Chapter 34

Vertebrates

PowerPoint® Lecture Presentations for

Biology

Eighth Edition

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Overview: Half a Billion Years of Backbones

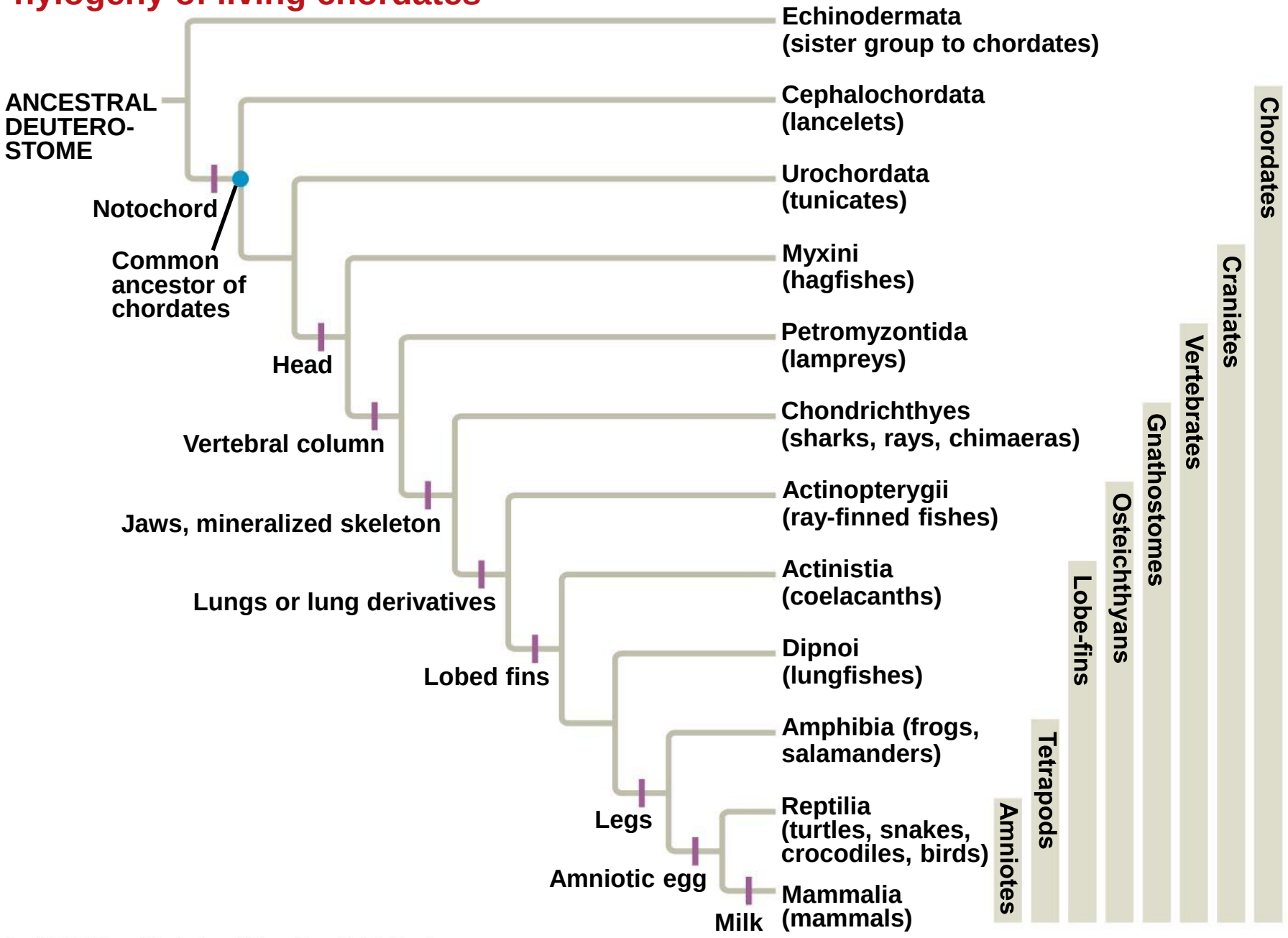
- Early in the Cambrian period, about 530 million years ago, an astonishing variety of animals inhabited Earth's oceans.
- One type of animal gave rise to vertebrates, one of the most successful groups of animals.
- The animals called **vertebrates** get their name from vertebrae, the series of bones that make up the backbone.
- There are about 52,000 species of vertebrates, including the largest organisms ever to live on the Earth.

Are humans among the descendants of this ancient organism?

Concept 34.1: Chordates have a notochord and a dorsal, hollow nerve cord

- Vertebrates are a subphylum within the phylum Chordata.
- **Chordates** are bilaterian animals that belong to the clade of animals known as Deuterostomia.
- Two groups of invertebrate deuterostomes, the urochordates and cephalochordates, are more closely related to vertebrates than to other invertebrates.

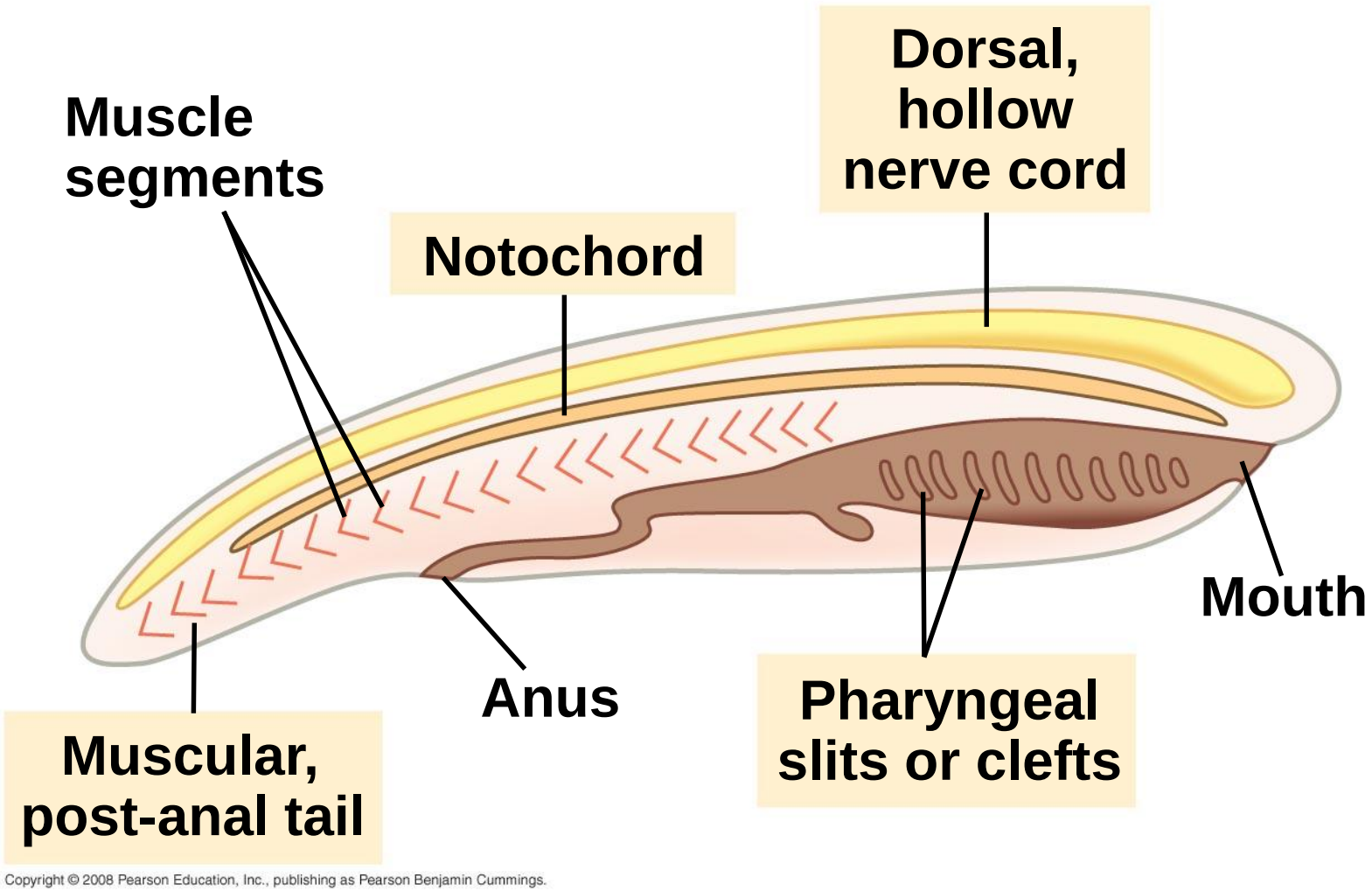
Phylogeny of living chordates



Derived Characters of Chordates

- All chordates share a set of derived characters.
- Some species have some of these traits only during embryonic development.
- ***Four key characters of chordates:***
  - ***Notochord***
  - ***Dorsal, hollow nerve cord***
  - ***Pharyngeal slits or clefts***
  - ***Muscular, post-anal tail***

Chordate characteristics



Notochord

- The **notochord** is a longitudinal, flexible rod between the digestive tube and nerve cord.
- It provides skeletal support throughout most of the length of a chordate.
- In most vertebrates, a more complex, jointed skeleton develops, and the adult retains only remnants of the embryonic notochord.

Dorsal, Hollow Nerve Cord

- The nerve cord of a chordate embryo develops from a plate of ectoderm that rolls into a tube dorsal to the notochord.
- The nerve cord develops into the central nervous system: the brain and the spinal cord.

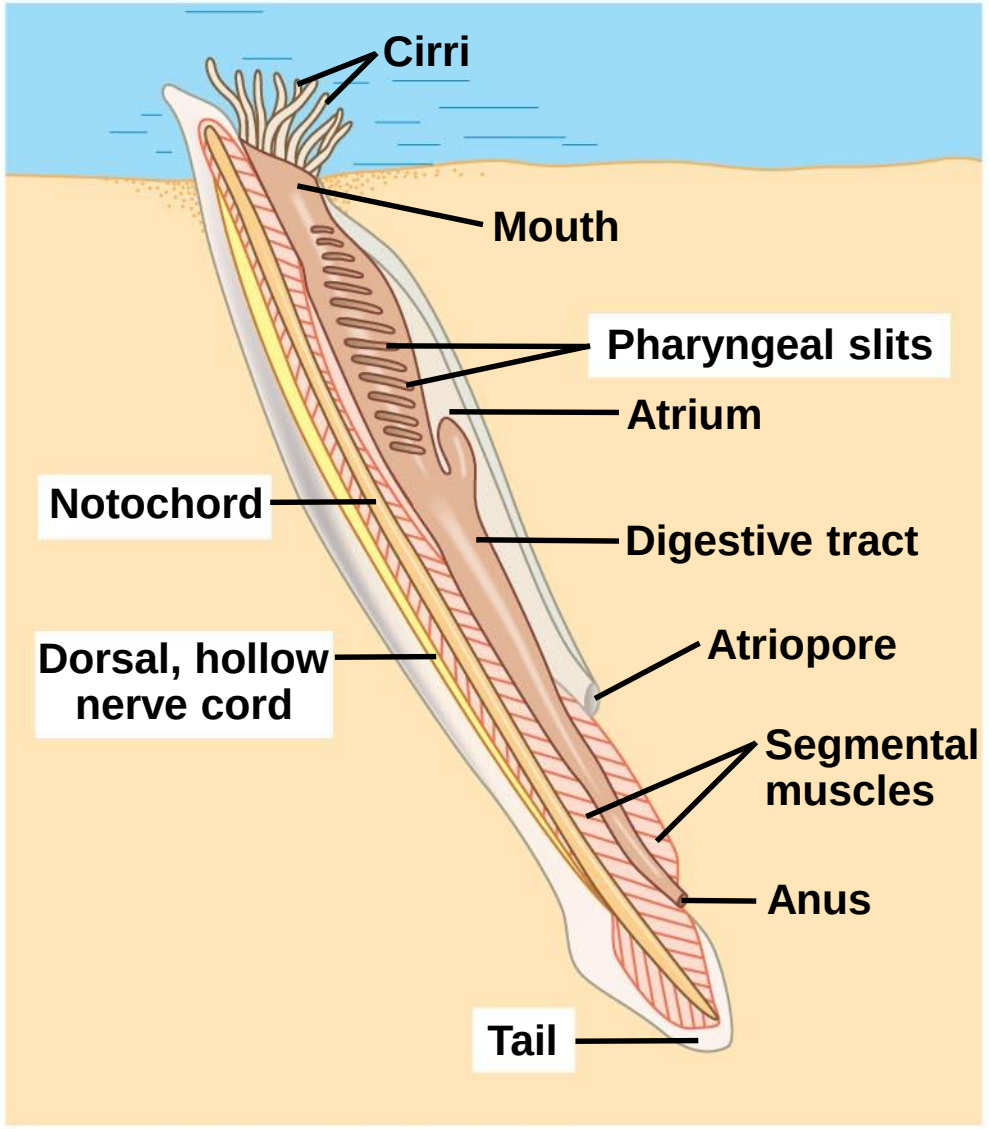
Pharyngeal Slits or Clefts

- In most chordates, grooves in the pharynx called **pharyngeal clefts** develop into slits that open to the outside of the body.
- Functions of **pharyngeal slits**:
  - Suspension-feeding structures in many invertebrate chordates
  - Gas exchange in vertebrates (except vertebrates with limbs, the tetrapods)
  - Develop into parts of the ear, head, and neck in tetrapods.

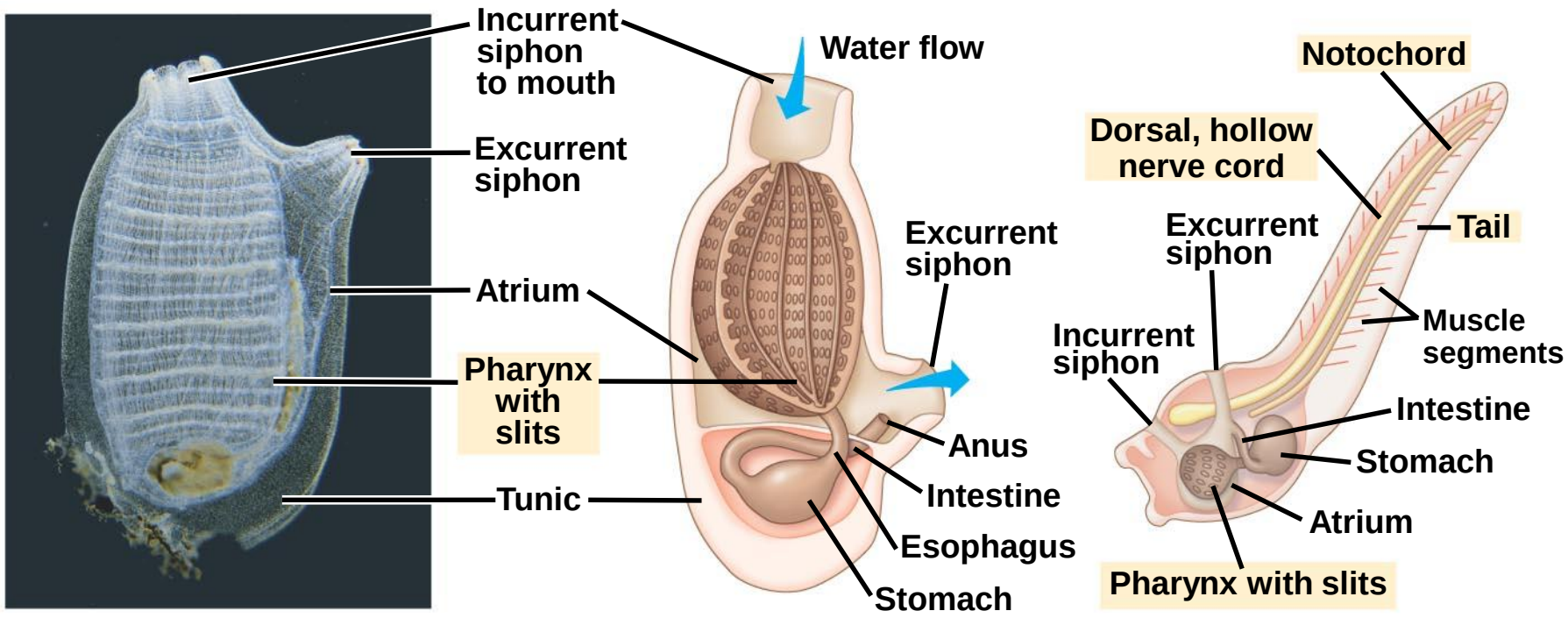
Muscular, Post-Anal Tail

- Chordates have a tail posterior to the anus.
- In many species, the tail is greatly reduced during embryonic development.
- The tail contains skeletal elements and muscles.
- It provides propelling force in many aquatic species.

Lancelets are named for their bladelike shape. They are marine suspension feeders. Adults retain characteristics of chordate body plan.



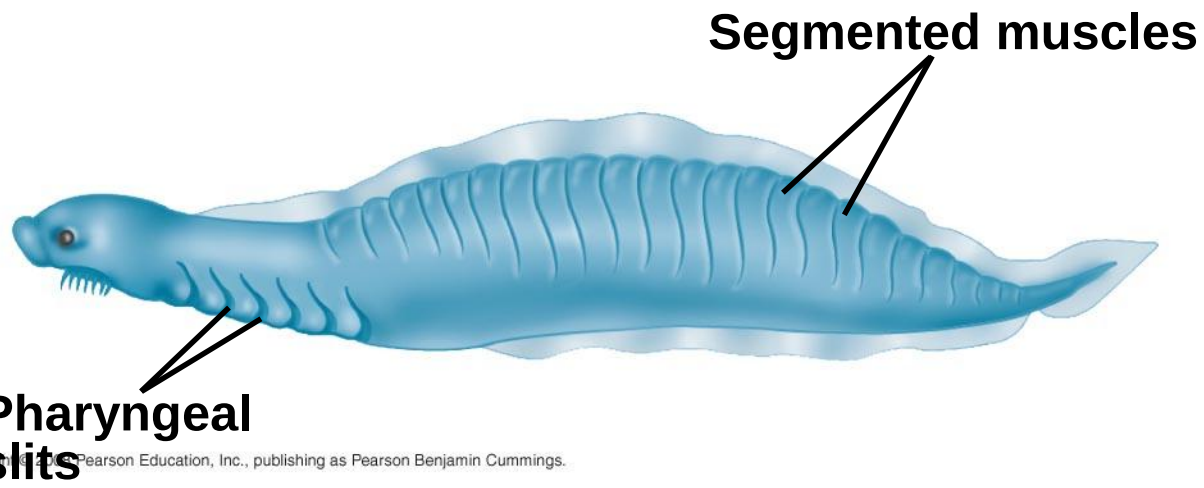
Tunicates (Urochordata) are more closely related to other chordates than are lancelets. They are marine suspension feeders commonly called sea squirts. As an adult, a tunicate draws in water through an incurrent siphon, filtering food particles. Juveniles, not adults, have a notochord.



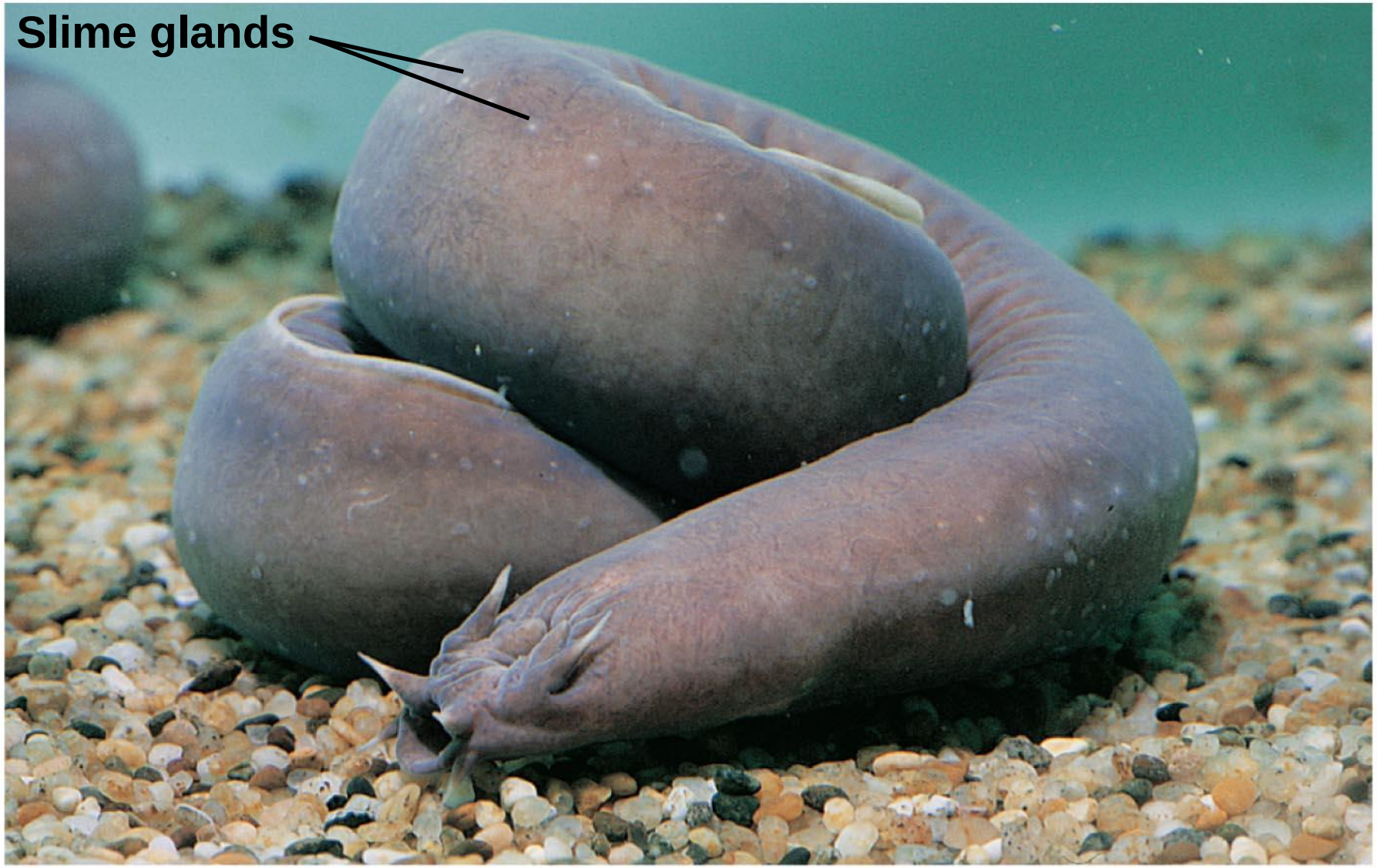
An adult tunicate

A tunicate larva

Fossil of an early Chordate



Hagfishes have a cartilaginous skull and axial rod of cartilage derived from the notochord, but lack jaws and vertebrae



Derived Characters of Vertebrates

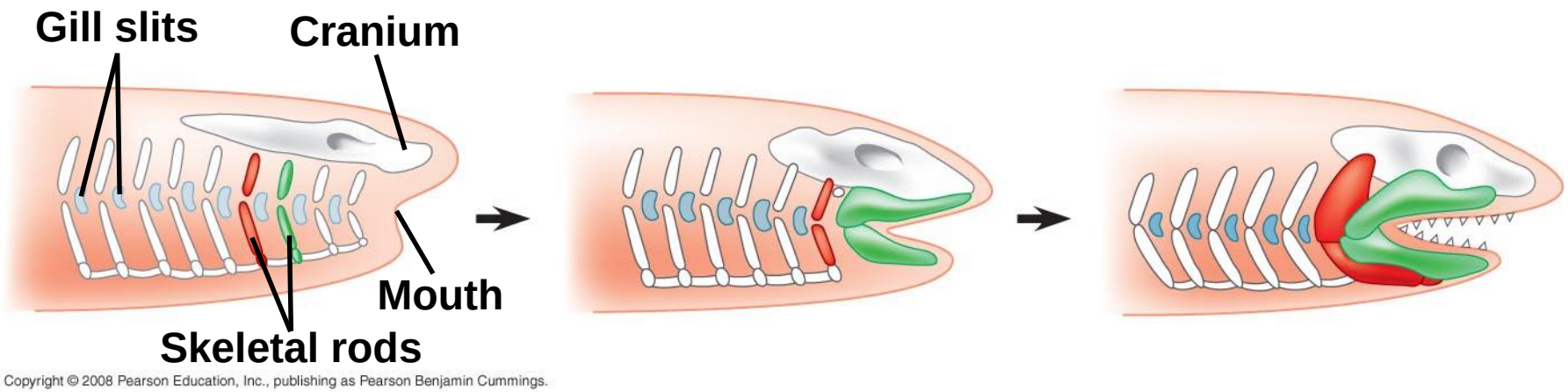
- During the Cambrian period, a lineage of craniates evolved into vertebrates. Vertebrates became more efficient at capturing food and avoiding being eaten.
- Vertebrates have the following derived characters:
  - Vertebrae enclosing a spinal cord
  - An elaborate skull
  - Fin rays, in the aquatic forms.

Lampreys represent the oldest living lineage of vertebrates. They are jawless vertebrates inhabiting various marine and freshwater habitats.

Origins of Bone and Teeth

- Mineralization appears to have originated with vertebrate mouthparts.
- The vertebrate endoskeleton became fully mineralized much later.
- Today, *jawed vertebrates*, or ***gnathostomes***, outnumber jawless vertebrates.
- Gnathostomes jaws might have evolved from skeletal supports of the pharyngeal slits.

Hypothesis for the evolution of vertebrate jaws

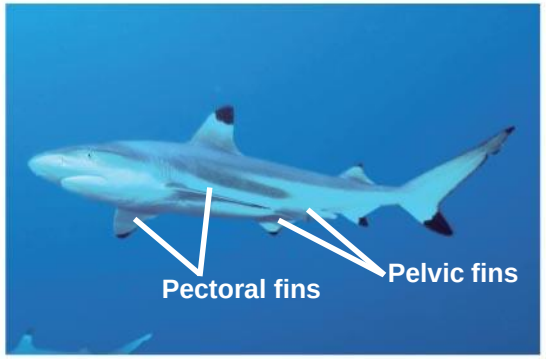


- Other characters common to gnathostomes:
  - An additional duplication of **Hox genes**
  - An enlarged forebrain associated with enhanced smell and vision
  - In aquatic gnathostomes, the **lateral line system**, which is sensitive to vibrations.

Chondrichthyans (Sharks, Rays, and Their Relatives)

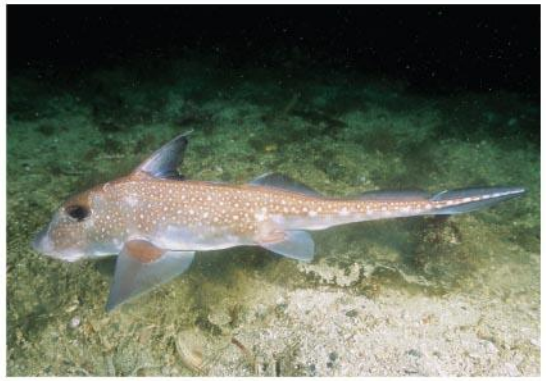
- **Chondrichthyans** (Chondrichthyes) have a skeleton composed primarily of cartilage.
- The cartilaginous skeleton evolved secondarily from an ancestral mineralized skeleton.
- The largest and most diverse group of chondrichthyans includes the sharks, rays, and skates.

Chondrichthyans



(a) Blacktip reef shark (*Carcharhinus melanopterus*)

(b) Southern stingray (*Dasyatis americana*)



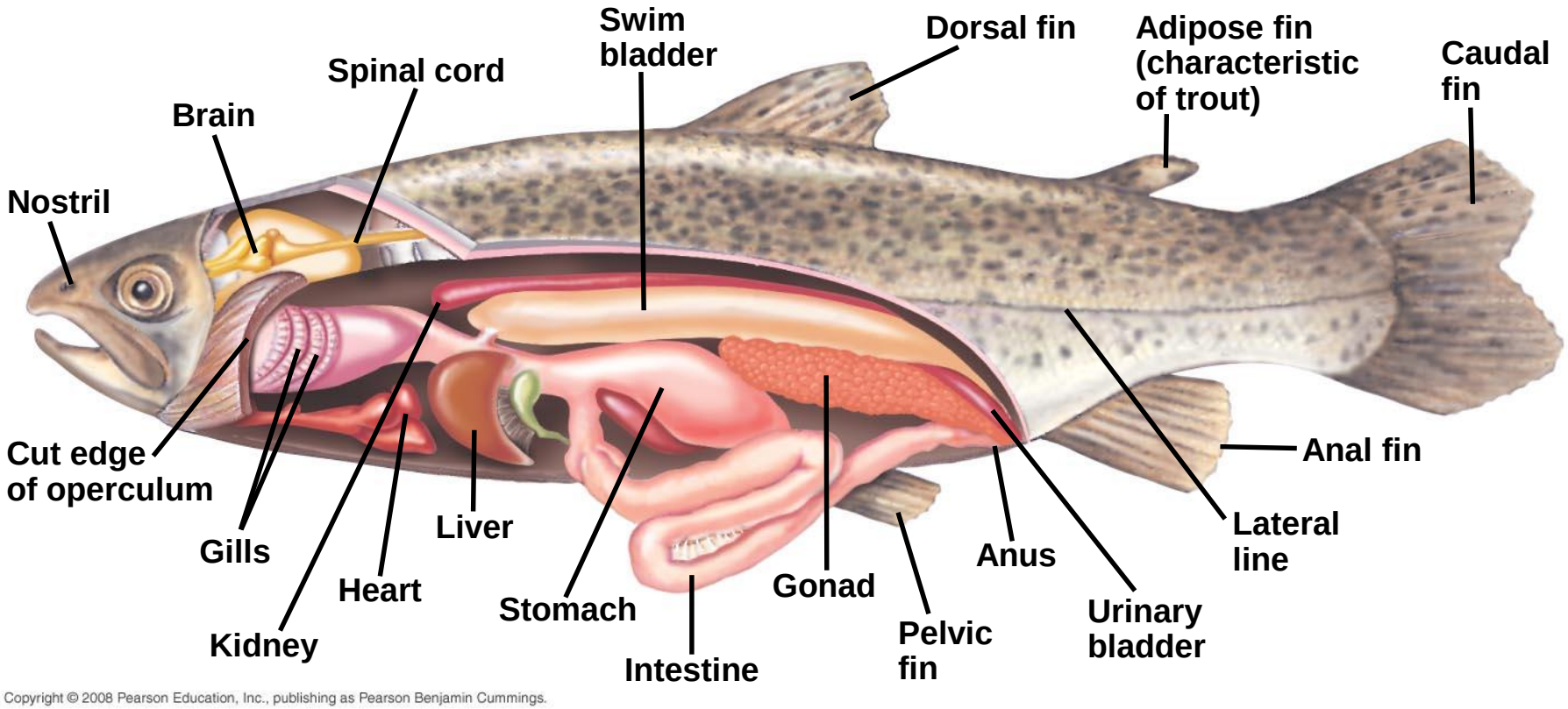
(c) Spotted ratfish (*Hydrolagus colliei*)

- Most sharks
  - Have a streamlined body and are swift swimmers
  - Are carnivores
  - Have a short digestive tract; a ridge called the *spiral valve* increases the digestive surface area
  - Have acute senses.

- Shark eggs are fertilized internally but embryos can develop in different ways:
  - **Oviparous**: eggs hatch outside the mother's body.
  - **Ovoviviparous**: the embryo develops within the uterus and is nourished by the egg yolk.
  - **Viviparous**: the embryo develops within the uterus and is nourished through a yolk sac placenta from the mother's blood.
- The reproductive tract, excretory system, and digestive tract empty into a common **cloaca.**

- The vast majority of vertebrates belong to a clade of gnathostomes called Osteichthyes.
- ***Osteichthyes*** includes the bony fish and tetrapods.
- They have a *bony endoskeleton.*
- Aquatic osteichthyans are the vertebrates we informally call fishes.
- Most fishes breathe by drawing water over gills protected by an **operculum.**
- Fishes control their buoyancy with an air sac known as a **swim bladder.**

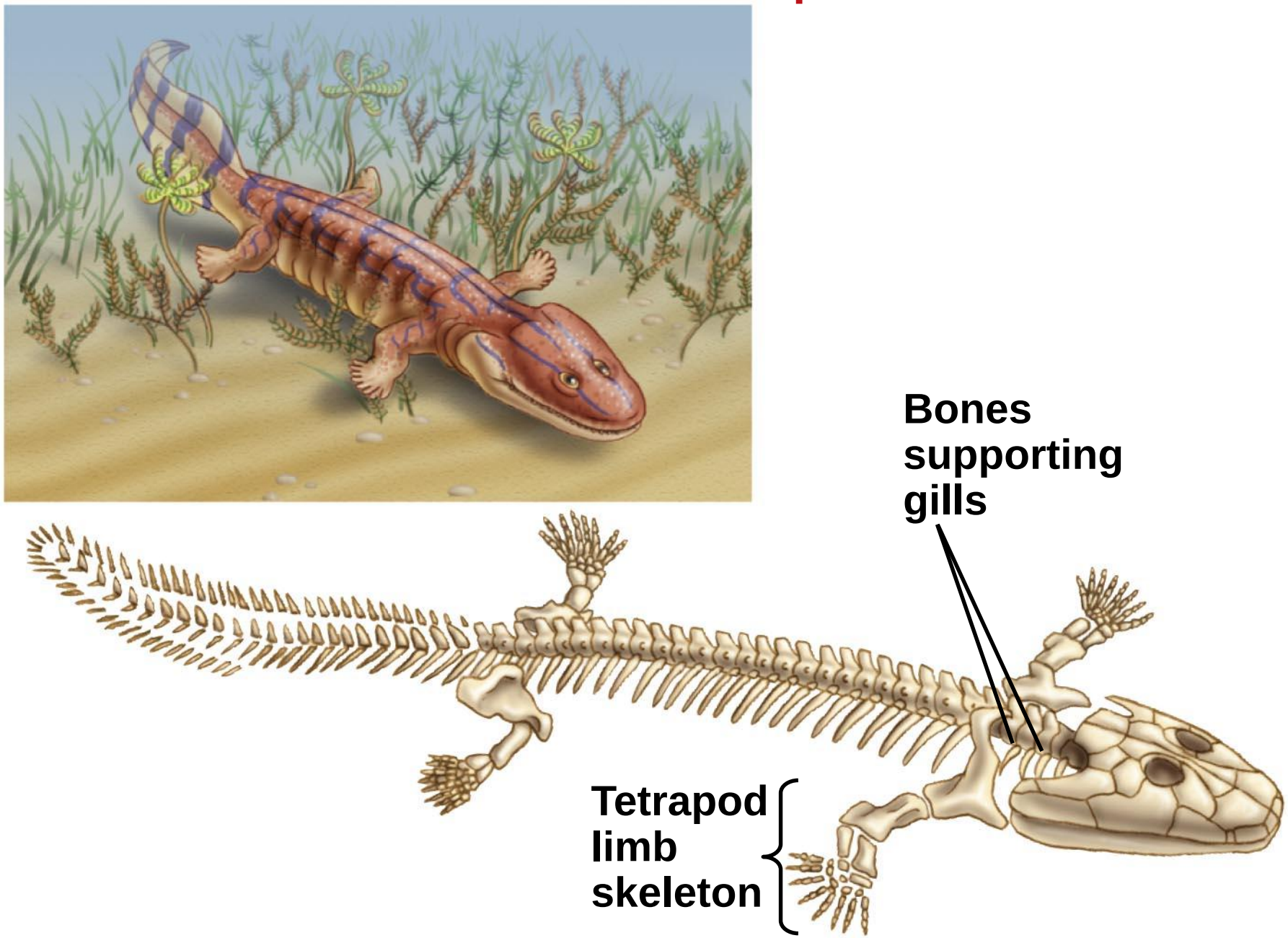
Anatomy of a trout - bony fish - Osteichthyes



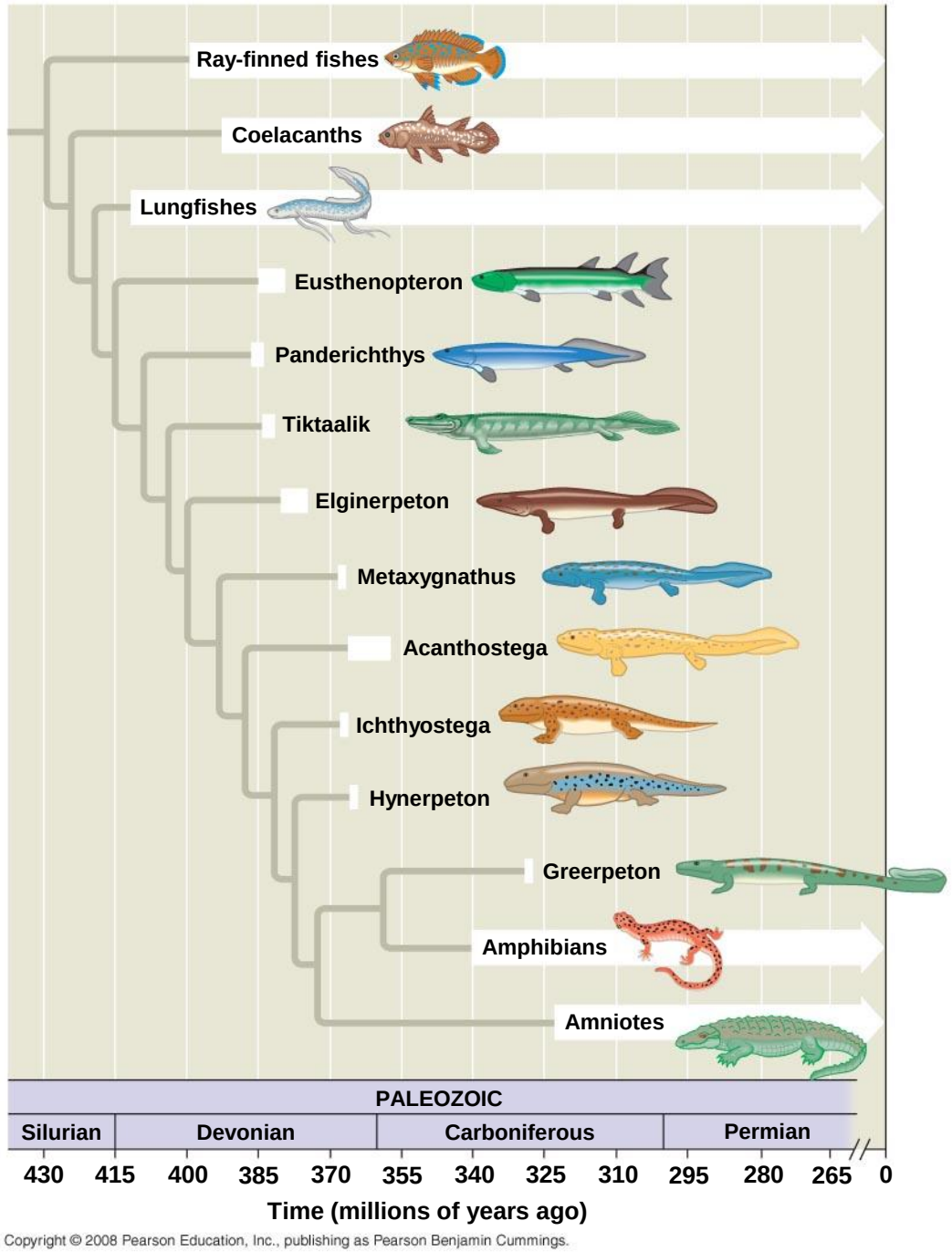
Derived Characters of Tetrapods

- **Tetrapods** have some specific adaptations:
  - Four limbs, and feet with digits
  - Ears for detecting airborne sounds.
- In one lineage of lobe-fins, the fins became progressively more limb-like while the rest of the body retained adaptations for aquatic life.
- For example, *Acanthostega* lived in Greenland 365 million years ago.

A Devonian era relative of tetrapods



Origin of Tetrapods



Amphibians

- **Amphibians** (class Amphibia) are represented by about 6,150 species of organisms in three orders.
- *Amphibian* means "both ways of life," referring to the metamorphosis of an aquatic larva into a terrestrial adult.
- Most amphibians have moist skin that complements the lungs in gas exchange.
- Fertilization is external in most species, and the eggs require a moist environment.

Amphibians

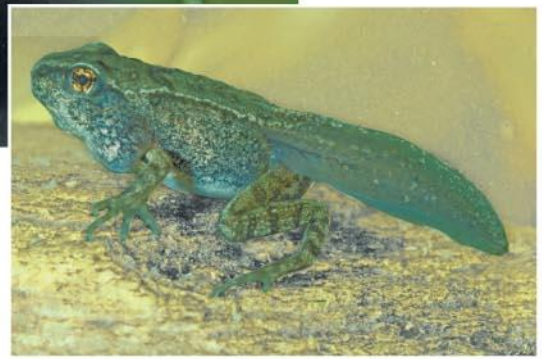
(a) Order Urodela

(b) Order Anura

(c) Order Apoda

The “dual life” of a frog

(a) Tadpole



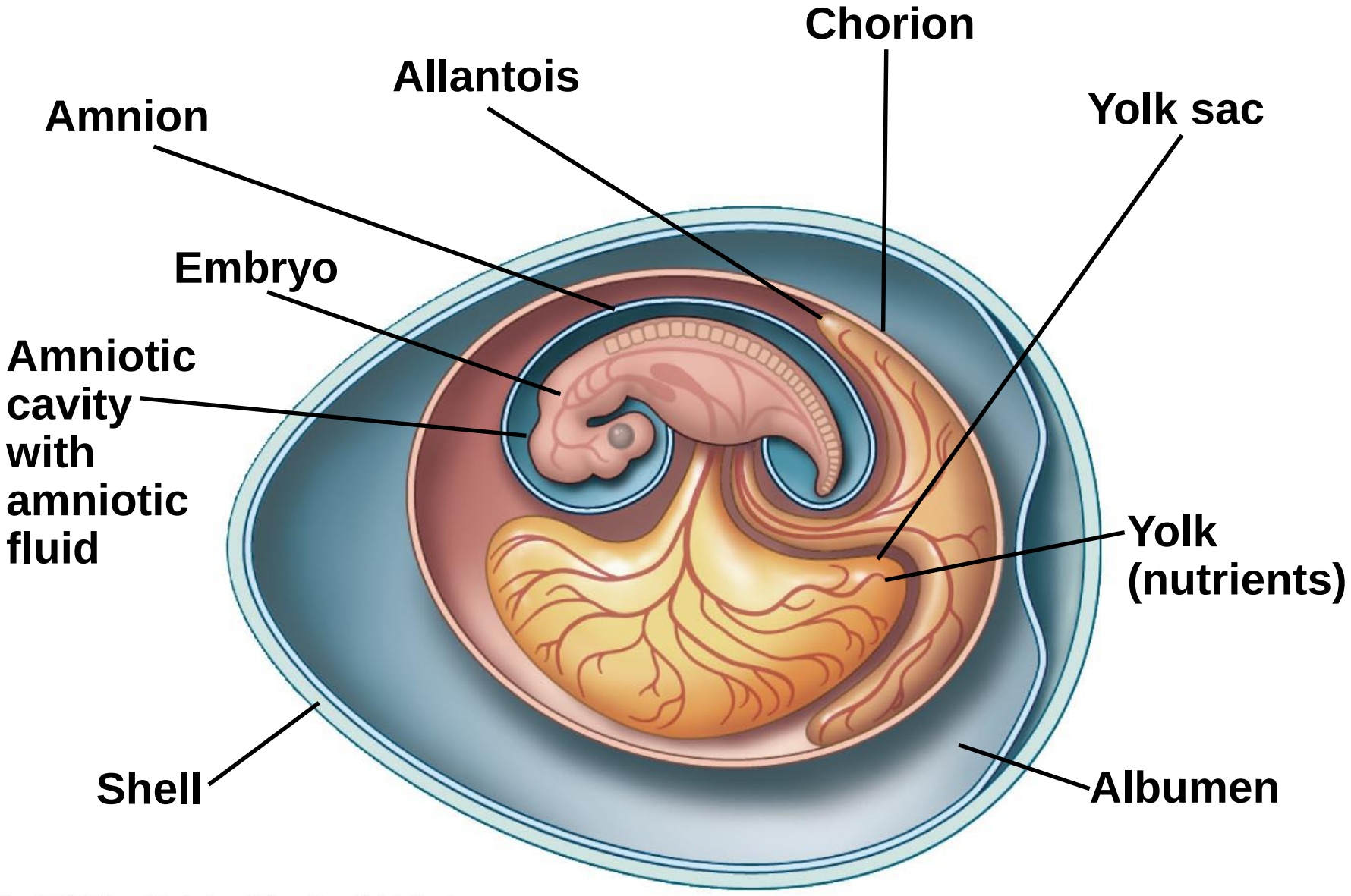
(b) During metamorphosis

(c) Mating adults

Concept 34.6: Amniotes are tetrapods that have a terrestrially adapted egg

- **Amniotes** are a group of tetrapods whose living members are the reptiles, including birds, and mammals.
- Amniotes are named for the major derived character of the clade, the ***amniotic egg***, which contains membranes that protect the embryo.
- The ***extraembryonic membranes*** *are the* ***amnion, chorion, yolk sac,*** *and* ***allantois***.
- Amniotes have other terrestrial adaptations, such as relatively impermeable skin and the ability to use the rib cage to ventilate the lungs.

The amniotic egg



Reptiles - lay shelled eggs on land

- The **reptile** clade includes the tuataras, lizards, snakes, turtles, crocodilians, birds, and the extinct dinosaurs.
- Reptiles have scales that create a waterproof barrier.
- Most reptiles are **ectothermic**, absorbing external heat as the main source of body heat.
- Birds are **endothermic**, capable of keeping the body warm through metabolism.

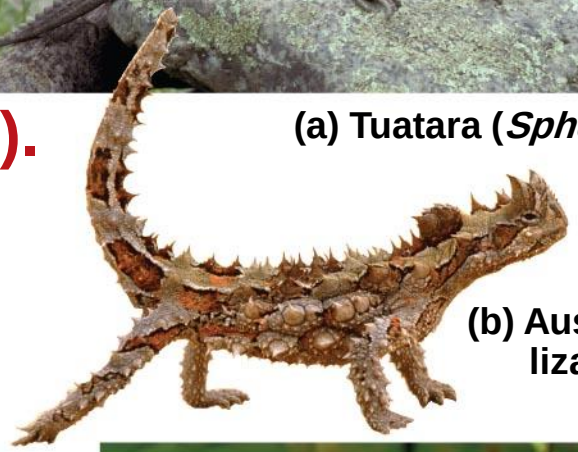
Hatching reptiles

- Dinosaurs diversified into a vast range of shapes and sizes.
- They included bipedal carnivores called **theropods.**
- Paleontologists have discovered signs of parental care among dinosaurs.
- Dinosaurs, with the exception of birds, became extinct by the end of the Cretaceous. Their extinction may have been partly caused by an asteroid.

Extant reptiles

(other than birds).

(a) Tuatara (*Sphenodon punctatus*)



(b) Australian thorny devil lizard (*Moloch horridus*)

(c) Wagler's pit viper (*Tropidolaemus wagleri*)

(d) Eastern box turtle (*Terrapene carolina carolina*)

(e) American alligator (*Alligator mississippiensis*)