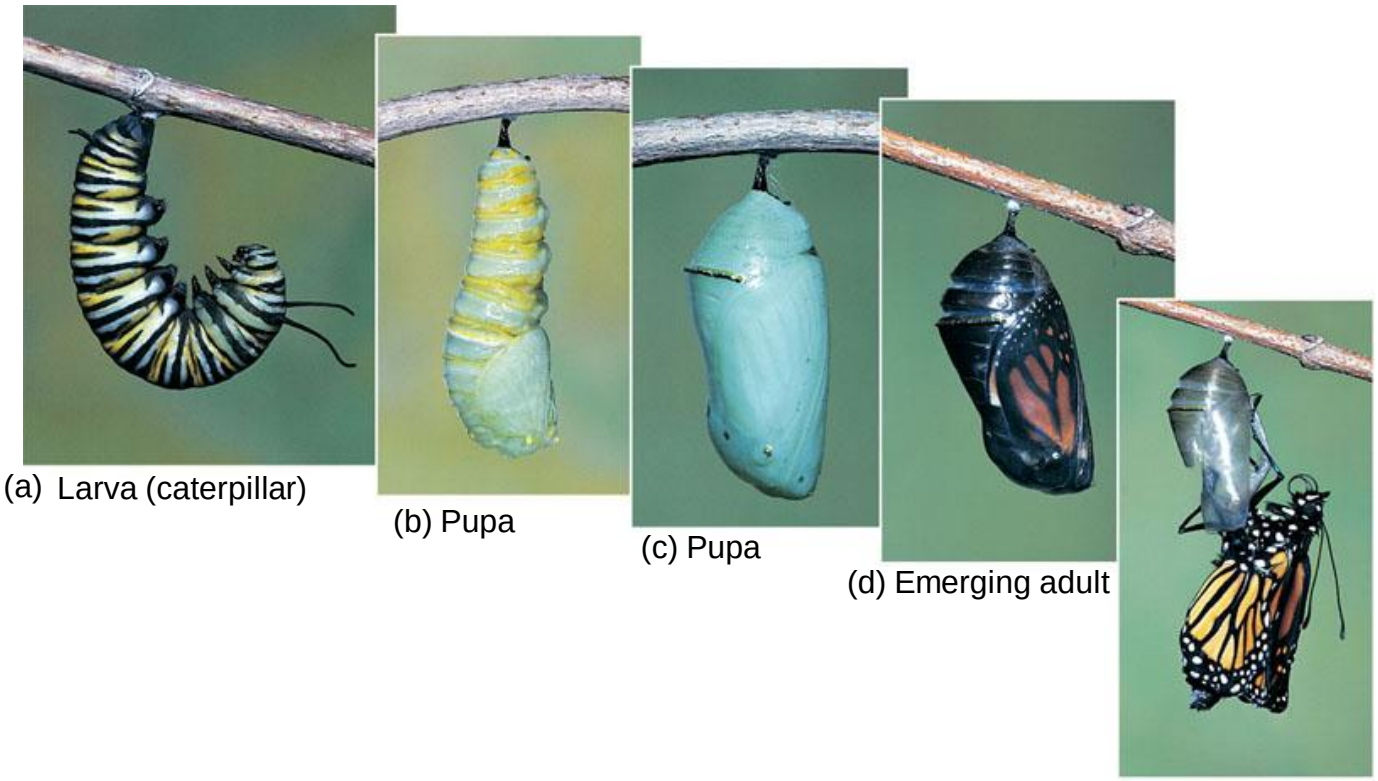


Figure 33.6a–e

Crustaceans

- While arachnids and insects thrive on land
  - Crustaceans, for the most part, have remained in marine and freshwater environments

- Crustaceans, subphylum Crustacea
  - Typically have biramous, branched, appendages that are extensively specialized for feeding and locomotion

- Decapods are all relatively large crustaceans
  - And include lobsters, crabs, crayfish, and shrimp

Ghost crabs

- Planktonic crustaceans include many species of copepods
  - Which are among the most numerous of all animals

Krill

Phylum Echinodermata

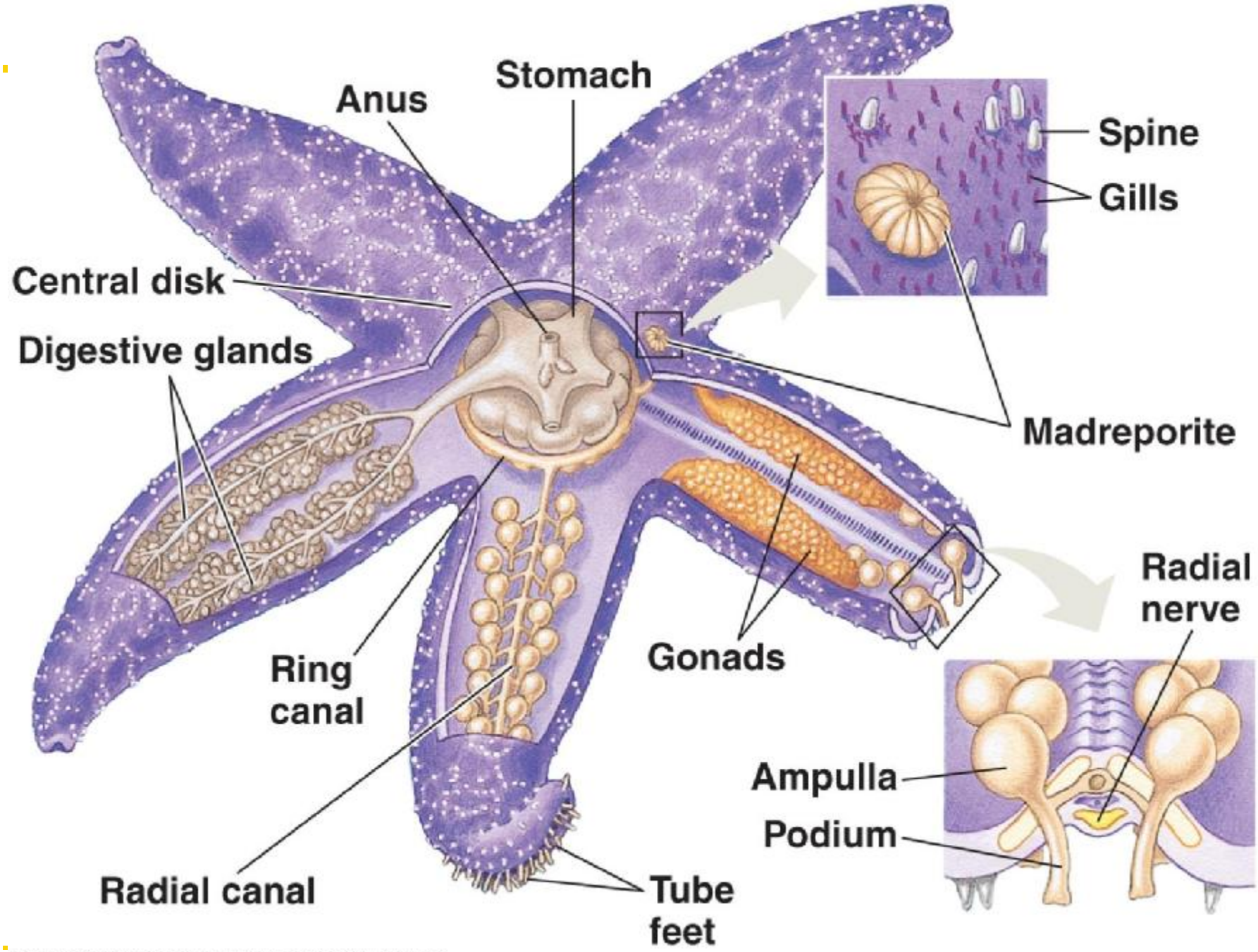
- Echinoderms and chordates are deuterostomes
- At first glance, sea stars and other echinoderms, phylum Echinodermata
  - May seem to have little in common with phylum Chordata, which includes the vertebrates

- Chordates and echinoderms share characteristics of deuterostomes
  - Radial cleavage
  - Development of the coelom from the archenteron
  - Formation of the mouth at the end of the embryo opposite the blastopore

Echinoderms

- Sea stars and most other echinoderms
  - Are slow-moving or sessile marine animals
- A thin, bumpy or spiny skin
  - Covers an endoskeleton of hard calcareous plates

- Unique to echinoderms is a water vascular system
  - A network of hydraulic canals branching into tube feet that function in locomotion, feeding, and gas exchange



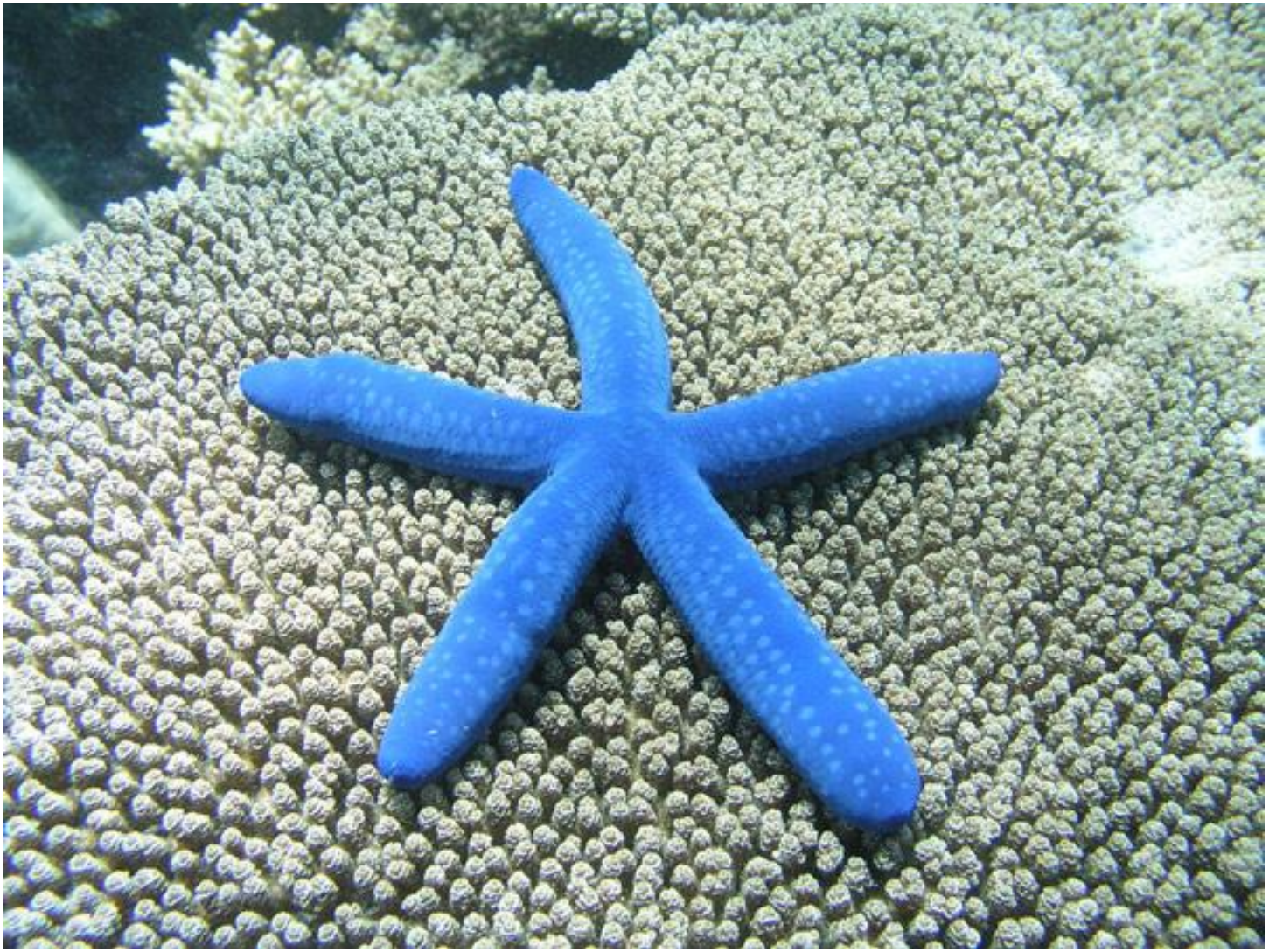
- The radial anatomy of many echinoderms
  - Evolved secondarily from the bilateral symmetry of ancestors

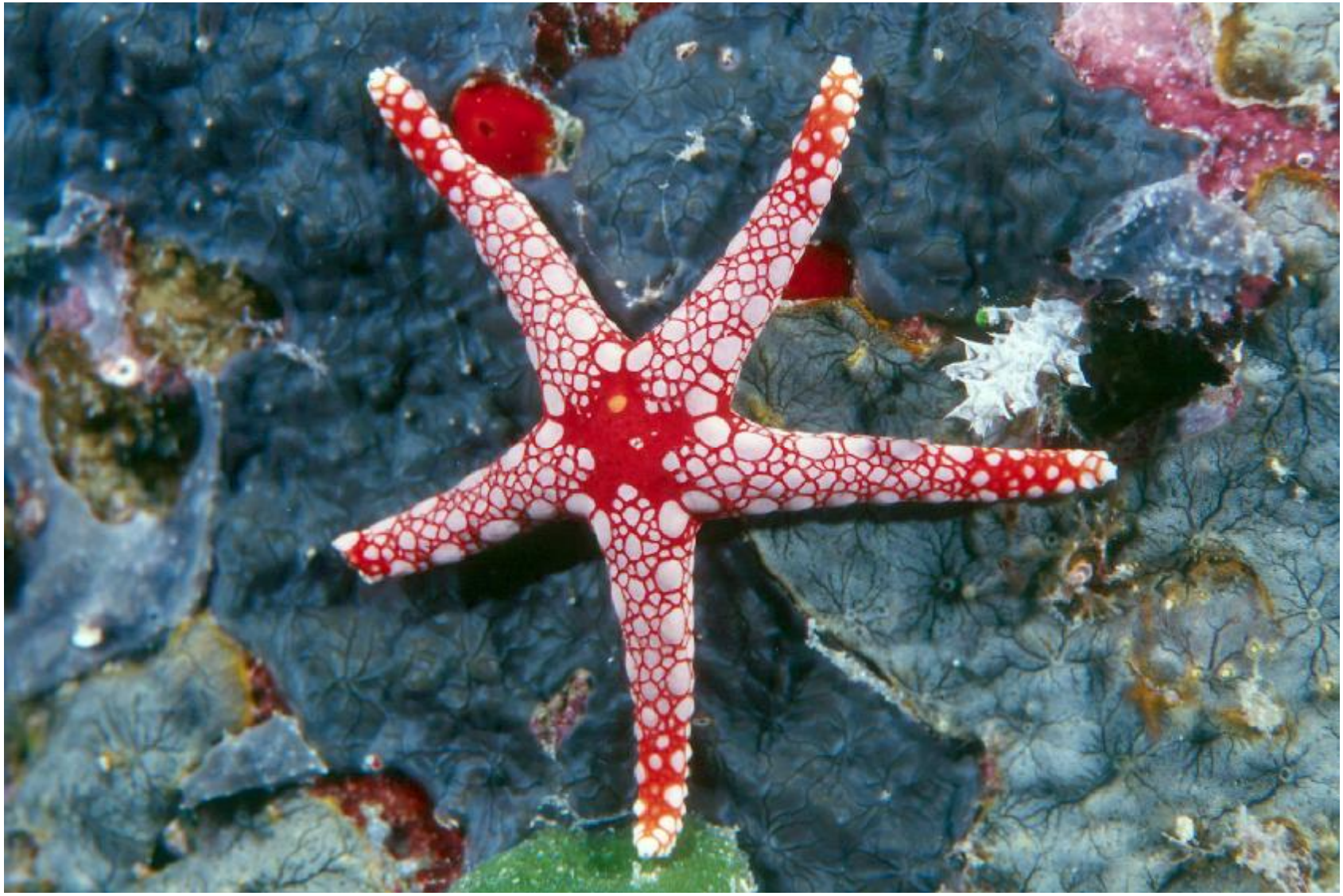
- Living echinoderms are divided into six classes
  - Asteroidea
  - Ophiuroidea
  - Echinoidea
  - Crinoidea
  - Holothuroidea
  - Concentricycloidea

Sea Stars (class Asteroidea)

- Sea stars,
  - Have multiple arms radiating from a central disk
- The undersurfaces of the arms
  - Bear tube feet, each of which can act like a suction disk

Sea star





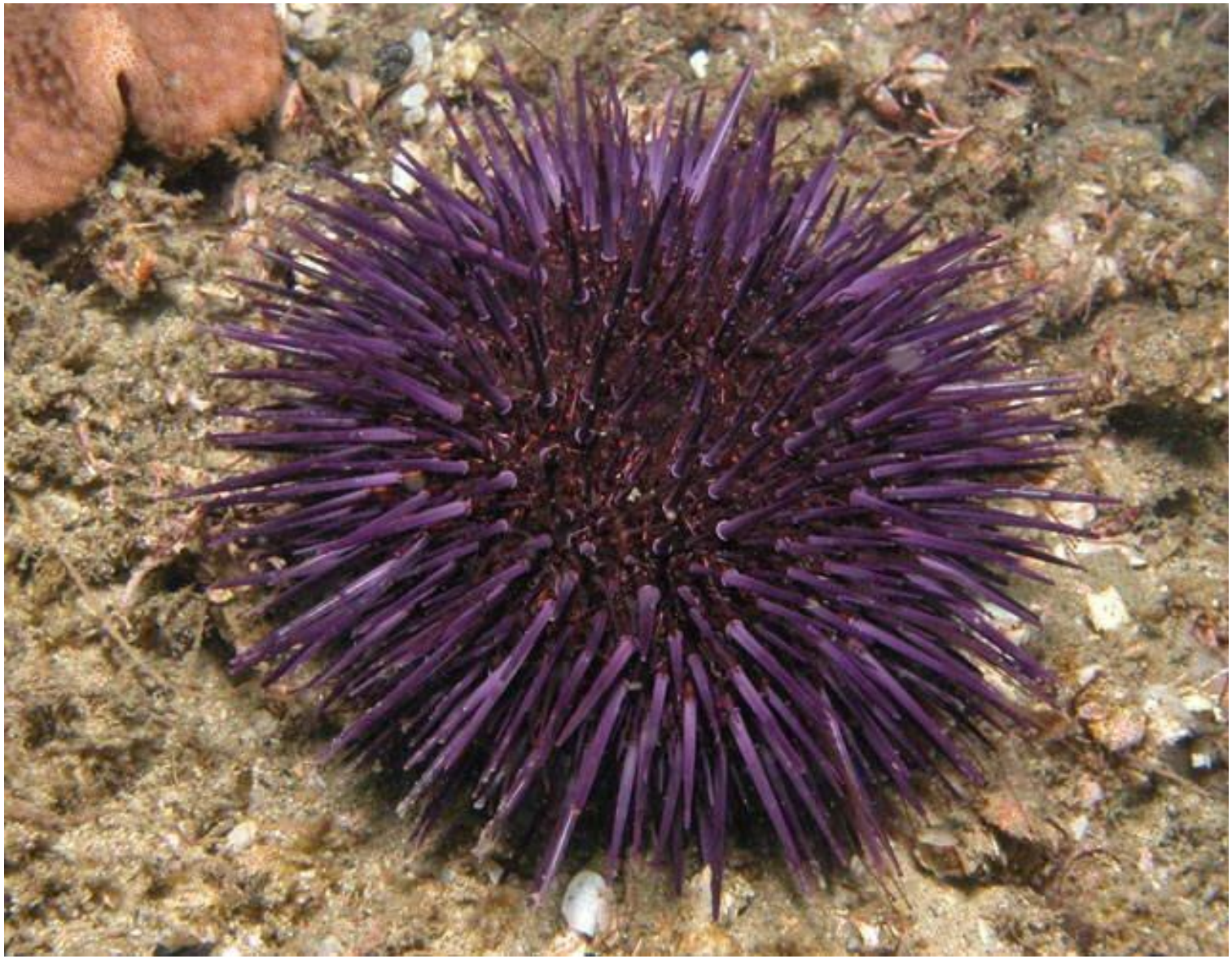
Brittle Stars (class Ophiuroidea)

- Brittle stars have a distinct central disk
  - And long, flexible arms

Sea Urchins and Sand Dollar (class Echinoidea)

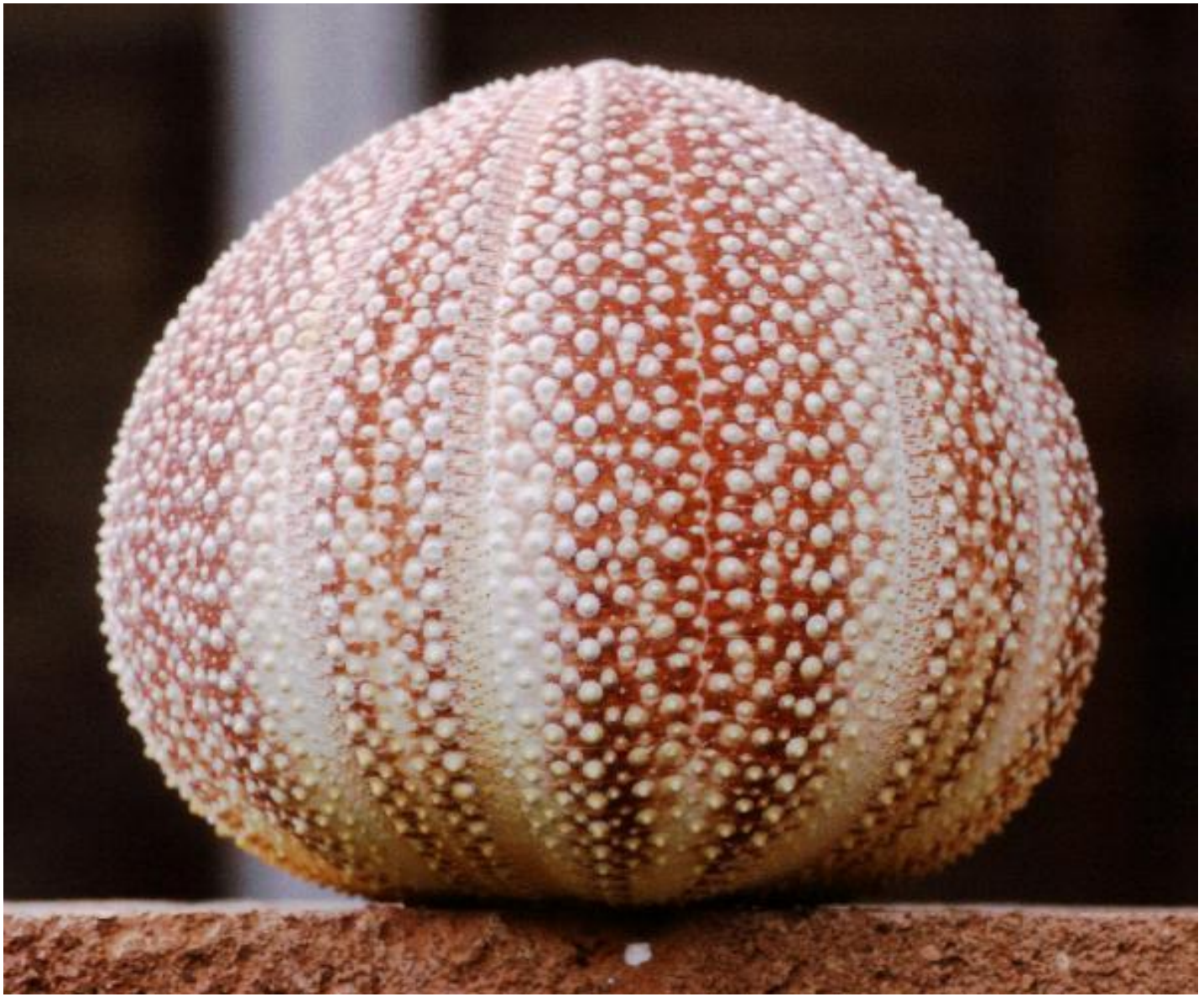
- Sea urchins and sand dollars have no arms
  - But they do have five rows of tube feet that function in movement

Sea Urchin



Sea Urchin

Sea Urchin



Sand Dollar

Sea Lilies and Feather Stars (class Crinoidea)

- Sea lilies
  - Live attached to the substrate by a stalk
- Feather stars
  - Crawl about using their long, flexible arms

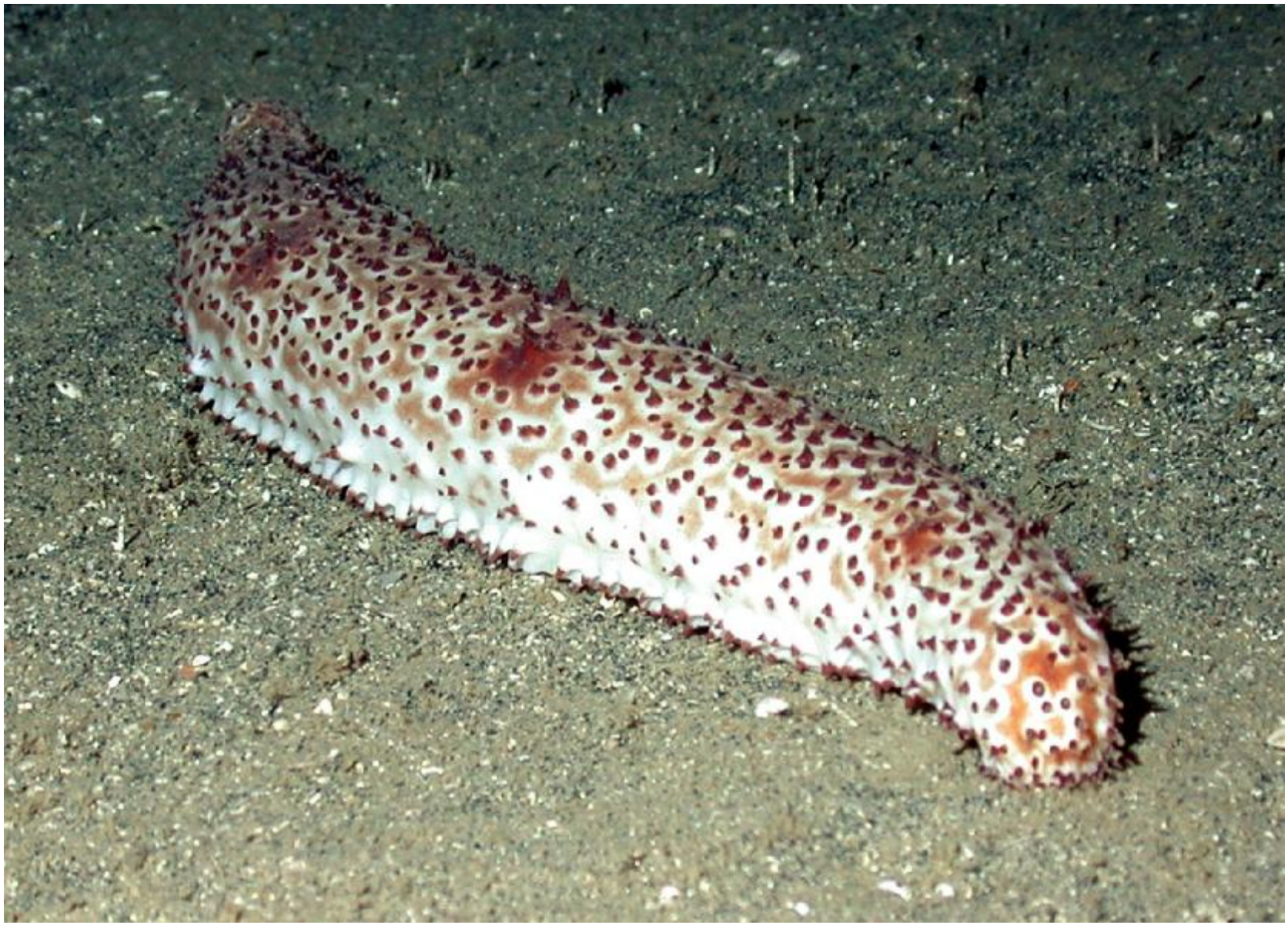
Sea Lily

Feather Star

Sea Cucumbers (class Holothuroidea)

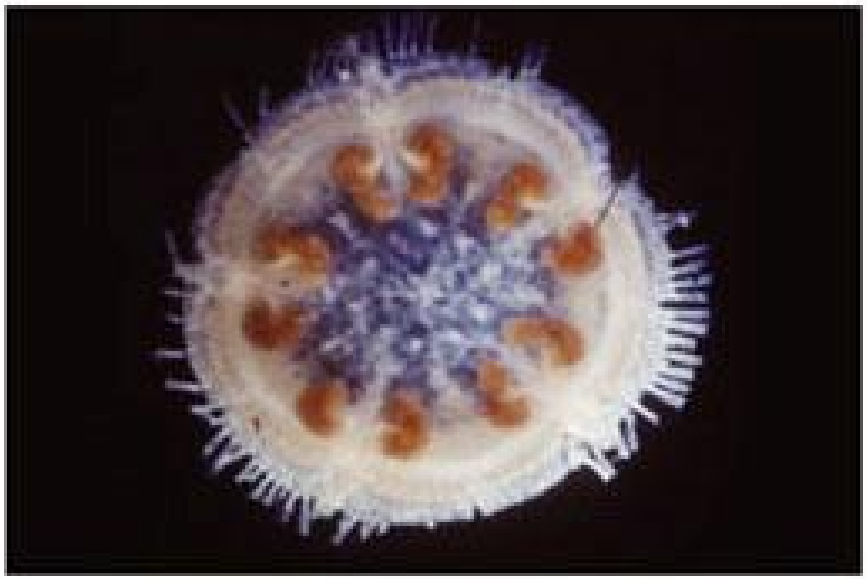
- Sea cucumbers
  - Upon first inspection do not look much like other echinoderms
  - Lack spines, and their endoskeleton is much reduced

Sea Cucumber



Sea Daisies (class Concentricycloidea)

- Sea daisies were discovered in 1986
  - And only two species are known

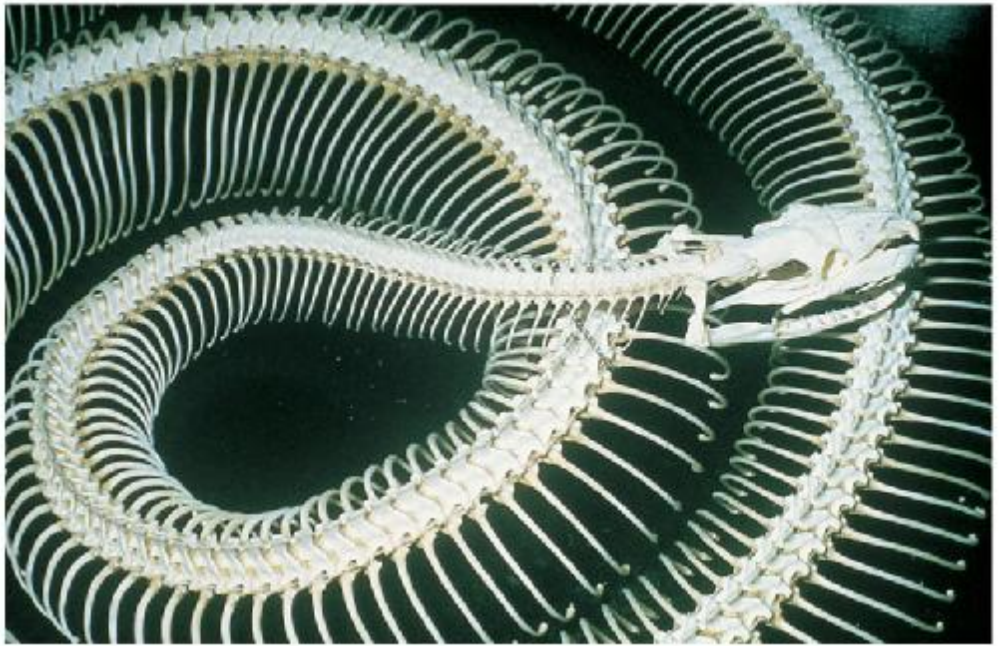


A sea daisy

- Barnacles are a group of mostly sessile crustaceans
  - Whose cuticle is hardened into a shell

THE VERTEBRATE GENEALOGY

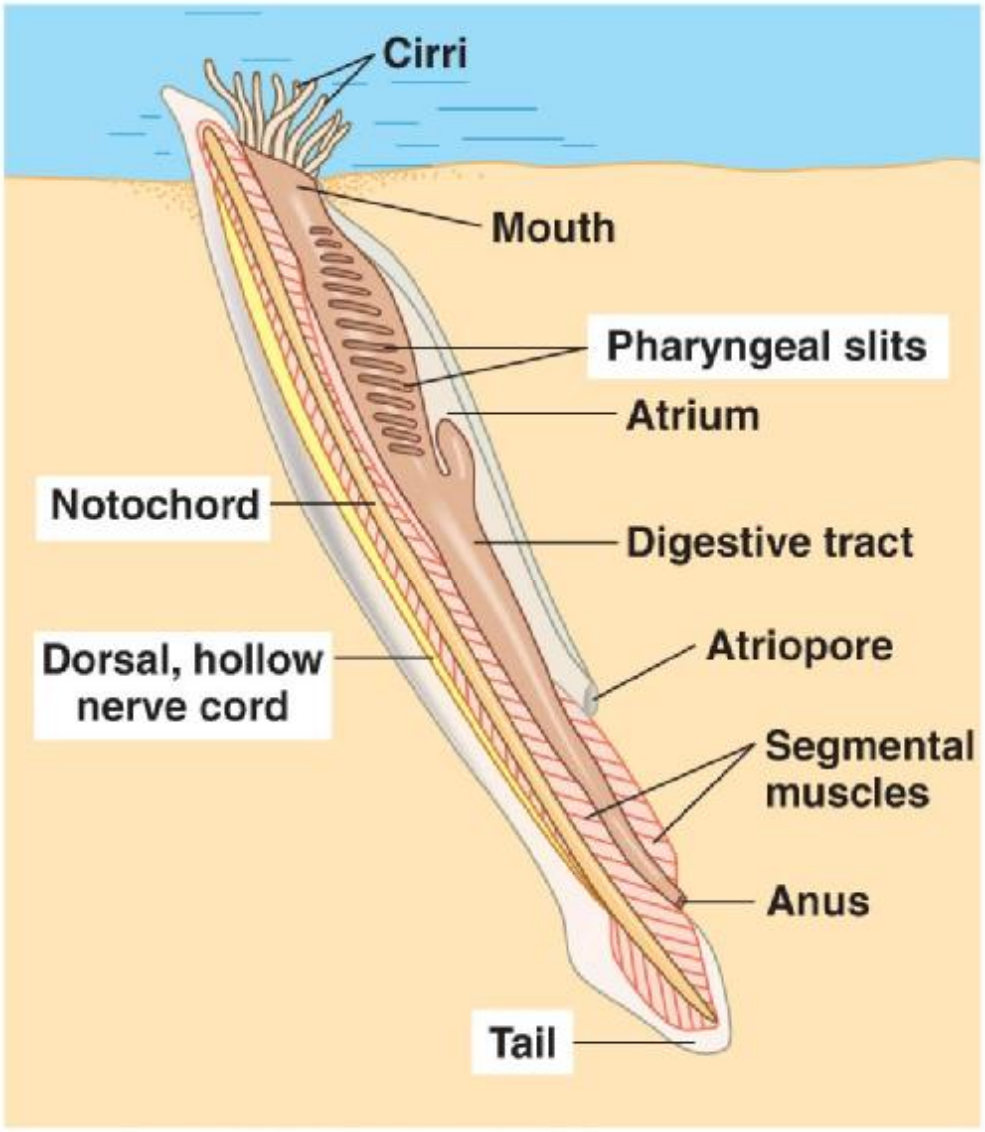
- Vertebrates
  - Are represented by mammals, birds, reptiles, amphibians, and fishes
  - Have unique features, including the cranium and backbone

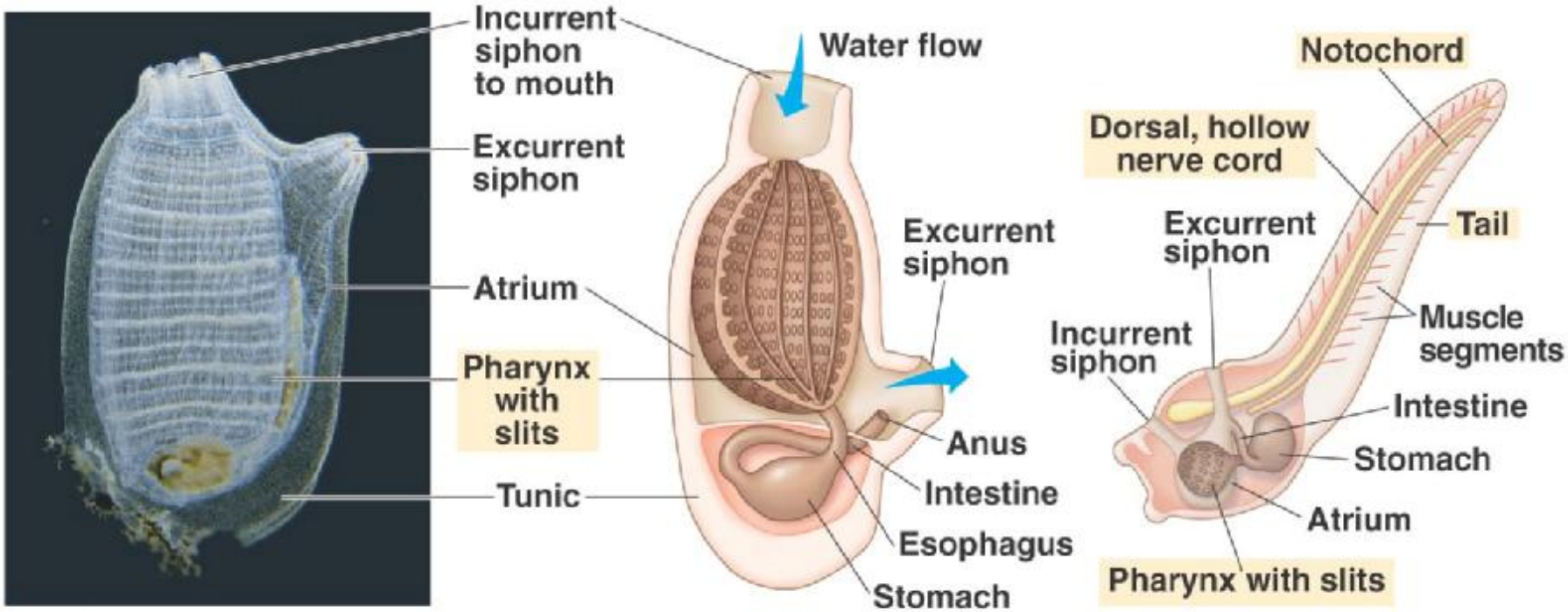


Characteristics of Chordates

- Phylum Chordata
  - Includes the subphylum of vertebrates

- Other subphyla include the lancelets and tunicates, which share four key chordate characteristics

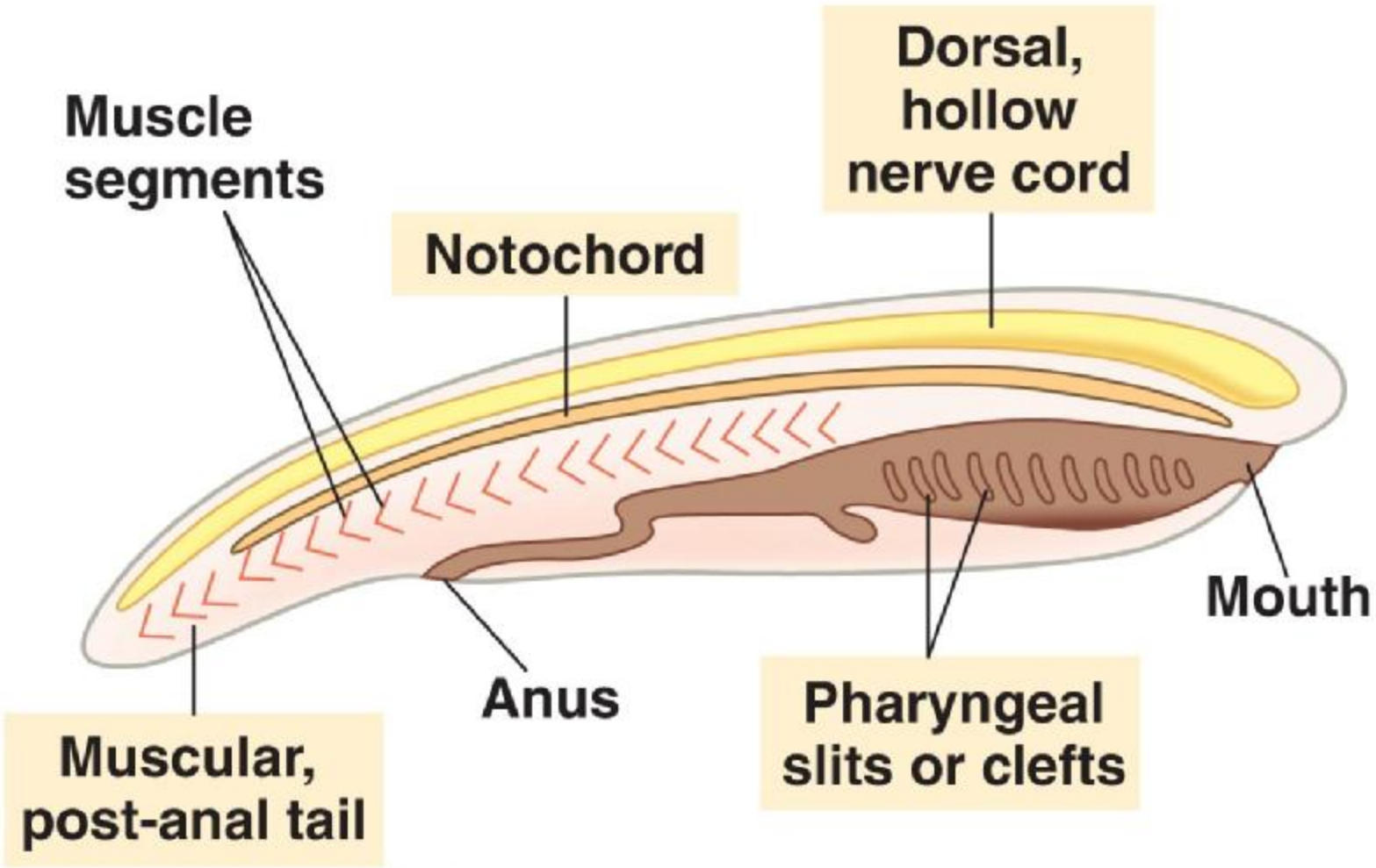




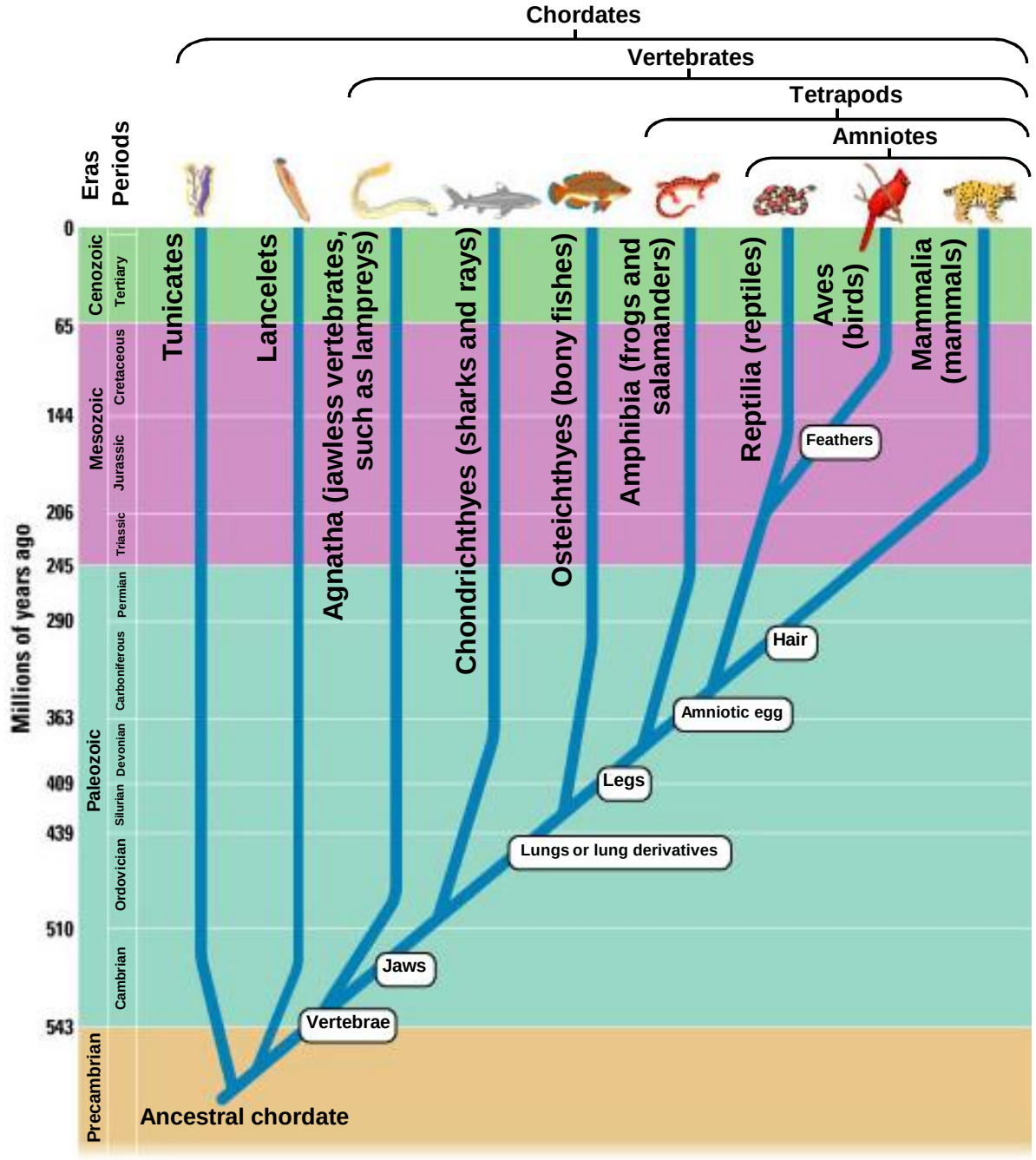
An adult tunicate

A tunicate larva

- The four chordate hallmarks are
  - A dorsal, hollow nerve cord
  - A notochord
  - Pharyngeal slits
  - A post-anal tail



- An overview of chordate and vertebrate evolution


Chordates
Vertebrates
Tetrapods
Amniotes
Eras
Periods
Millions of years ago
0
65
144
206
245
290
363
409
439
510
543
Cenozoic
Tertiary
Mesozoic
Cretaceous
Jurassic
Triassic
Paleozoic
Permian
Carboniferous
Devonian
Silurian
Ordovician
Cambrian
Precambrian
Tunicates
Lancelets
Agnatha (jawless vertebrates, such as lampreys)
Chondrichthyes (sharks and rays)
Osteichthyes (bony fishes)
Amphibia (frogs and salamanders)
Reptilia (reptiles)
Aves (birds)
Mammalia (mammals)
Feathers
Hair
Amniotic egg
Legs
Lungs or lung derivatives
Jaws
Vertebrae
Ancestral chordate

Fishes

- The first vertebrates probably evolved during the early Cambrian period, about 540 million years ago

- These early vertebrates, the agnathans, lacked jaws
- Agnathans are represented today by lampreys

- Lampreys are jawless vertebrates
  - Inhabiting various marine and freshwater habitats

Hagfishes

- The two major groups of living fishes are the classes
  - Chondrichthyes = Cartilaginous fishes
  - Osteichthyes = Bony fishes

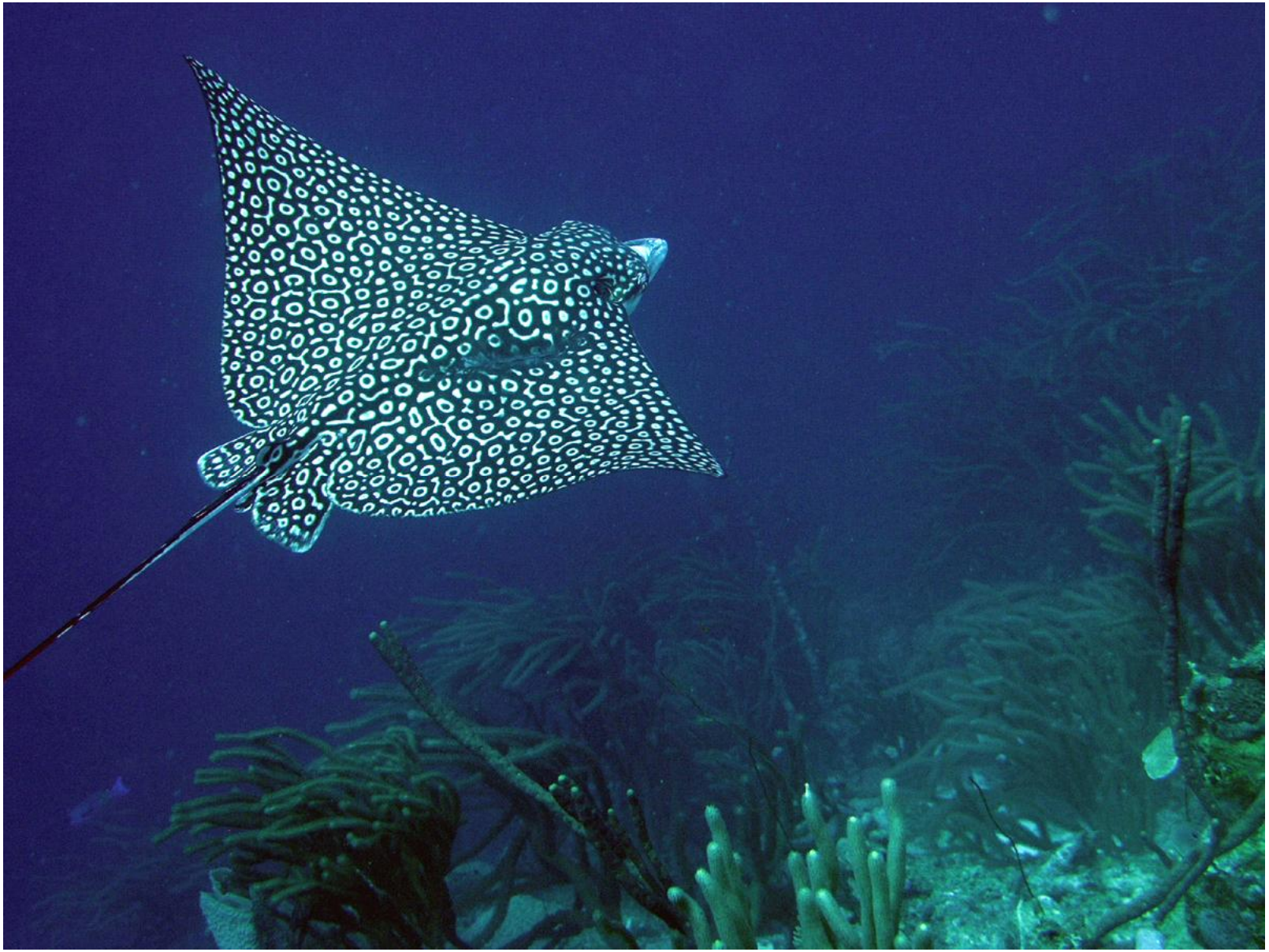
Chondrichthyans (Sharks, Rays, and Their Relatives)

- Members of class Chondrichthyes
  - Have a skeleton that is composed primarily of cartilage
- The cartilaginous skeleton
  - Evolved secondarily from an ancestral mineralized skeleton

- The largest and most diverse subclass of Chondrichthyes
  - Includes the sharks and rays

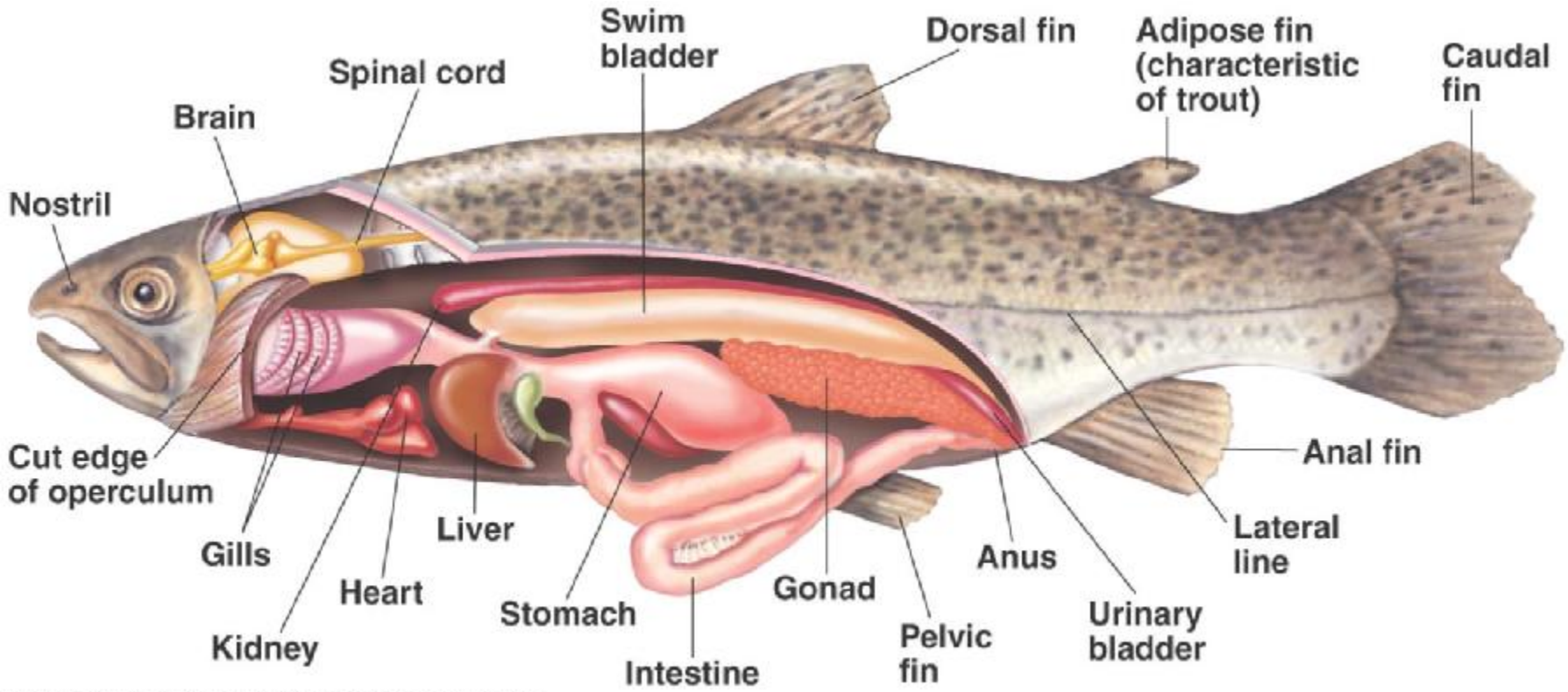
Shark

Stingray



- Nearly all living osteichthyans
  - Have a bony endoskeleton
- Aquatic osteichthyans
  - Are the vertebrates we informally call fishes
  - Control their buoyancy with an air sac known as a swim bladder

- Fishes breathe by drawing water over four or five pairs of gills
  - Located in chambers covered by a protective bony flap called the operculum



- Most bony fishes are ray-finned fishes
- A second evolutionary branch includes lungfishes and lobe-finned fishes

Yellowfin tuna *(Thunnus albacares)*

Clownfish *(Amphiprion ocellaris)*

Seahorse

Leafly Sea Dragon

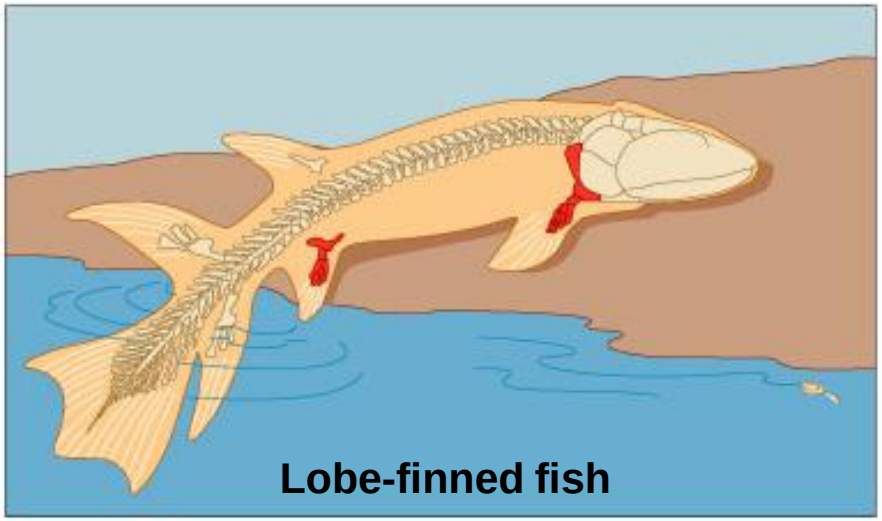
Coelacanths

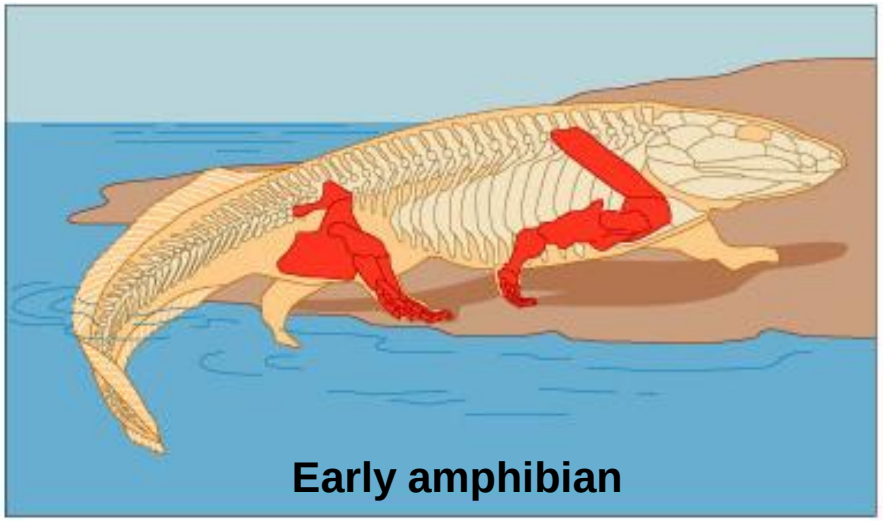
Lung fish

Amphibians

- Members of the class Amphibia
  - Exhibit a mixture of aquatic and terrestrial adaptations
  - Usually need water to reproduce

- Amphibians
  - Were the first vertebrates to colonize land
  - Descended from fishes that had lungs and fins with muscles





- Terrestrial vertebrates are collectively called tetrapods, which means “four legs”

Urodeles (salamanders)

Poisson Dart Frog

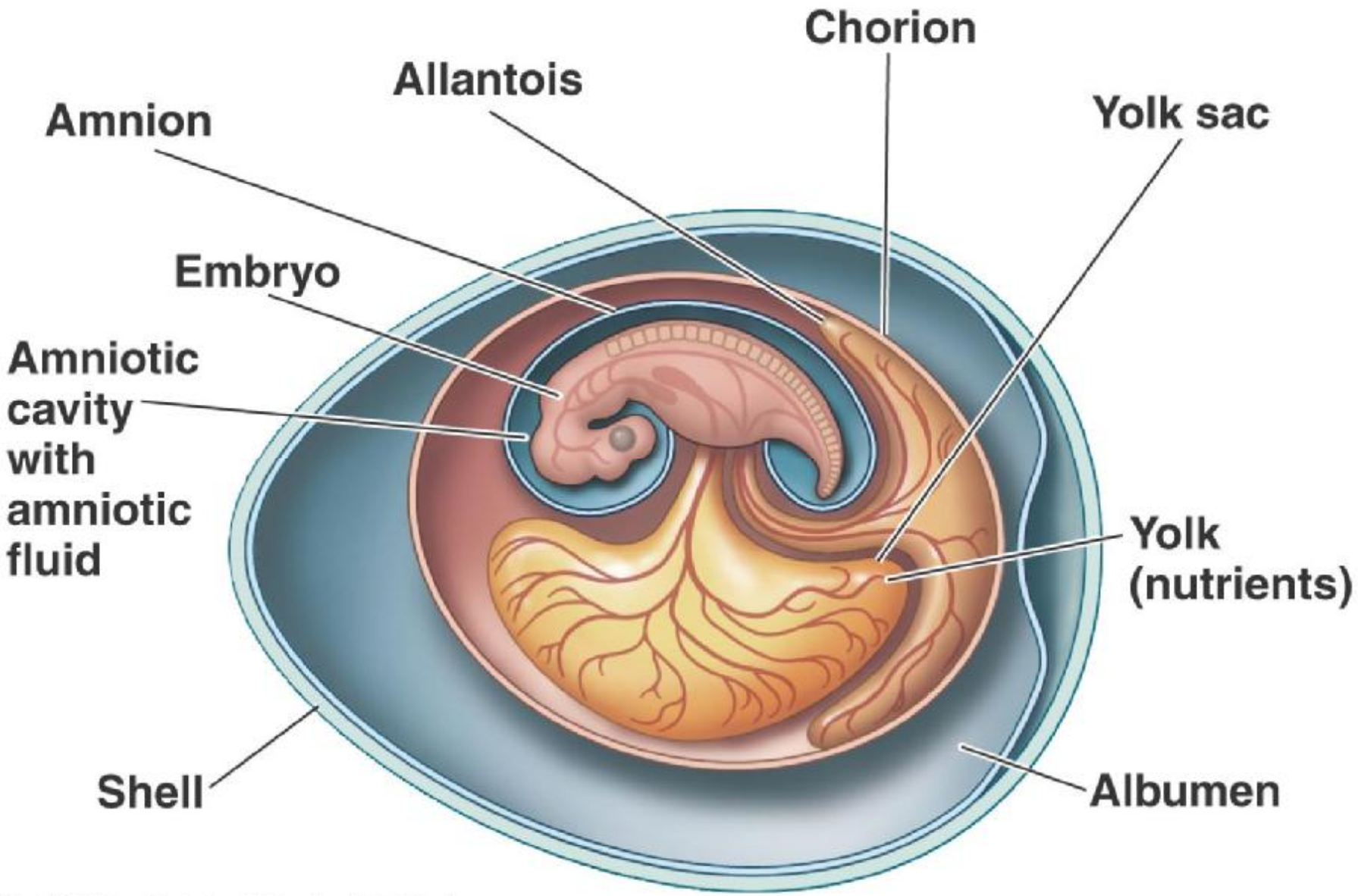
Golden Toad

Caecilian

Reptiles

- Class Reptilia
  - Includes snakes, lizards, turtles, crocodiles, and alligators
  - Can live totally on land

- Adaptations for living on land include
  - Scales to prevent dehydration
  - Lungs for breathing
  - The amniotic egg



- Reptiles are ectotherms, which obtain their body heat from the environment

Thorny devil lizard

Komodo dragon

Squamate

Snakes

Turtle

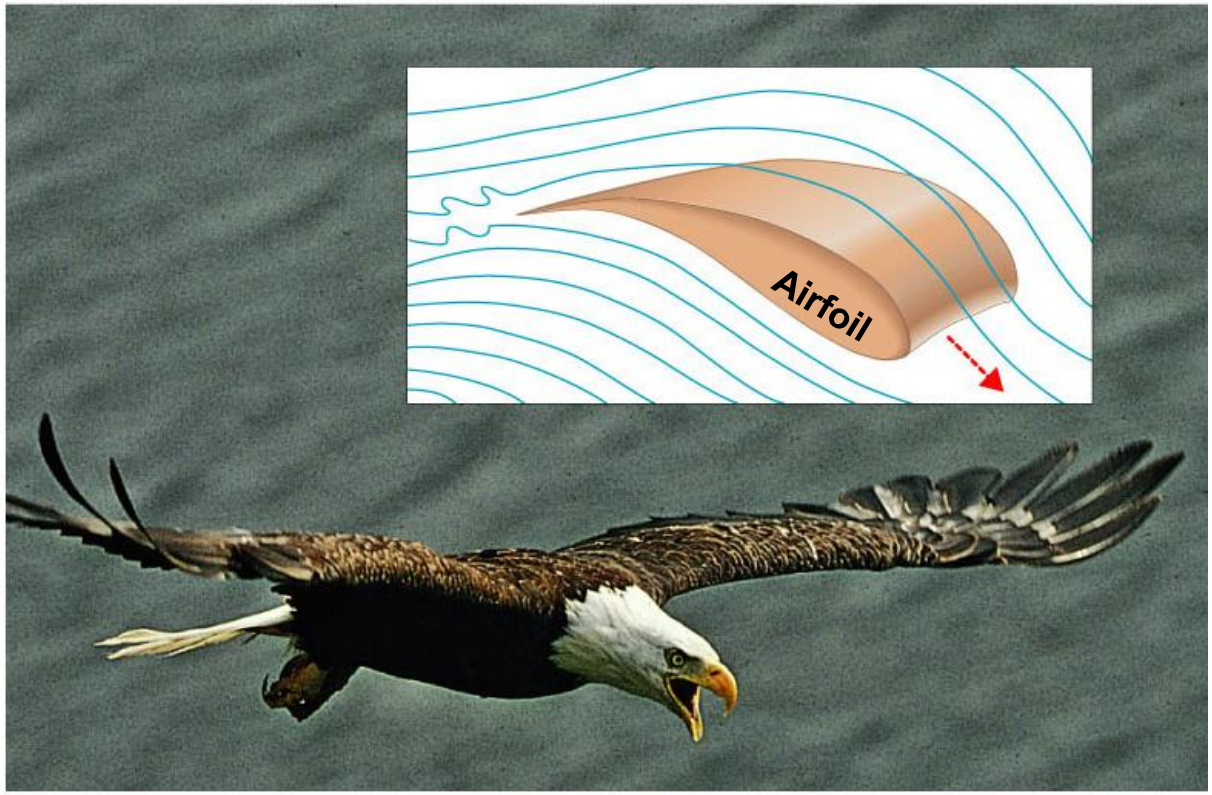
Alligators

Birds

- Class Aves
  - Evolved during the great reptilian radiation of the Mesozoic era
  - Evolved the ability to fly

- Bird anatomy and physiology are modified for flight
  - Bones are honeycombed, which makes them lighter
  - Some specific organs are absent, which reduces weight
  - A warm, constant body temperature is maintained through endothermy

- A bird’s wings
  - Illustrate the same principles of aerodynamics as the wings of an airplane



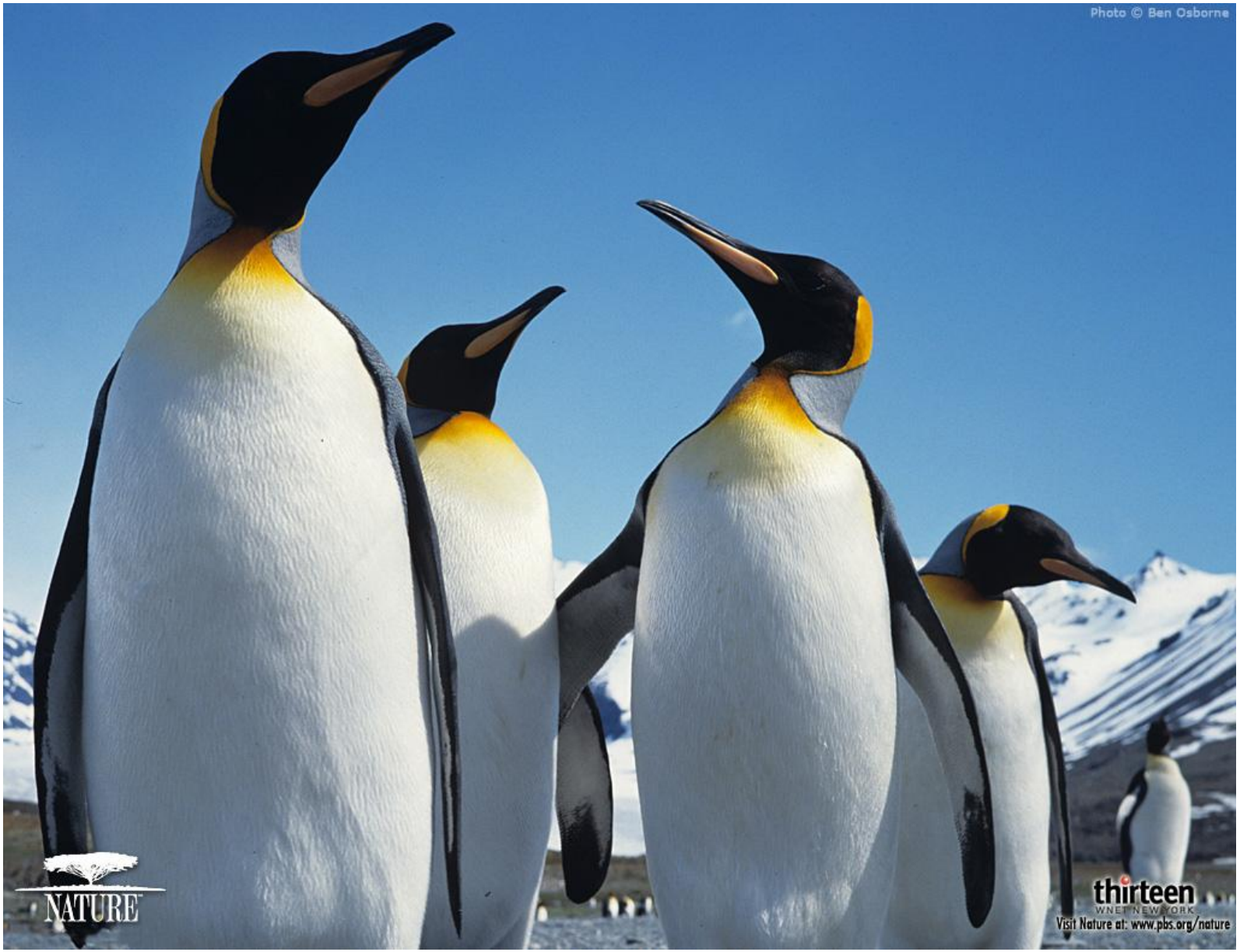
Emu

Ostrich

Eagle

Mallards

Penguin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Mammals

- Class Mammalia
  - Evolved from reptiles about 225 million years ago
  - Includes mostly terrestrial organisms

- Two features are mammalian hallmarks
  - Hair
  - Mammary glands that produce milk and nourish the young

- There are three major groups of mammals
  - Monotremes: the egg-laying mammals.
  - Marsupials: the pouched mammals
  - Eutherians: the placental mammals

Monotremes

- Monotremes
  - Are a small group of egg-laying mammals
  - Consist of echidnas and the platypus

Echidnas

Platypus

Marsupials

- Marsupials
  - Include opossums, kangaroos, and koalas

Opossums

Kangaroo

Koala

- A marsupial is born very early in its development
  - And completes its embryonic development while nursing within a maternal pouch called a marsupium

A young brushtail possum

Eutherians

- Eutherians
  - Their placentas provide more intimate and long-lasting association between the mother and her developing young than do marsupial placentas