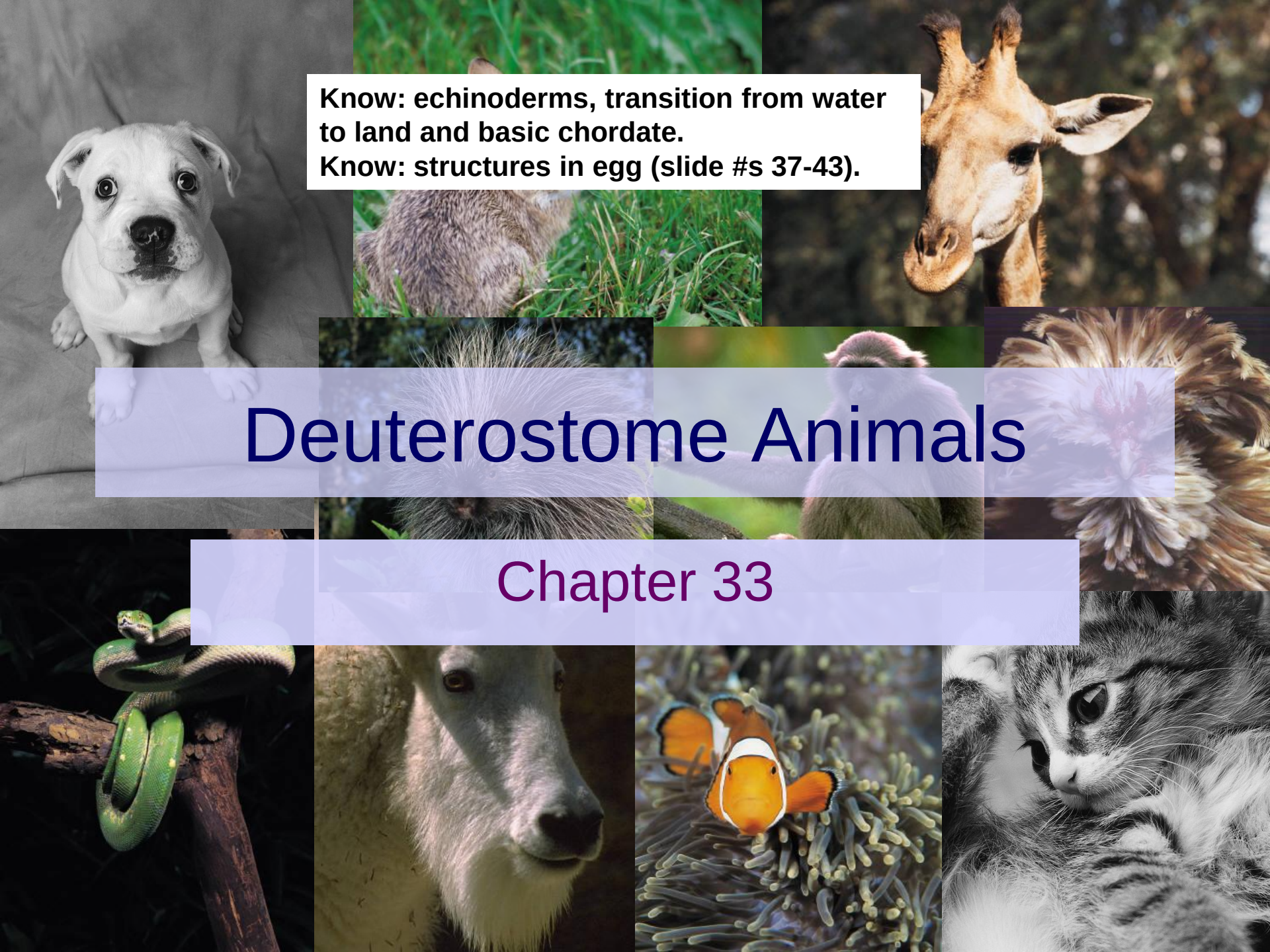


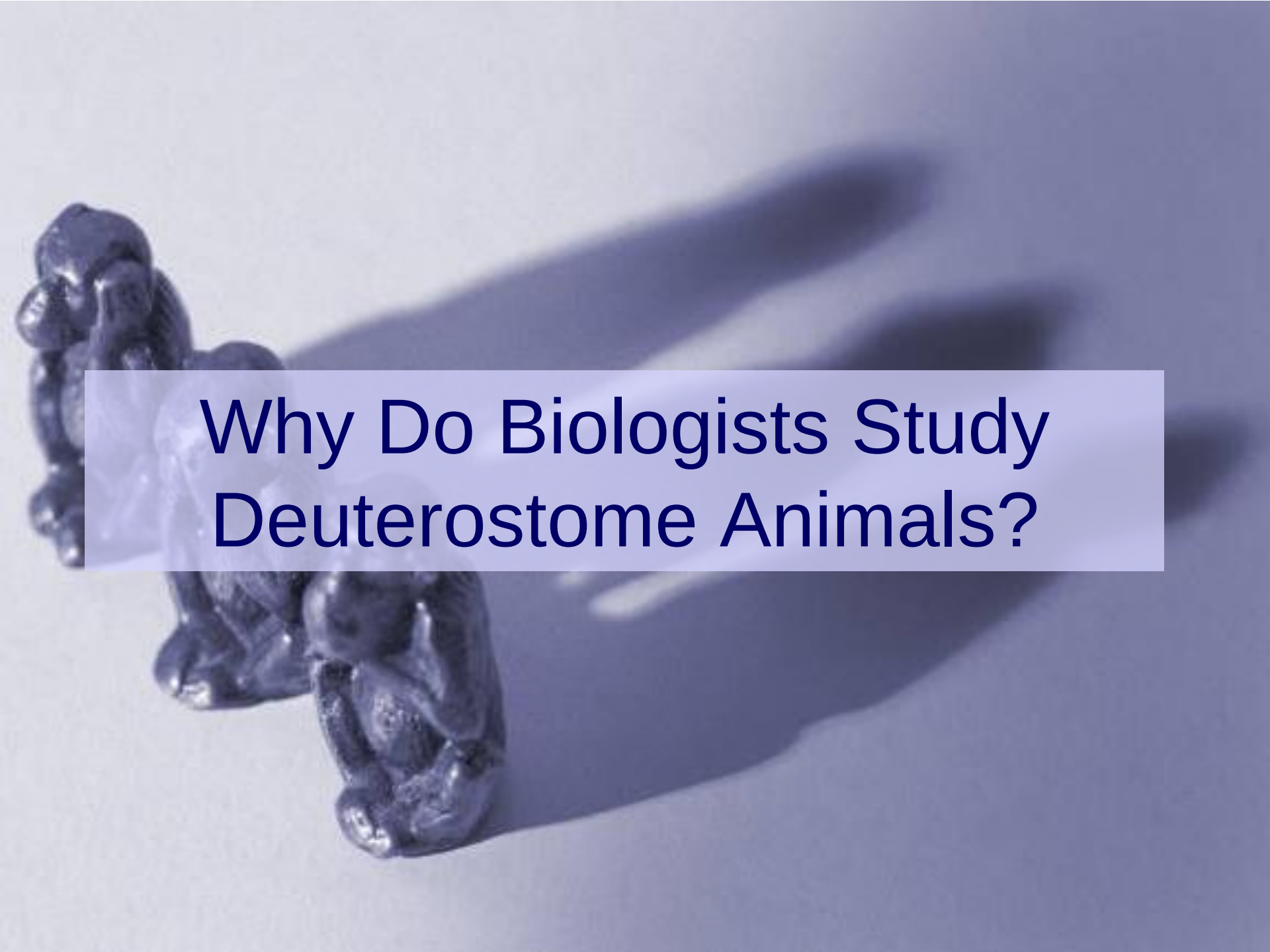
Know: echinoderms, transition from water to land and basic chordate.
Know: structures in egg (slide #s 37-43).

Deuterostome Animals

Chapter 33

Deuterostome Animals

- Largest-bodied and most morphologically complex animals
- Three phyla of deuterostomes:
  - **Echinodermata**
  - **Hemichordata**
  - **Chordata**
- Chordates include the **vertebrates**, which are animals that have a skull.
  - Animals that lack a skull are collectively called the **invertebrates**.



Why Do Biologists Study Deuterostome Animals?

Deuterostomes

- Humans are deuterostomes and other species in our lineage interest us
- Deuterostomes play important roles in ecological interactions
- Key consumers and predators in both marine and terrestrial ecosystems
- We depend on vertebrates for food, power for agriculture in pre-industrial societies, and companionship

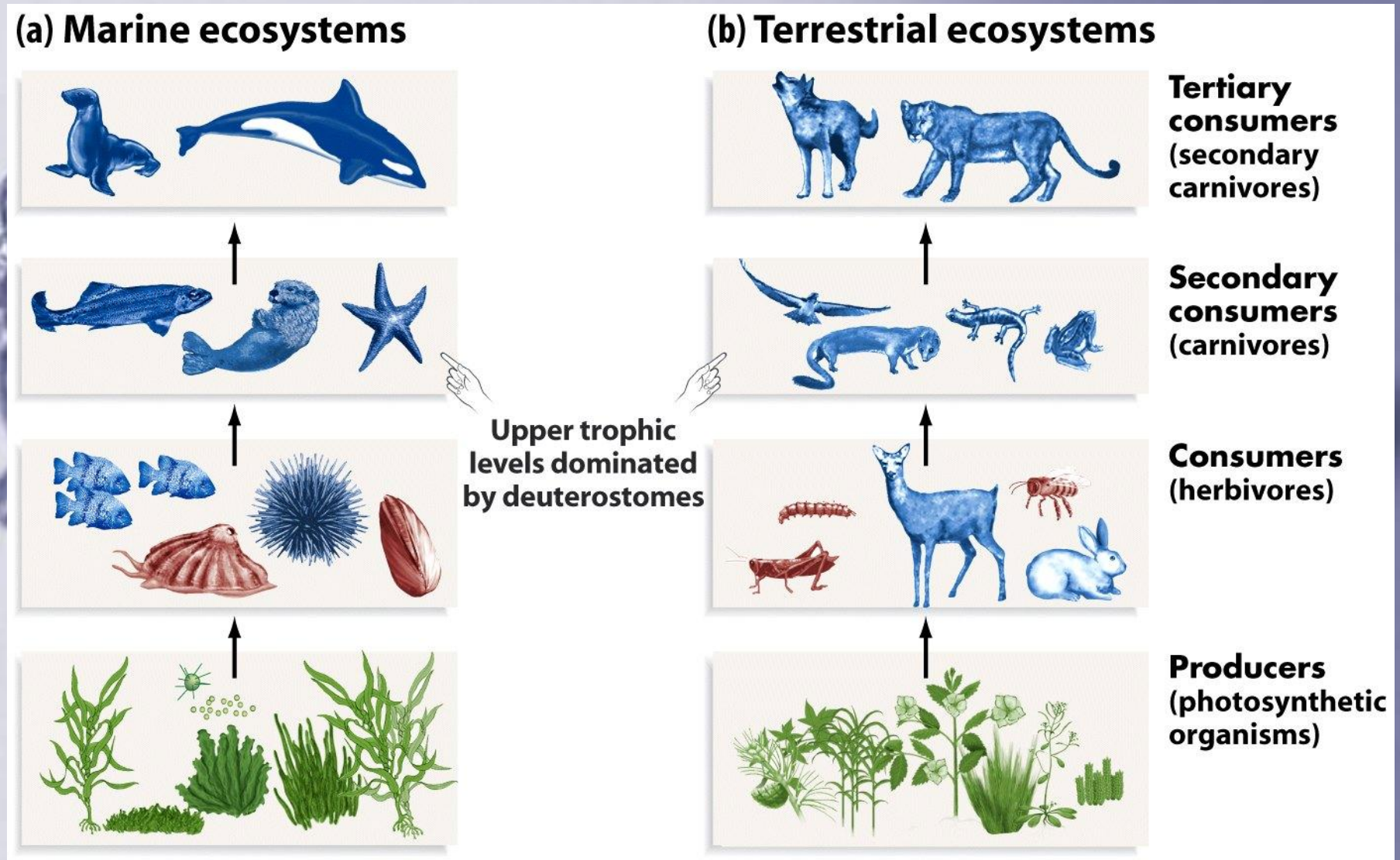
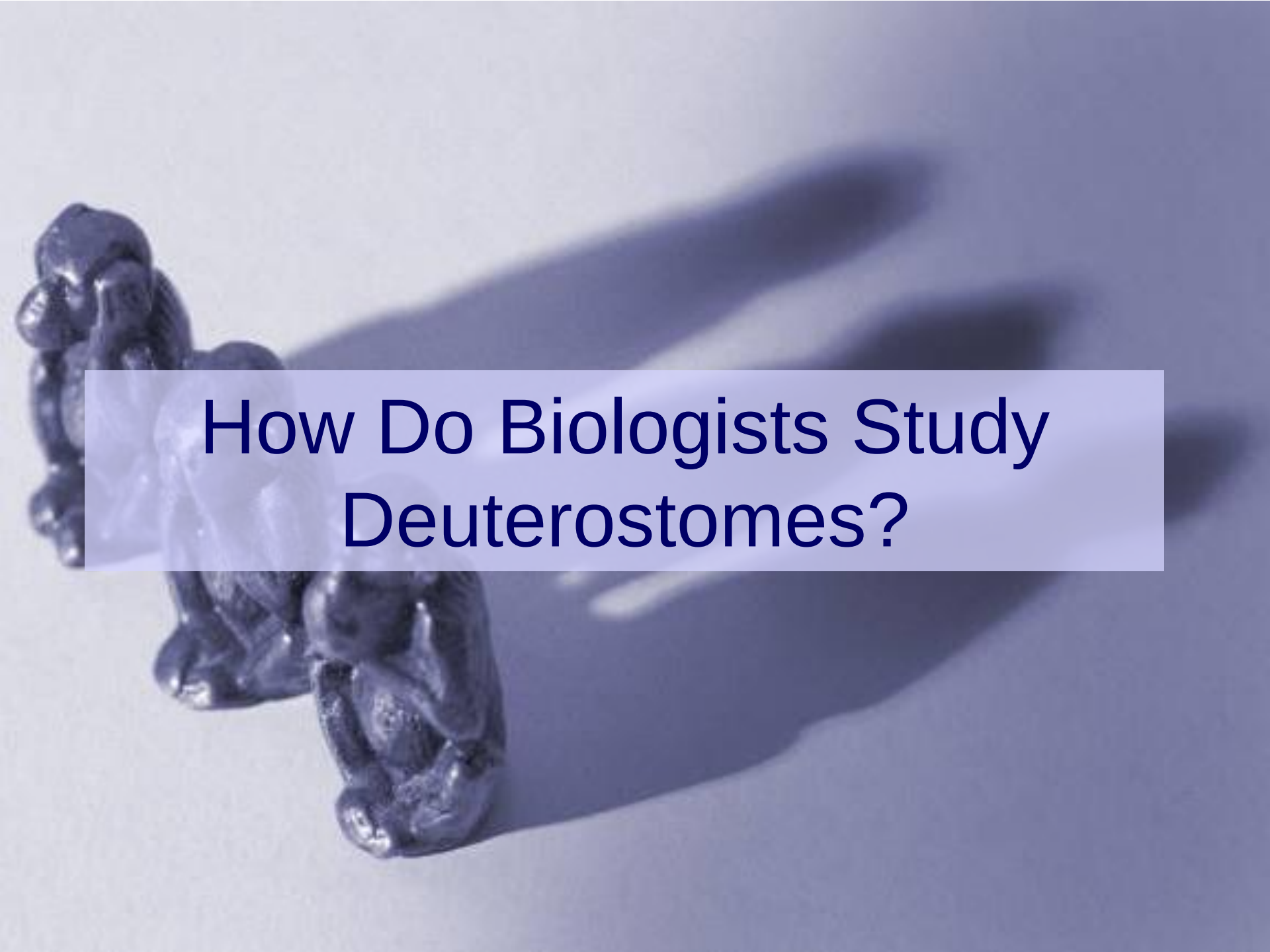


Figure 33-1 Biological Science, 2/e



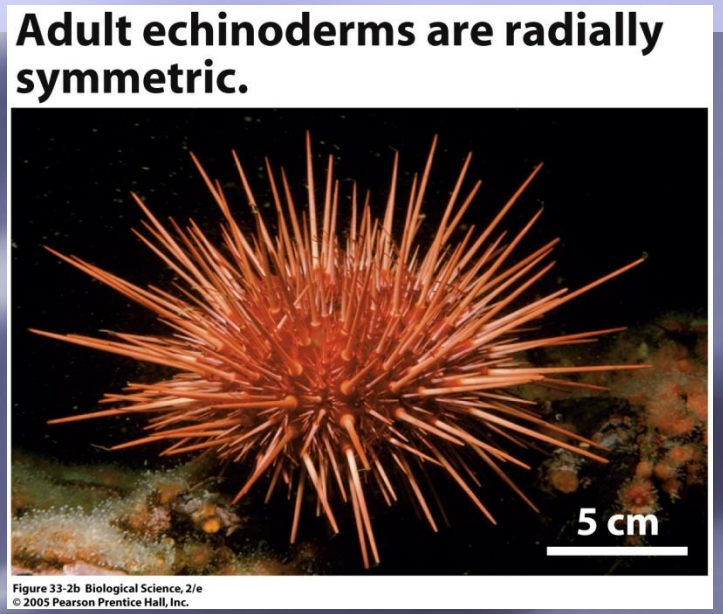
How Do Biologists Study Deuterostomes?

Studying Deuterostomes

- To understand the diversity of deuterostomes, it is important to understand
- (1) the diversity in body plans observed in the three phyla
- (2) how vertebrates evolved from invertebrates
- (3) how vertebrates made the water-to-land transition.

Echinoderm Body Plan

- During the evolution of echinoderms, there was a **reversion to a type of radial symmetry**
- Chordates and hemichordates are bilaterally symmetrical



Echinoderm Body Plan

- The echinoderm body contains a series of fluid-filled tubes and chambers called the **water vascular system**
- Forms a hydrostatic skeleton
  - **Has tube feet**, which are elongated fluid-filled structures
  - **Podia** are sections of the tube feet that project outside the body and are involved in motion along a substrate.

Echinoderm Body Plan

Echinoderms have a water vascular system.

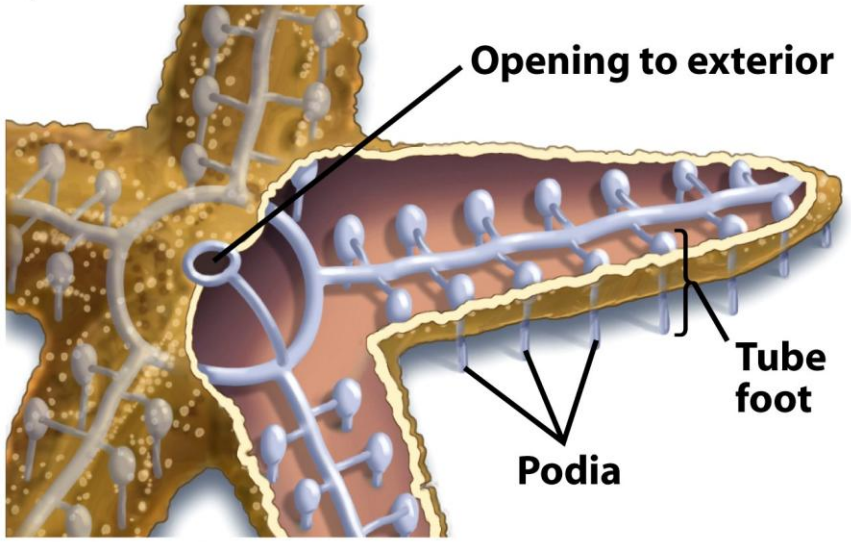


Figure 33-3a Biological Science, 2/e

Podia project from the underside of the body.

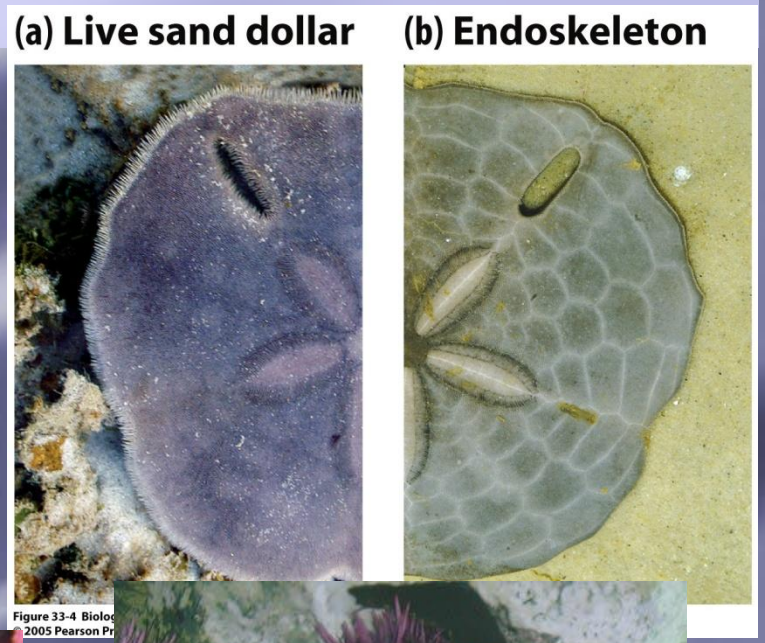
Figure 33-3b Biological Science, 2/e

Podia project from the underside of the body.

Figure 33-3b Biological Science, 2/e

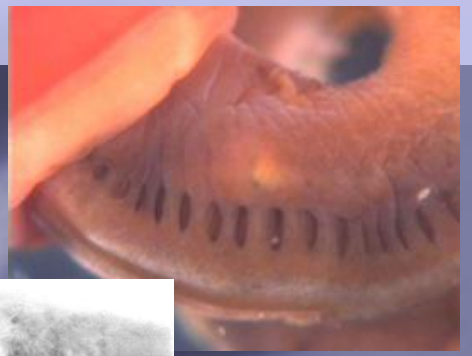
Echinoderm Body Plan

- Have an **endoskeleton**—a hard supportive structure inside the body



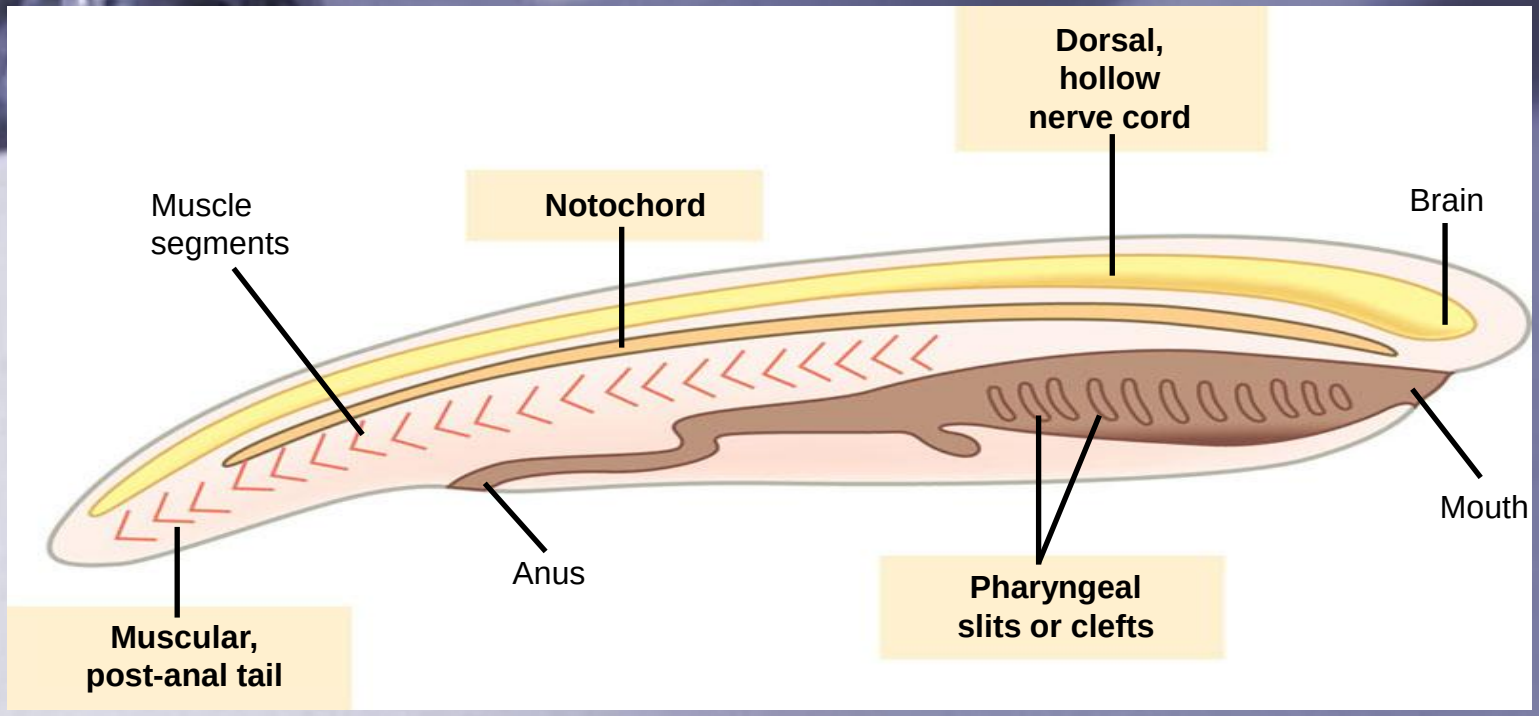
Chordate Body Plan

- The phylum Chordata is defined by the presence of four morphological features: (1) **pharyngeal gill slits**, (2) a **notochord**, (3) a **dorsal hollow nerve cord**, and (4) a muscular post-anal **tail**



Chordate Body Plan

- All chordates share this set of derived characters
  - Although some species possess some of these traits only during embryonic development

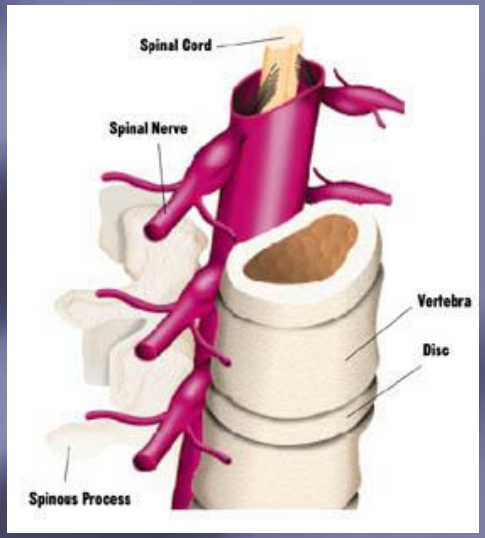


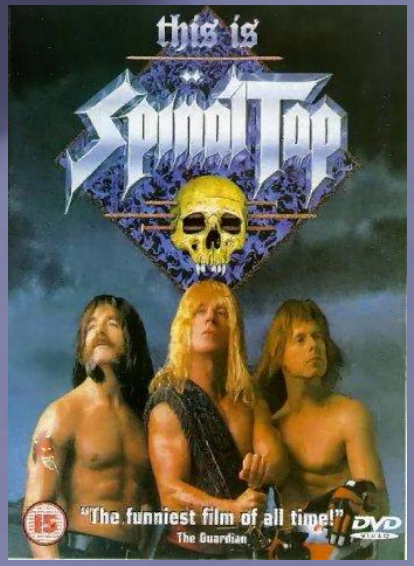
Notochord

- The notochord
  - Is a longitudinal, flexible rod located between the digestive tube and the nerve cord
  - 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
  - Reduced to disks between vertebra in humans

Dorsal, Hollow Nerve Chord

- The nerve cord of a chordate embryo
  - Develops from a plate of ectoderm that rolls into a tube dorsal to the notochord
  - Unique to chordates, other phyla have hollow nerve chords that are ventrally located
  - Develops into the central nervous system: the brain and the spinal cord

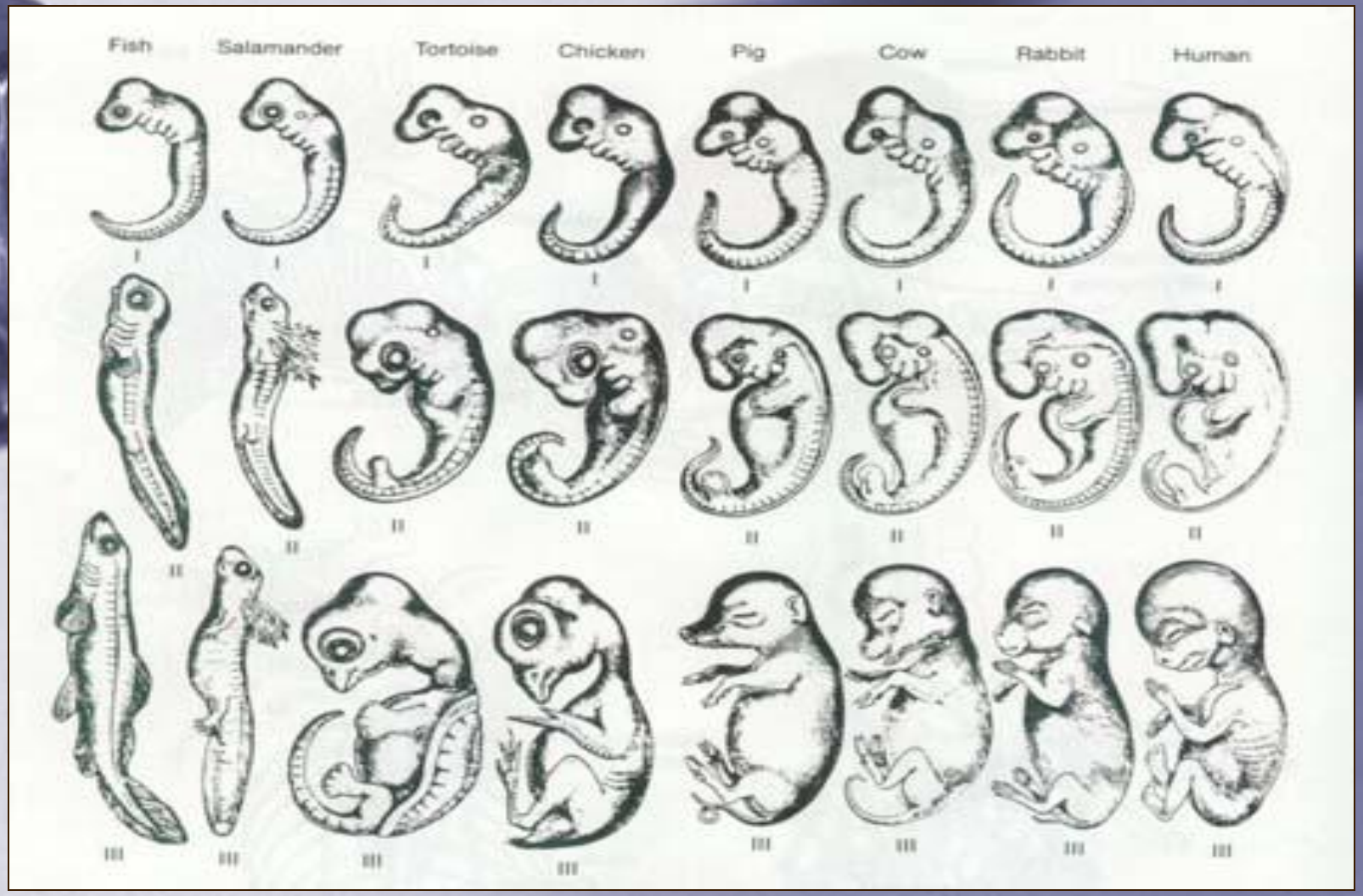




Pharangael Slits of Clefts

- In most chordates, grooves in the pharynx called pharyngeal clefts
  - Develop into slits that open to the outside of the body
- These pharyngeal slits
  - Function as suspension-feeding structures in many invertebrate chordates
  - Are modified for gas exchange in aquatic vertebrates
  - Develop into parts of the ear, head, and neck in terrestrial vertebrates

Pharangael Slits of Clefts

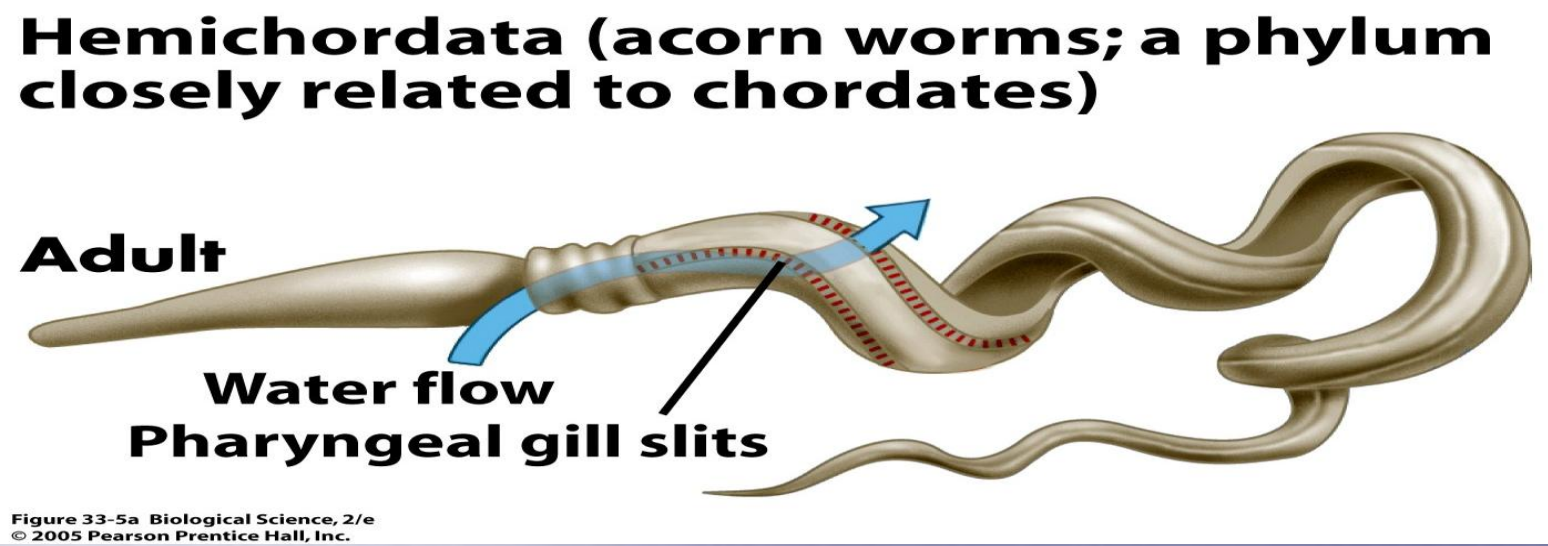


Muscular Post-Anal Tail

- Tail extending past the anus
- Lost in many species during embryonic development
- The chordate tail contains skeletal elements and muscles
  - And it provides much of the propelling force in many aquatic species

Phylum Hemichordata

- Not members of the Chordata phylum
- Have only one of the three features of chordates: pharyngeal gill slits that function in feeding and gas exchange



Phylum Chordata

- The three subphyla of chordates are
- **Urochodates**
  - Tunicates
  - suspension feeders that live attached to hard substrates in the ocean
- **Cephalochordates**
  - Lancelets
  - look like fish
- **Vertebrates**

Urochordata (tunicates)

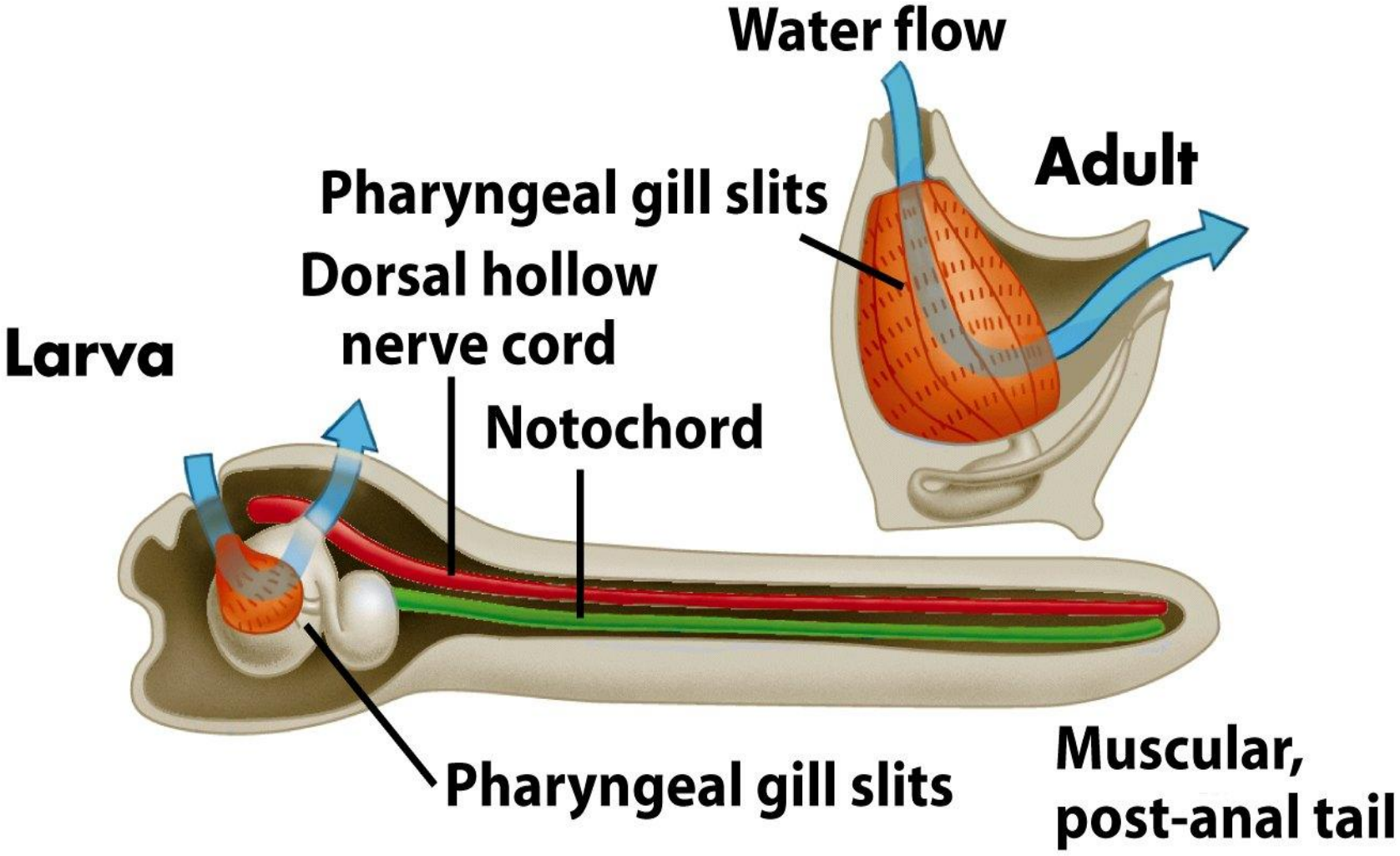


Figure 33-5b part 1 Biological Science, 2/e

Cephalochordata (lancelets)

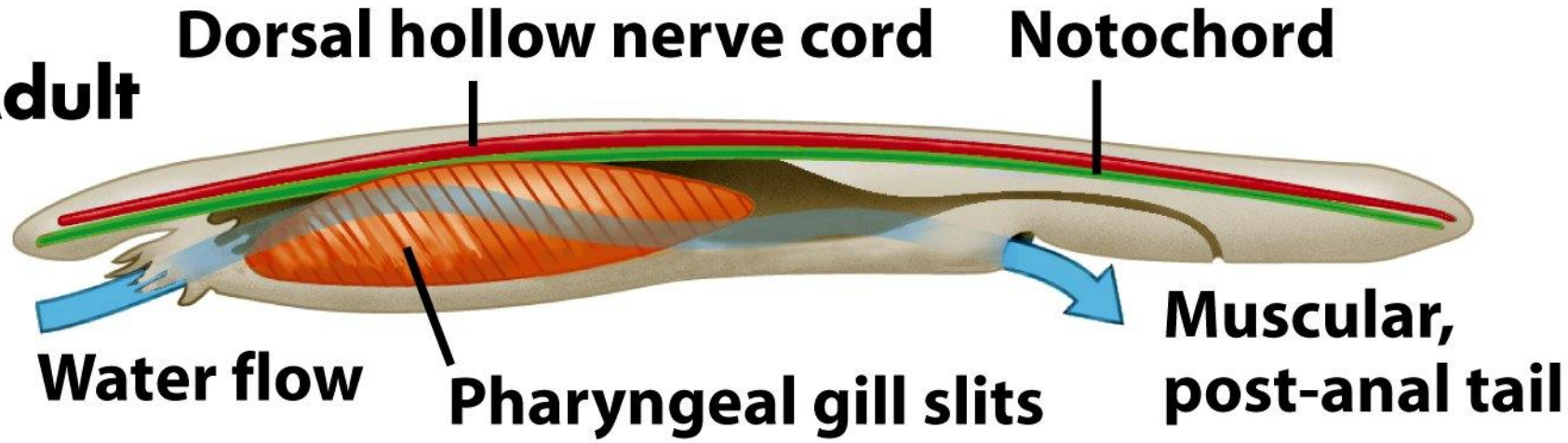


Figure 33-5b part 2 Biological Science, 2/e

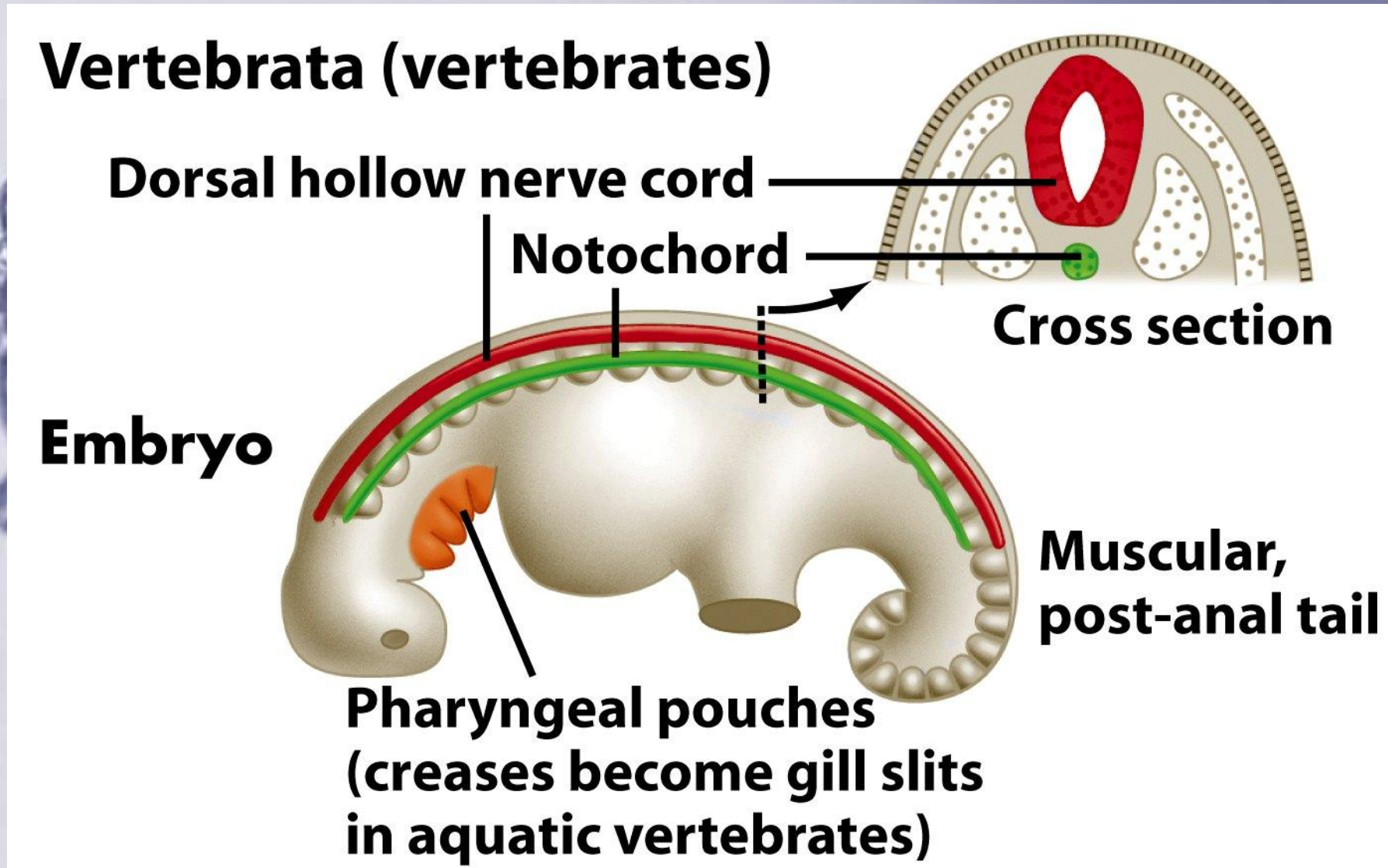


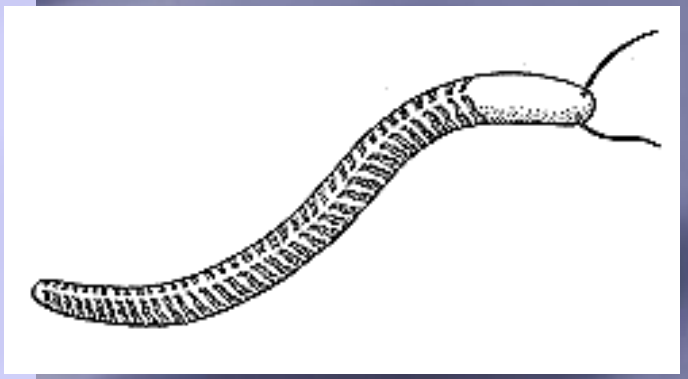
Figure 33-5b part 3 Biological Science, 2/e

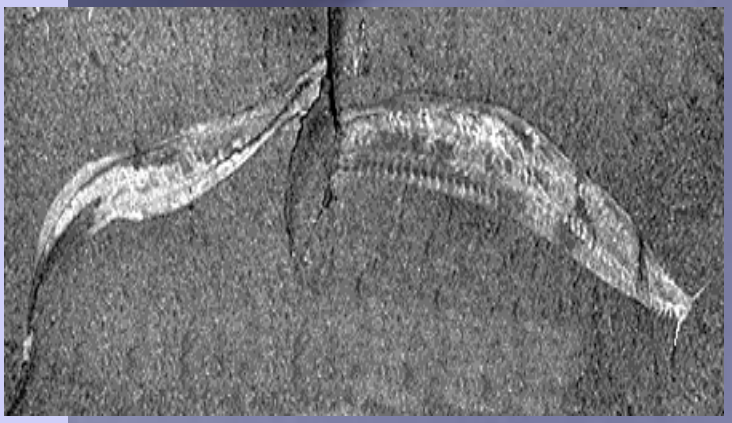
Using the Fossil Record

- The earliest vertebrates lived in the ocean about 530 million years ago
- Had endoskeletons made of **cartilage**
  - Pikaia, - has notochord, worm

    -like creatures that lived during

    the cambrian period





Milestones of Vertebrate Development

- A series of innovations occurred as the vertebrate lineage diversified

1. 480 mya- first fossils to contain **bone** in the form of an **exoskeleton** enveloping the body
2. First vertebrates with **jaws** appear 430 million years ago
3. **Tetrapods** (animals with four limbs) and the transition to land are dated at about 357 mya

Milestones of Vertebrate Development

4. First amniotes appeared 20 million years after the emergence of tetrapods
   - egg that has a watertight shell or case enclosing a membrane-bound food supply, water supply, and waste repository
- Includes all vertebrates except amphibians
- Significant because it gave vertebrates the ability to reproduce far from water

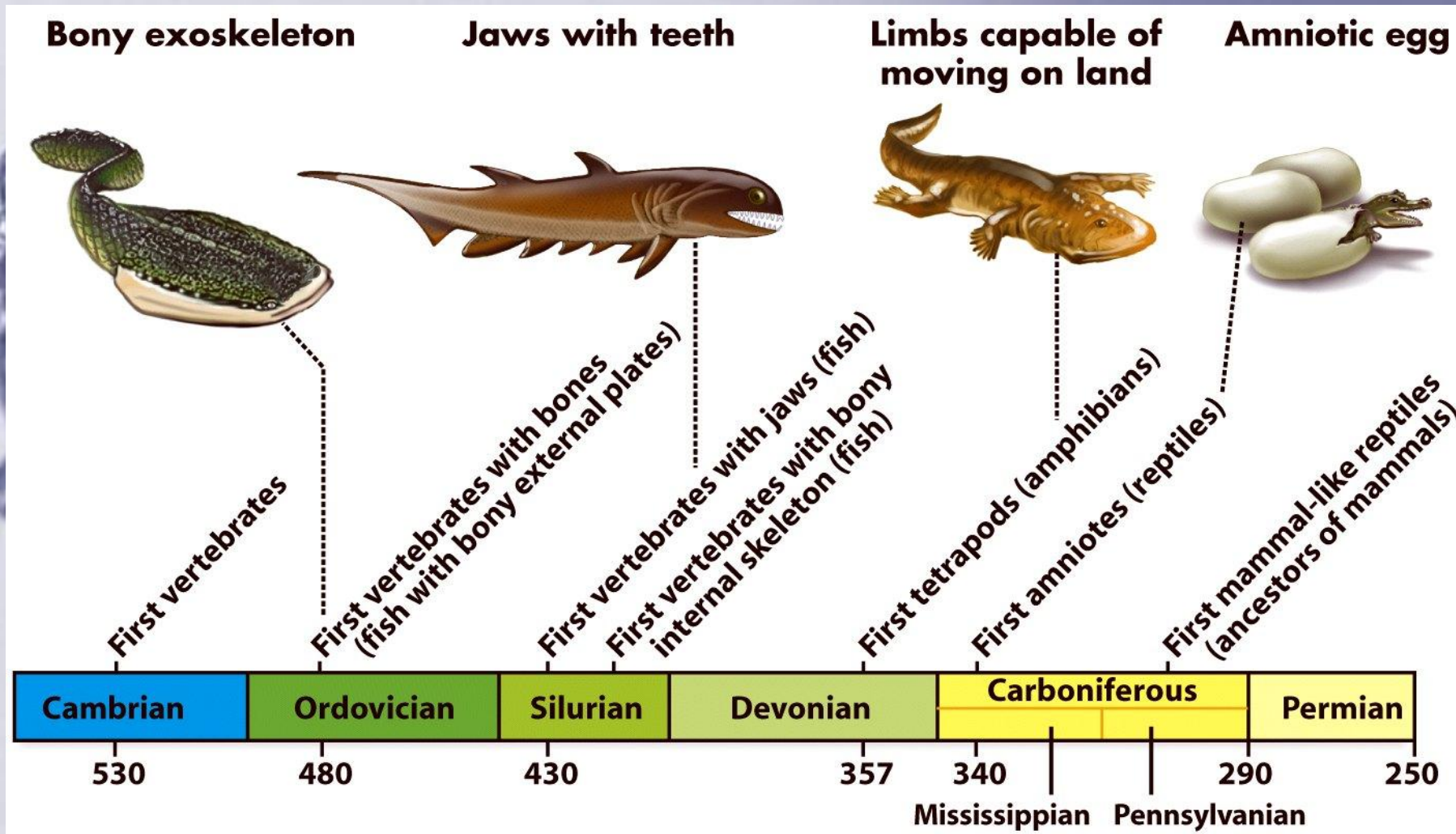


Figure 33-6 Biological Science, 2/e

Evaluating Molecular Phylogenies

- A phylogenetic tree of based on morphology and DNA agrees with the fossil record

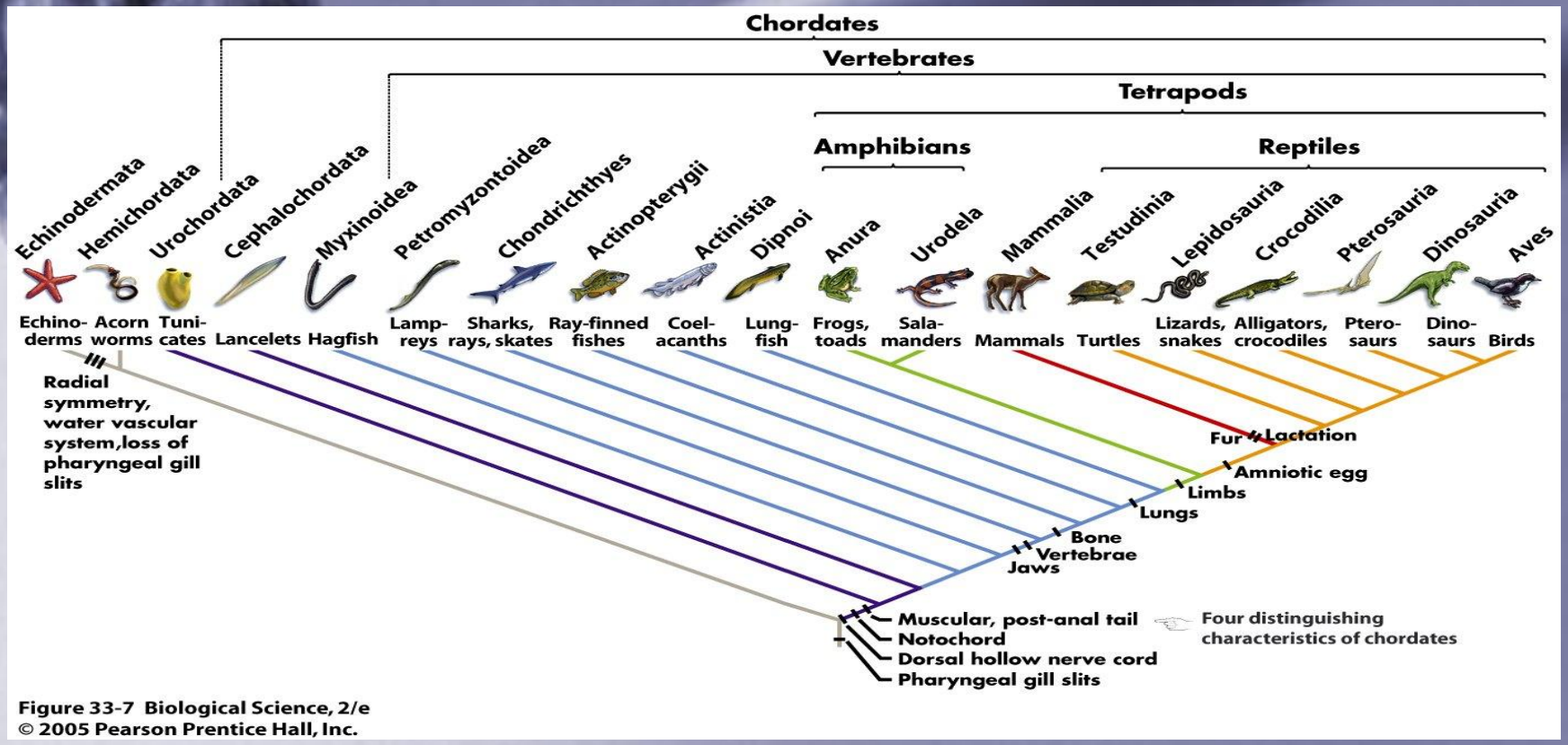


Figure 33-7 Biological Science, 2/e

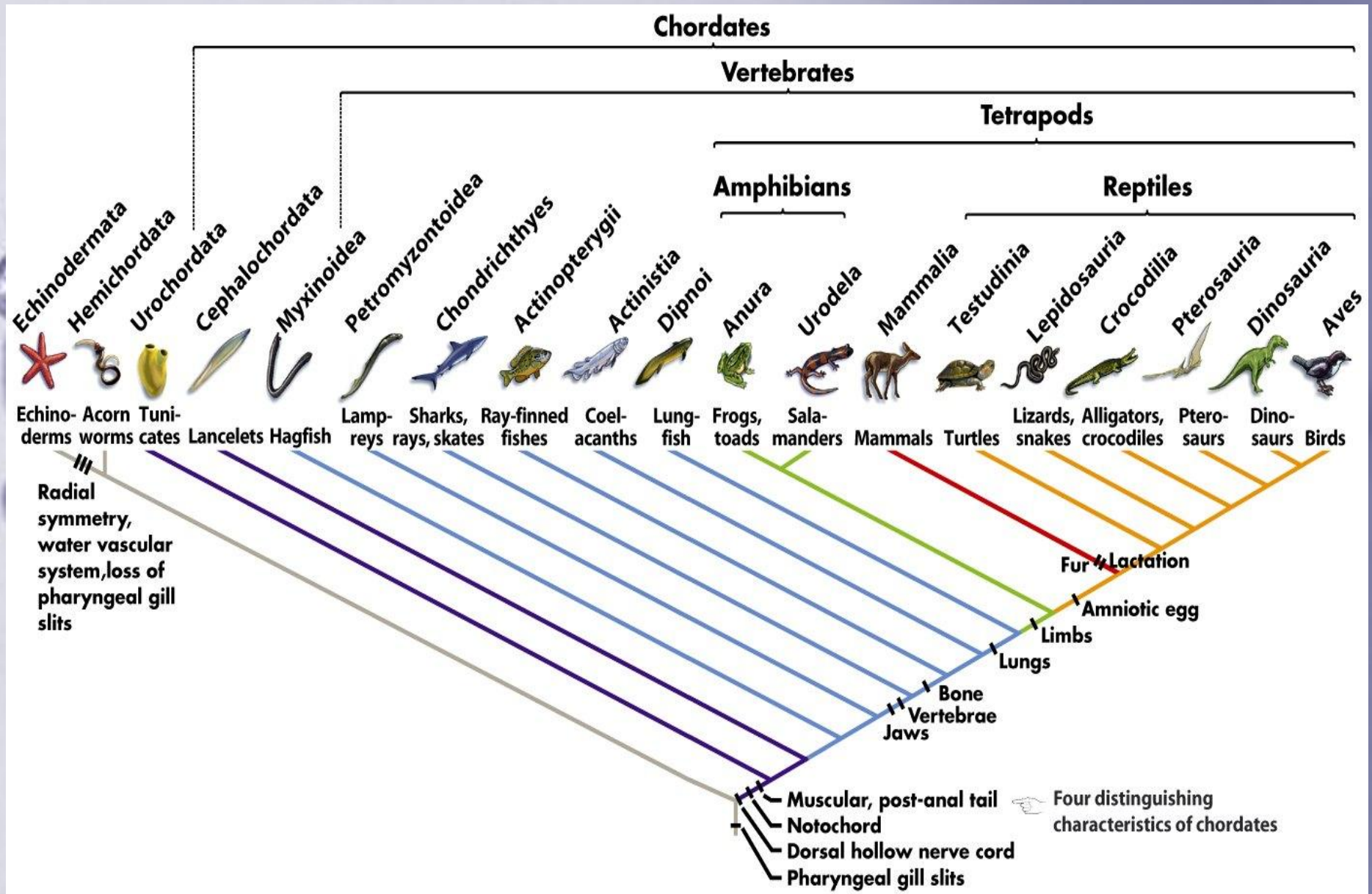


Figure 33-7 Biological Science, 2/e

What Themes Occur in the Diversification of Deuterostomes?

Deuterostome Diversity

- The most successful lineages are the echinoderms and the vertebrates
  - Due to the evolution of unique body plans
- Ray-finned fishes and tetrapods are the most species-rich lineages

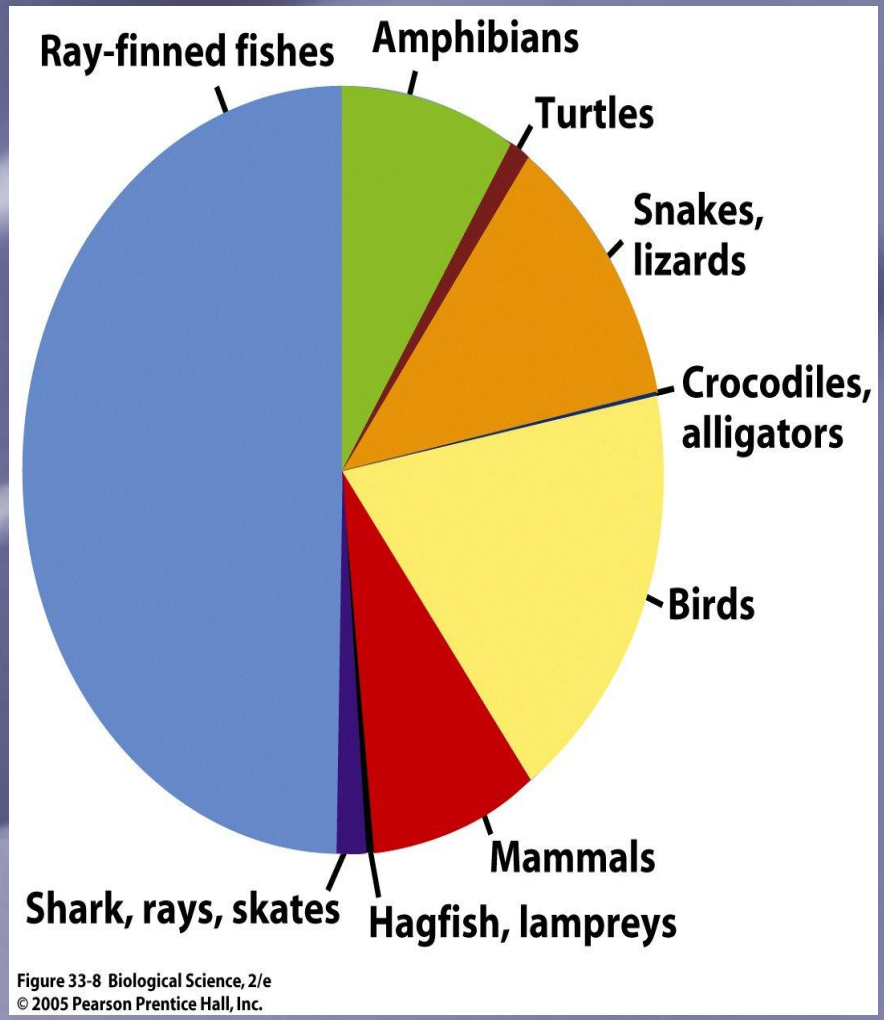


Figure 33-8 Biological Science, 2/e

Feeding

- Echinoderms and vertebrates have traits that make diverse ways of feeding possible
- Echinoderms suspension feed, deposit feed, harvest algae, or harvest other animals
- Podia play a key role in obtaining food

Podia trap particles during suspension feeding.

Figure 33-10b Biological Science, 2/e
© 2005 Pearson Prentice Hall, Inc.

Podia adhere to bivalve shells and pull them apart.

Figure 33-10a Biological Science, 2/e
© 2005 Pearson Prentice Hall, Inc.

The Vertebrate Jaw

- Vertebrates could not harvest food by biting until jaws evolved
- Hypothesis for the origin of the jaw is that mutation and natural selection increased the size and modified the orientation of the gill arches

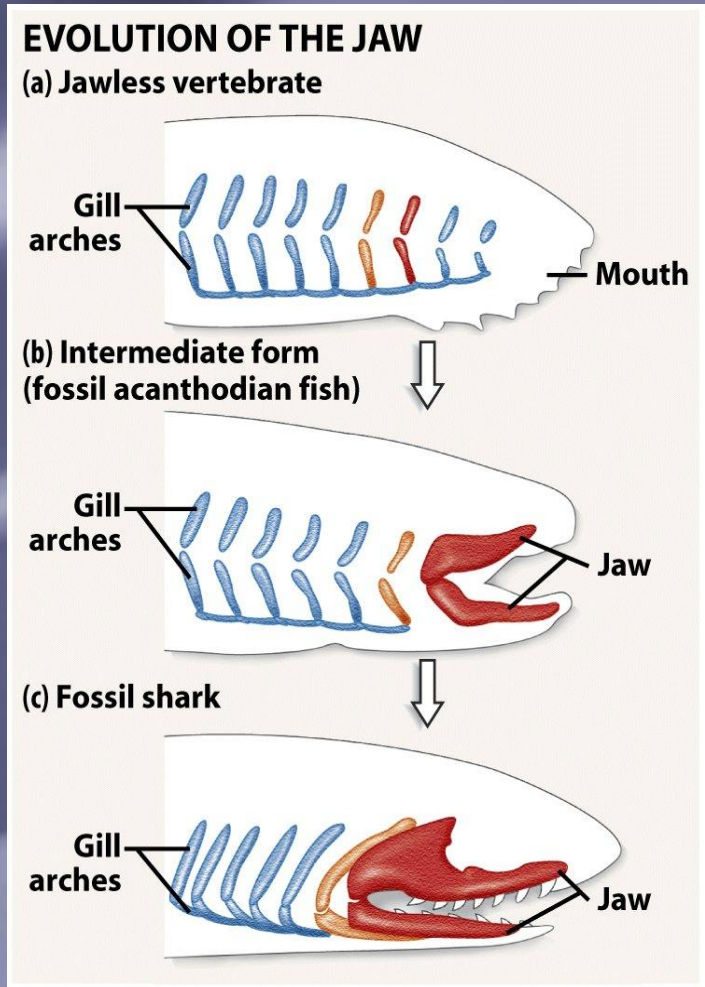


Figure 33-11 Biological Science, 2/e

Movement

- Fossils and molecular evidence provide confirmation of the fin-to-limb transition as the first tetrapods became more dependent on terrestrial habitats

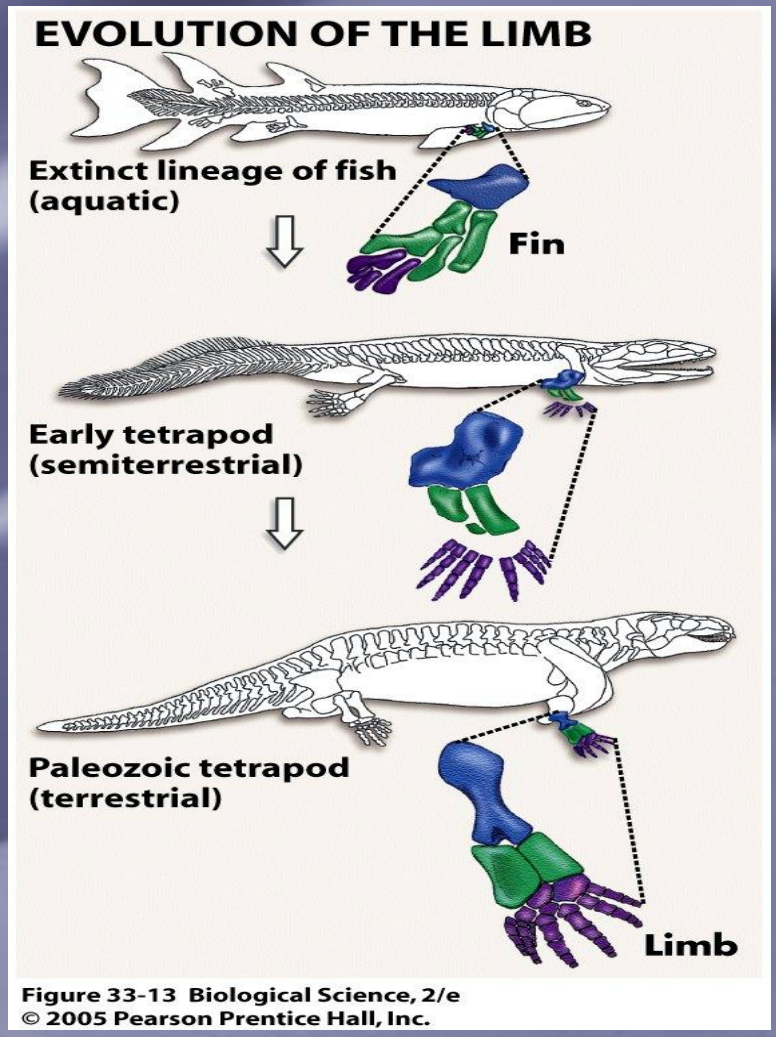


Figure 33-13 Biological Science, 2/e

Wings

- Wings and the ability to fly evolved independently in three lineages of tetrapods:
- Pterosaurs -extinct flying reptiles
- Birds
- Insects

Reproduction

- **Tetrapods** were the first vertebrates that could breed in terrestrial environments
- **Three major evolutionary innovations gave tetrapods this ability**:
  - (1) **the amniotic egg**
  - (2) the placenta
  - (3) elaboration of parental care

The Amniotic Egg

- Have shells that minimize water loss as the embryo, bathed in liquid, develops inside.

Amniotic Egg

- Watertight shell
- A membrane-bound supply of water in a protein-rich solution called **albumen**
- Embryo is enveloped in a protective inner membrane, or **amnion**
- **Yolk sac** contains nutrients for the growing embryo
- **Allantois** is a membranous pouch that holds waste materials

Amniotic Egg

- C**horion**-middle membrane
  - Separates the amnion, yolk sac, and allantois from the albumen
  - Provides a surface where gas exchange between the embryo and the surrounding air can take place

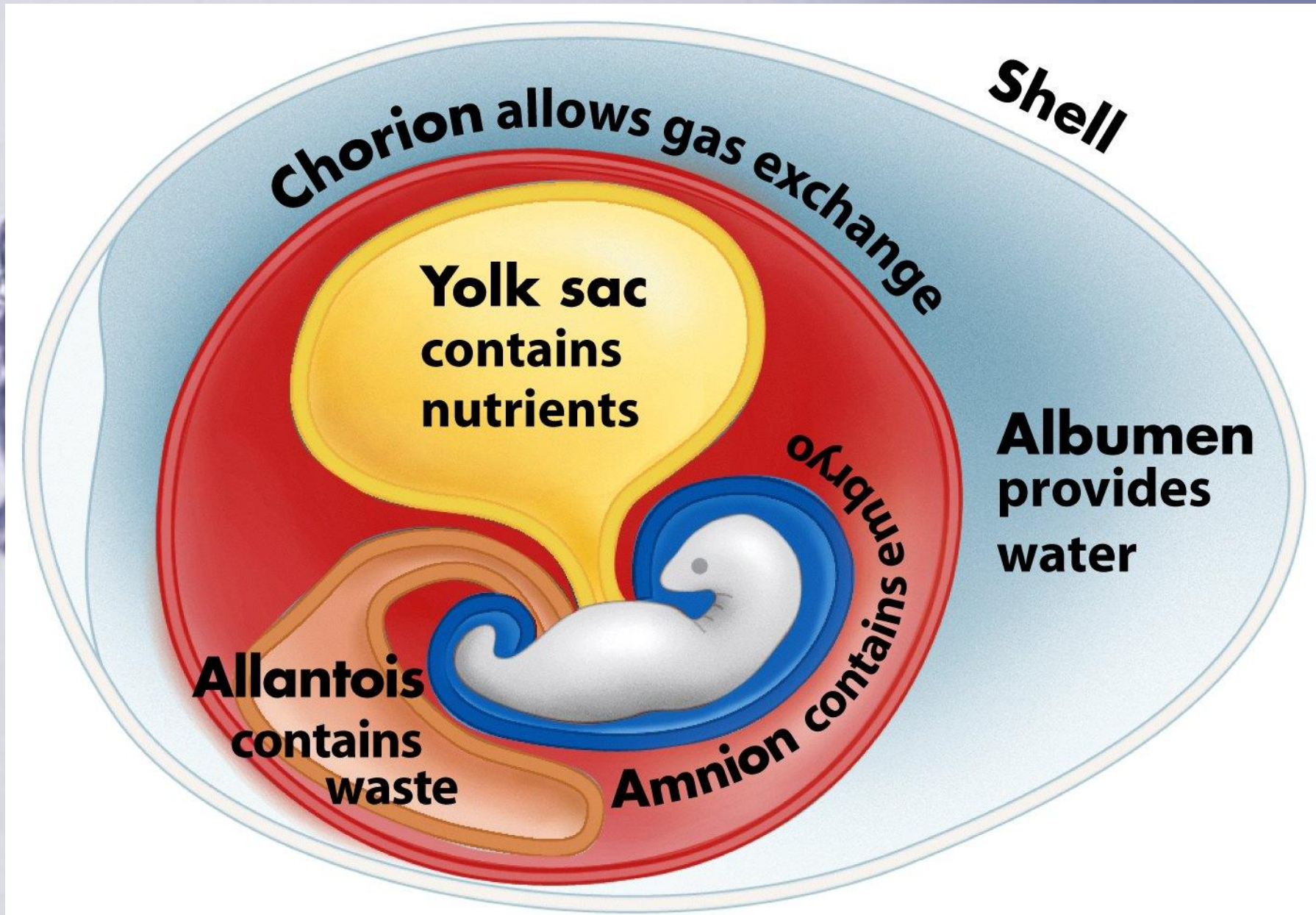


Figure 33-17 Biological Science, 2/e

The Placenta

- Egg-laying animals are oviparous; species that give birth are viviparous
- Viviparous animals have a placenta
  - Facilitates the flow of oxygen and nutrients from mother to offspring
- **After gestation**, the embryo emerges from the mother's body

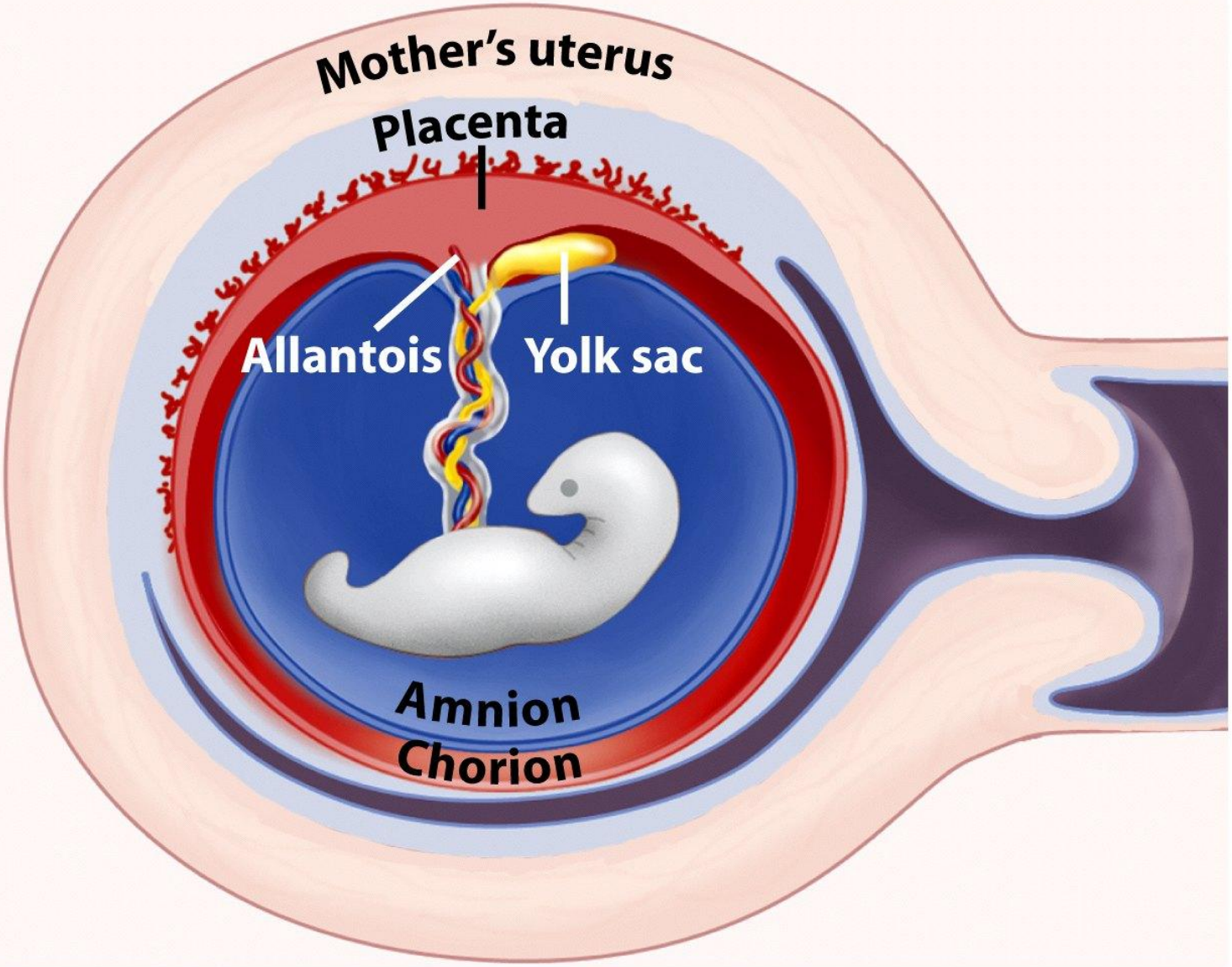


Figure 33-18 Biological Science, 2/e

Parental Care

- **Parental care** is any action by a parent that improves the ability of its offspring to survive
- Mammals and birds provide the most extensive parental care
- Mammals also lactate

Mammal mothers feed and protect newborn young.

Figure 33-19a Biological Science, 2/e

Many bird species have extensive parental care.

Figure 33-19b Biological Science, 2/e

Key Lineages of Deuterostomes

Echinodermata

- Named for the spines or spikes observed in many species
- Bilaterally symmetric as larvae but develop into radially symmetric adults
- Have a water vascular system
- Produce calcium carbonate plates under their skin to form an endoskeleton.

Lineages of Echinoderms

- There are five major lineages of echinoderms living today:
- (1) feather stars and sea lilies
- (2) brittle stars and basket stars
- (3) sea cucumbers
- (4) sea stars
- (5) sea urchins and sand dollars

Feather star

Figure 33-20a Biological Science, 2/e

Brittle star (crawling on a sponge)

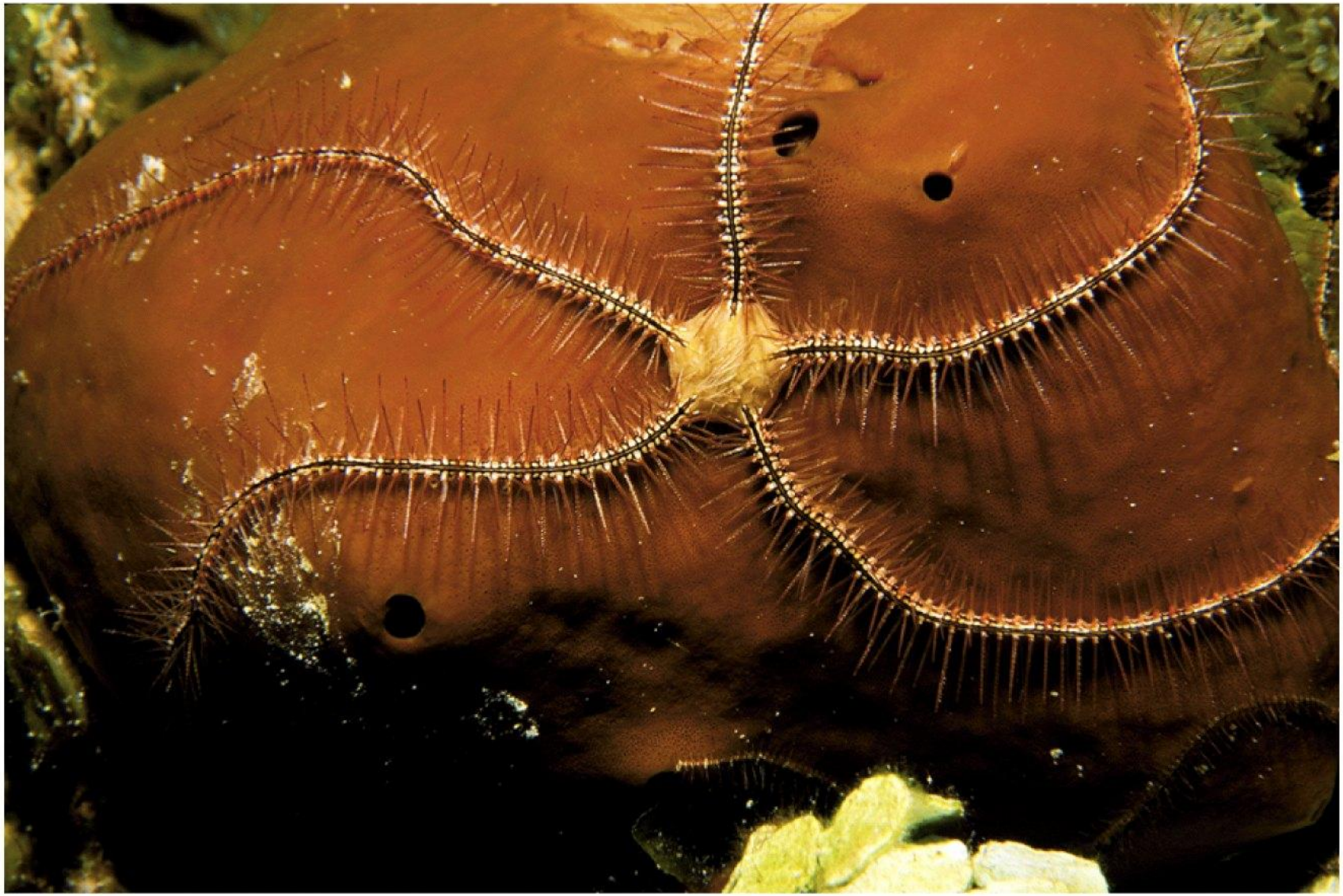


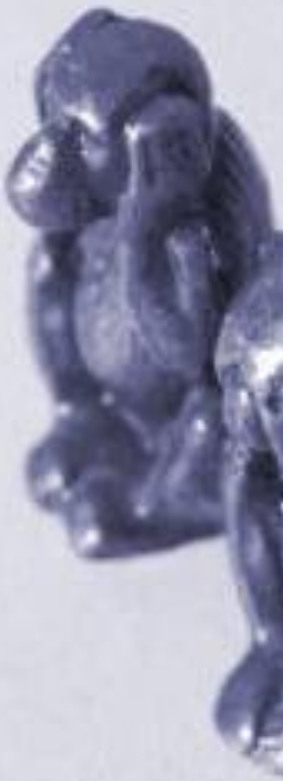
Figure 33-20b Biological Science, 2/e

Sea cucumber

Figure 33-20c Biological Science, 2/e

Echinodermata—Asteroidea (Sea Stars)

- Sea stars, class Asteroidea
  - 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



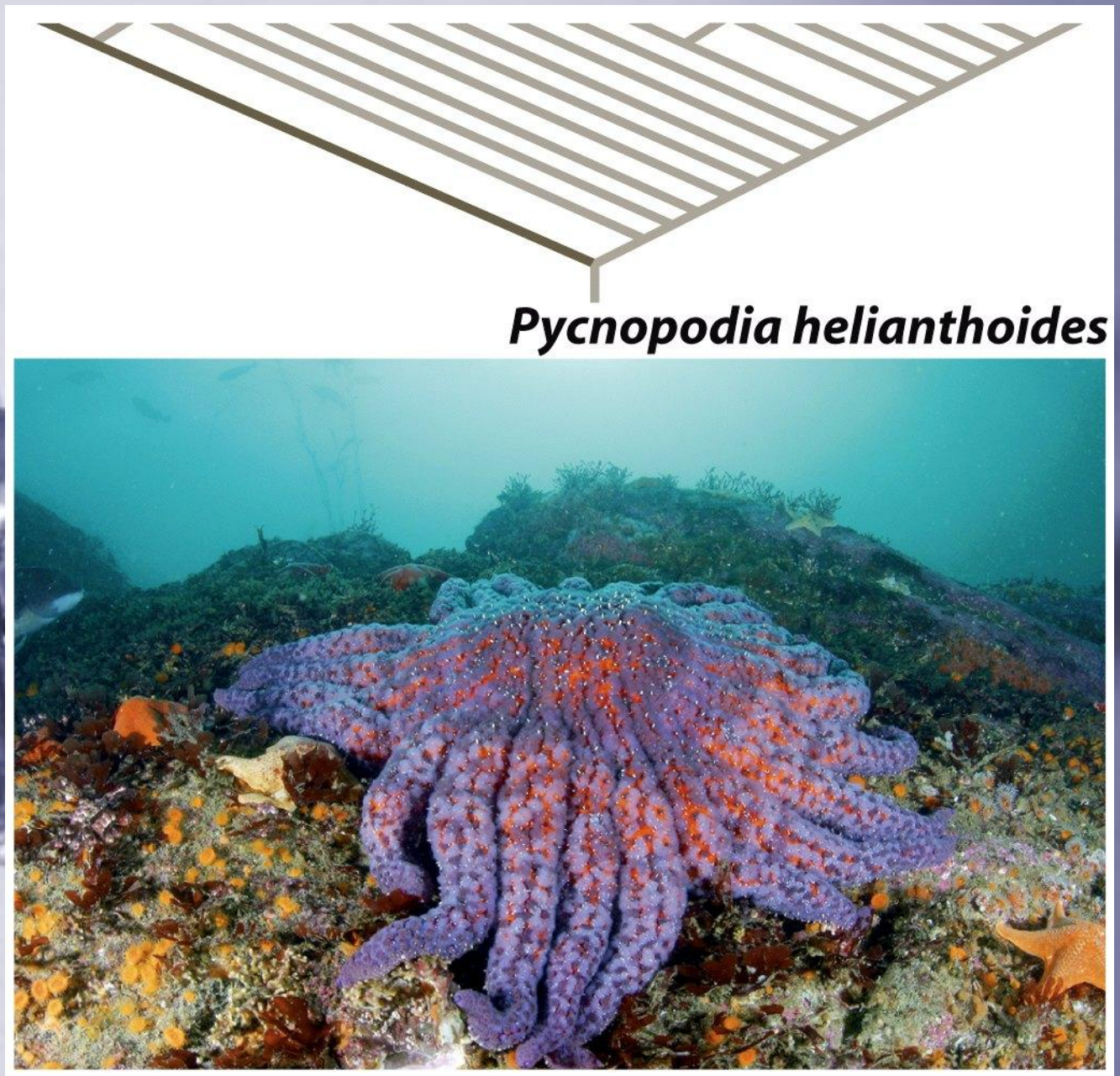


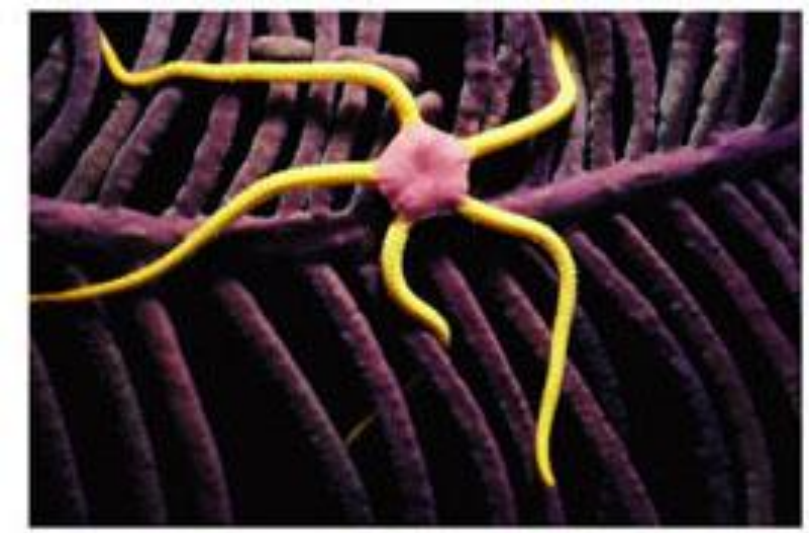
Figure 33-21 Biological Science, 2/e

Sea Lilies and Feather Stars

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

Brittle Stars

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



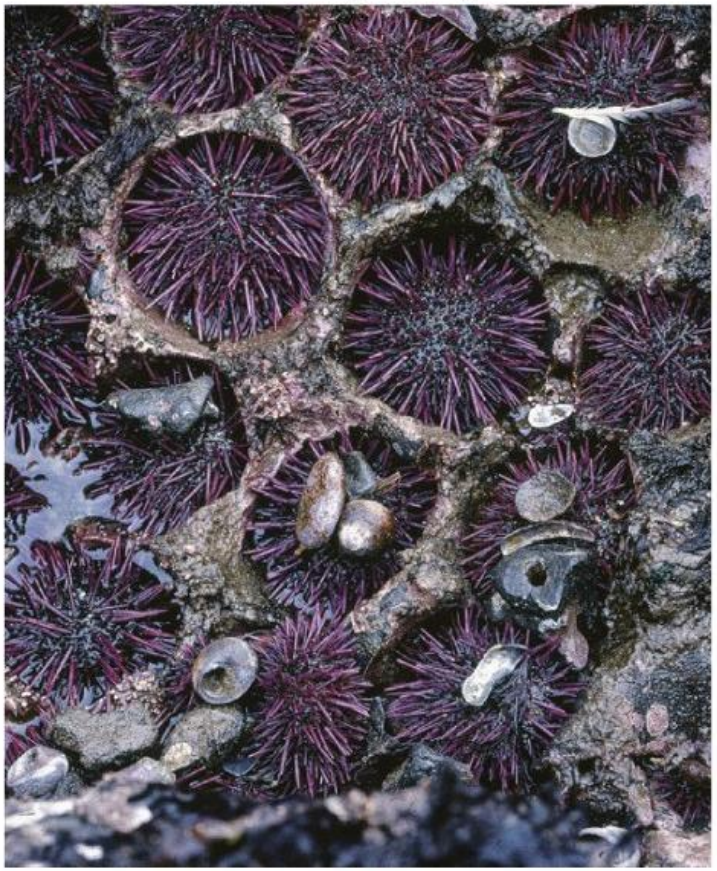
(b) A brittle star (class Ophiuroidea)

Echinodermata—Echinoidea (Sea Urchins and Sand Dollars)

- Sea urchins and sand dollars have no arms
  - But they do have five rows of tube feet that function in movement
- Have a unique, jawlike feeding structure

(a) Sea urchin

Strongylocentrotus purpuratus



(b) Sand dollar

Dendraster excentricus

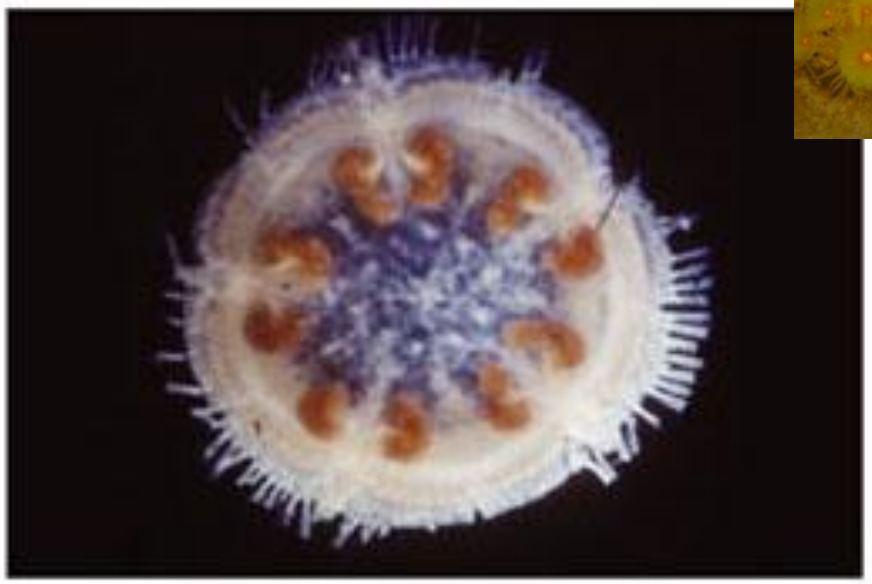
Figure 33-22 Biological Science, 2/e

Sea Cucumbers

- Lack spines, and their endoskeleton is much reduced
- Has five rows of tube feet

Sea Daisies

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



Key Lineages: Chordata

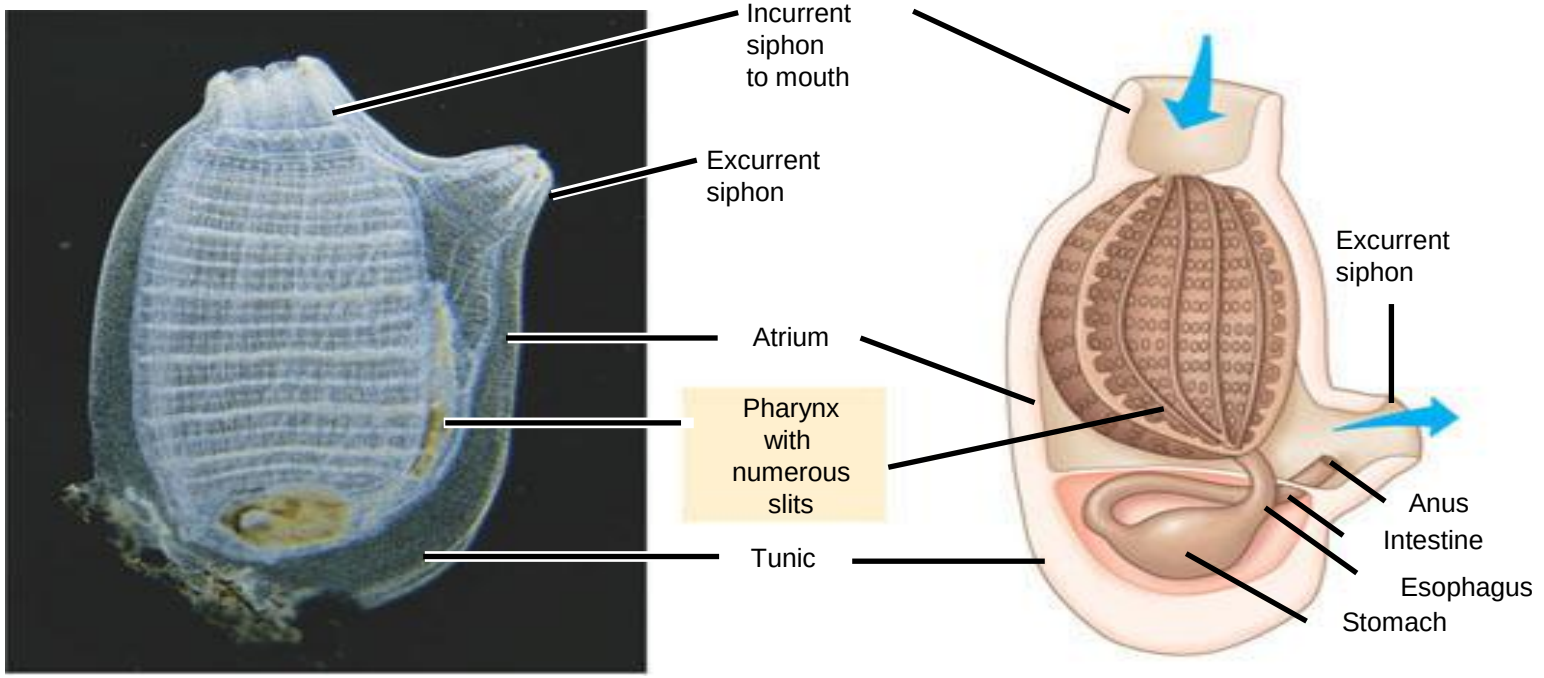
33.5 Key Lineages: Chordata

- Three subphyla of chordates:
  - Urochordates
  - Cephalochordates
  - Vertebrates
- At some stage in life have all the characteristics of a chordate

Tunicates

- Subphylum Urochordata
  - Belong to the deepest-branching lineage of chordates
  - Are marine suspension feeders commonly called sea squirts

- As an adult
  - A tunicate draws in water through an incurrent siphon, filtering food particles

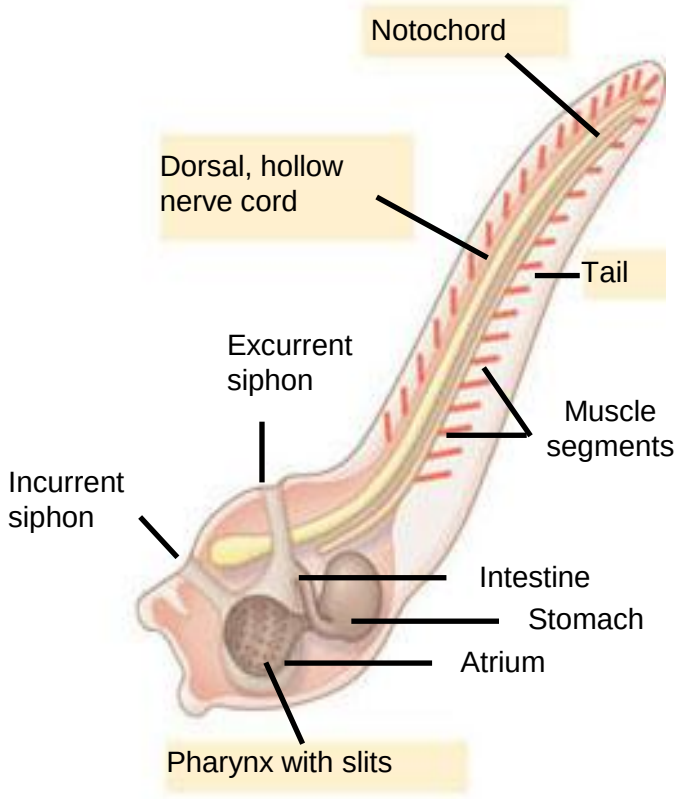


(a) An adult tunicate, or sea squirt, is a sessile animal (photo is approximately life-sized).

(b) In the adult, prominent pharyngeal slits function in suspension feeding, but other chordate characters are not obvious.

Tunicates

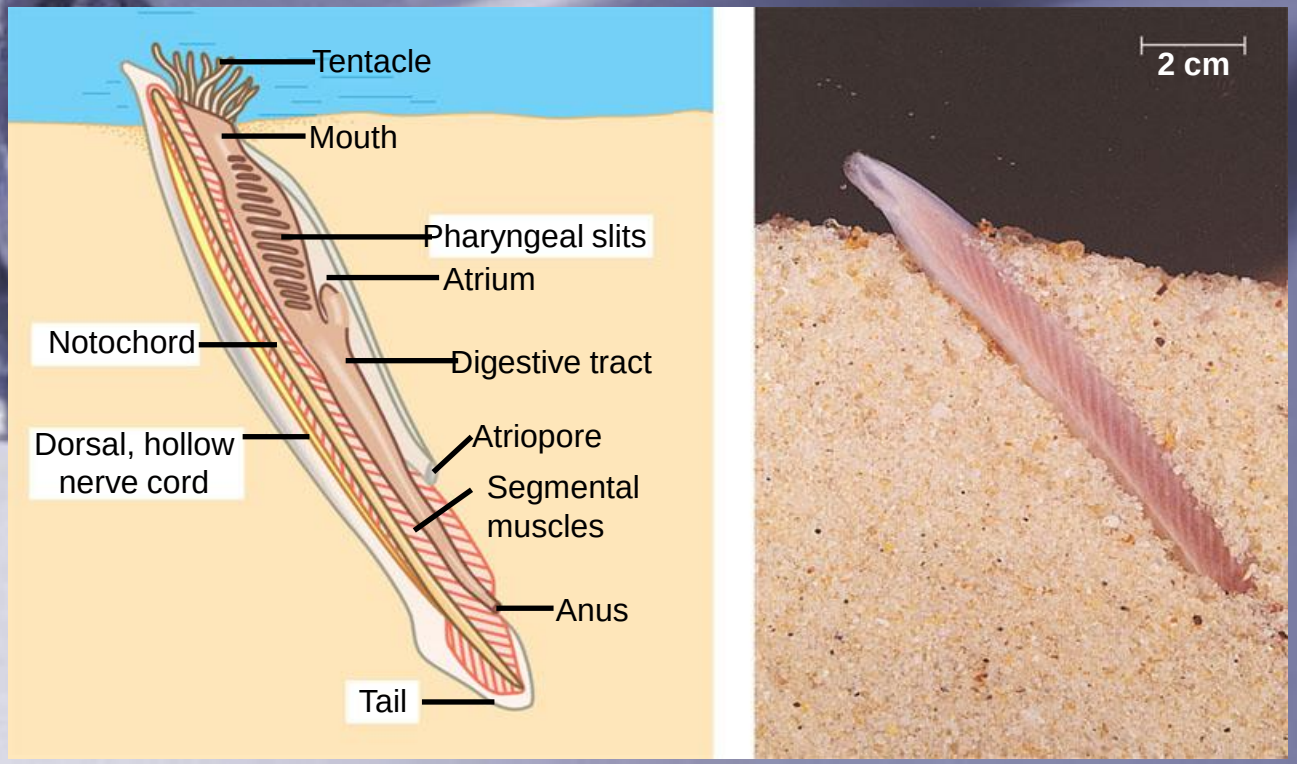
- Tunicates most resemble chordates during their larval stage
  - Which may be as brief as a few minutes
  - Uses its tail to swim to find a suitable substrate on which to settle



(c) A tunicate larva is a free-swimming but nonfeeding "tadpole" in which all four chief characters of chordates are evident.

Lancelets

- Lancelets, subphylum Cephalochordata
  - Are named for their bladelike shape



Lancelets

- Lancelets are marine suspension feeders
  - That retain the characteristics of the chordate body plan as adults
    - Post anal tail, pharyngeal slits, notochord, hollow nerve chord
  - Eat plankton caught in their pharynx when they swim up and down
  - Burrow backwards into the sand and eat passively as well

Vertebrates

- Named for a column of **vertebrae** along the dorsal side of most species
  - cartilaginous or bony
- Cranium, or **skull**, that encloses the large brain

Chordata—Myxinoidea (Hagfish) and Petromyzontoidea (Lampreys)

Myxinoidea and Petromyzontoidea

- Only vertebrates that lack jaws
- Hagfish lack a vertebral column
- Lampreys have small pieces of cartilage along the length of their dorsal hollow nerve cord

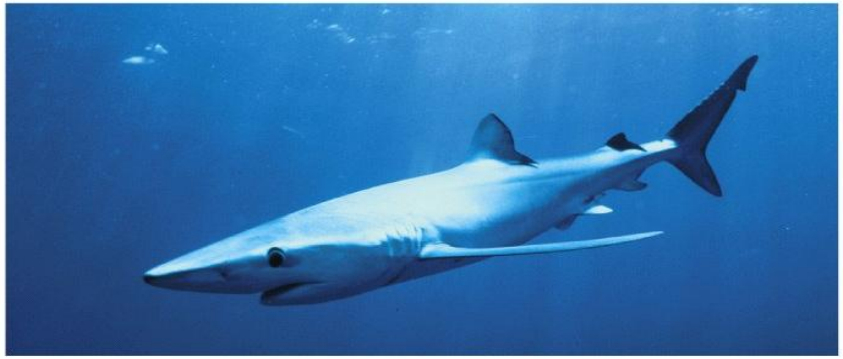
Figure 33-23 Biological Science, 2/e

Chondrichthyes (Sharks, Rays, Skates)

- Sharks, rays and their relatives
- Distinguished by their cartilaginous skeleton, the presence of jaws, and the existence of paired fins
- Biggest and most successful vertebrate predators in the oceans

(a) Sharks are torpedo shaped.

Prionace glauca



(b) Skates and rays are flat.

Taeniura melanospila

Figure 33-24 Biological Science, 2/e

Chordata—Actinopterygii (Ray-Finned Fishes)

- Fins supported by long bony rods arranged in a ray pattern
- Most ancient living vertebrates that have a skeleton made of bone
  - Control their buoyancy with an air sac known as a swim bladder
- Originated in fresh water and adapted to salt water

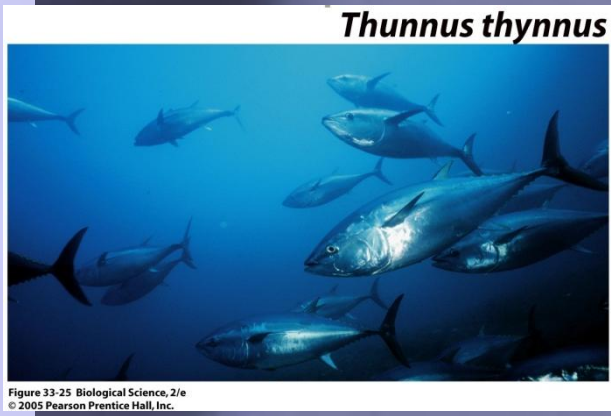
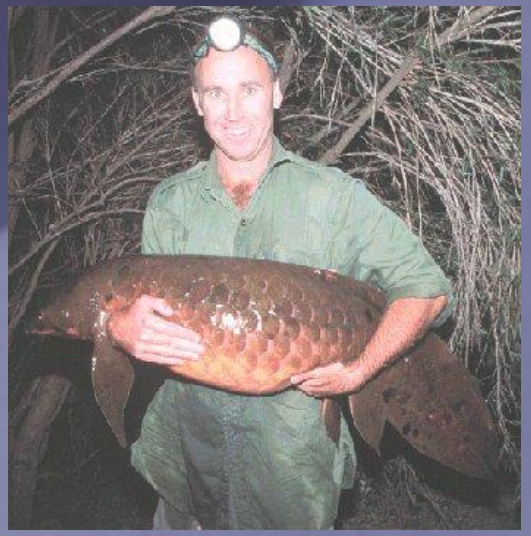


Figure 33-25 Biological Science, 2/e

Chordata—Actinistia (Coelacanths) and Dipnoi (Lungfish)

- Coelacanths and lungfish
- Independent lineages but are often grouped together as **lobe-finned fishes**
- Fins that are supported by an array of bones and muscles, similar to those observed in tetrapod limbs

Figure 33-26 Biological Science, 2/e



Chordata—Amphibia (Frogs, Salamanders, Caecilians)

- Feed on land, but most must lay their eggs in water
- Amphibians are the most ancient tetrapods
- About 4,800 species of organisms

Chordata: Mammalia (Mammals)

- Mammals are endotherms that have **hair** or **fur** to insulate the body
- Have **mammary glands** for lactation
- 3 lineages of mammals: monotremes, marsupials, and eutherians

The Major Orders of Mammals

ORDERS AND EXAMPLES	MAIN CHARACTERISTICS
Monotremata Platypuses, echidnas  Echidna	Lay eggs; no nipples; young suck milk from fur of mother
Proboscidea Elephants  African elephant	Long, muscular trunk; thick, loose skin; upper incisors elongated as tusks
Sirenia Manatees, dugongs  Manatee	Aquatic; finlike forelimbs and no hind limbs; herbivorous
Xenarthra Sloths, anteaters, armadillos  Tamandua	Reduced teeth or no teeth; herbivorous (sloths) or carnivorous (anteaters, armadillos)
Lagomorpha Rabbits, hares, picas  Jackrabbit	Chisel-like incisors; hind legs longer than forelegs and adapted for running and jumping
Carnivora Dogs, wolves, bears, cats, weasels, otters, seals, walruses  Coyote	Sharp, pointed canine teeth and molars for shearing; carnivorous
Cetartiodactyla **Artiodactyls** Sheep, pigs cattle, deer, giraffes  Bighorn sheep	Hooves with an even number of toes on each foot; herbivorous
Cetaceans Whales, dolphins, porpoises  Pacific white-sided porpoise	Aquatic; streamlined body; paddle-like forelimbs and no hind limbs; thick layer of insulating blubber; carnivorous

ORDERS AND EXAMPLES	MAIN CHARACTERISTICS
Marsupialia Kangaroos, opossums, koalas  Koala	Embryo completes development in pouch on mother
Tubulidentata Aardvark  Aardvark	Teeth consisting of many thin tubes cemented together; eats ants and termites
Hyracoidea Hyraxes  Rock hyrax	Short legs; stumpy tail; herbivorous; complex, multichambered stomach
Rodentia Squirrels, beavers, rats, porcupines, mice  Red squirrel	Chisel-like, continuously growing incisors worn down by gnawing; herbivorous
Primates Lemurs, monkeys, apes, humans  Golden lion tamarin	Opposable thumbs; forward-facing eyes; well-developed cerebral cortex; omnivorous
Perissodactyla Horses, zebras, tapirs, rhinoceroses  Indian rhinoceros	Hooves with an odd number of toes on each foot; herbivorous
Chiroptera Bats  Frog-eating bat	Adapted for flight; broad skinfold that extends from elongated fingers to body and legs; carnivorous or herbivorous
Eulipotyphla “Core insecti-vores”: some moles, some shrews  Star-nosed mole	Diet consists mainly of insects and other small invertebrates

Monotremata (Platypuses, Echidnas)

- Most ancient group of mammals living
- Lay eggs and have lower metabolic rates than other mammals

Mammalia—Marsupiala (Marsupials)

- **Marsupial** females have a placenta
- Young are born poorly developed after a short embryonic period
- Develop while attached to their mother's nipple, where they suck milk

(a) A young brushtail possum. The young of marsupials are born very early in their development. They finish their growth while nursing from a nipple (in their mother's pouch in most species).

Marsupials

- Existed world-wide during the mesozoic, but now are only found in Australia and a few in North and South America (3)
- In Australia, convergent evolution
  - Has resulted in a diversity of marsupials that resemble eutherians in other parts of the world

Mammalia—Eutheria (Placental Mammals)

- Most species-rich and morphologically diverse group of mammals
- Young are developed at birth than those of marsupials

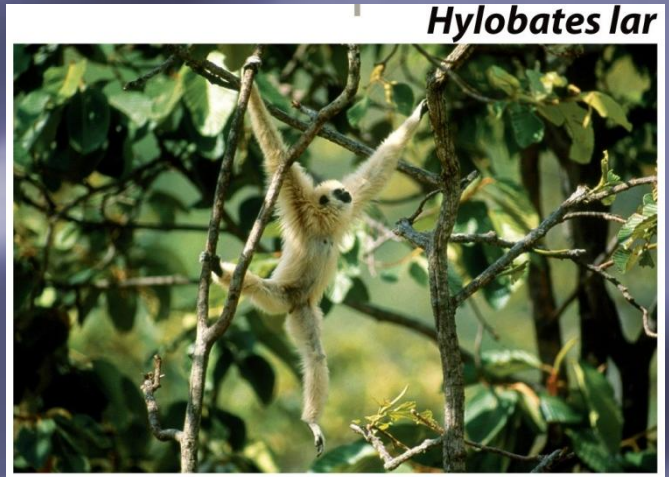


Figure 33-30 Biological Science, 2/e

Reptilia (Turtles, Snakes, Lizards, Crocodiles, and Birds)

- One of the two major living lineages of amniotes—the other lineage consisting of today's mammals
- There are four major lineages of reptiles: (1) turtles, (2) snakes and lizards, (3) crocodiles and alligators, and (4) birds
- Ectothermic

Testudinia (Turtles, Tortoises)

- Distinguished by a shell composed of bony plates that fuse to the vertebrae and ribs
- Lack teeth, but their jawbone and lower skull form a bony beak

Figure 33-31 Biological Science, 2/e

Lepidosauria (Lizards, Snakes)

- Most lizards have well-developed jointed legs, but snakes are limbless

Figure 33-32 Biological Science, 2/e

Crocodilia (Crocodiles, Alligators)

- Only 21 species of **crocodiles** and **alligators** are known
- The placement of their eyes and nostrils allows them to sit underwater for extended periods

Figure 33-33 Biological Science, 2/e

Aves (Birds)

- Birds descended from dinosaurs that had **feathers**
- Almost all bird species can fly
- Only **endotherms** (animals that regulate their body temperature internally)

Primates

- The mammalian order Primates include
  - Lemurs, tarsiers, monkeys, and apes
- Humans are members of the ape group
- Derived characteristics include:
  - Hands and feet adapted for grasping
  - A large brain and short jaws
  - Forward-looking eyes close together on the face, providing depth perception
  - Well-developed parental care and complex social behavior
  - A fully opposable thumb

Living Primates

- There are three main groups of living primates
  - The lemurs of Madagascar and the lorises and pottos of tropical Africa and southern Asia
  - Probably resemble the early arboreal primates

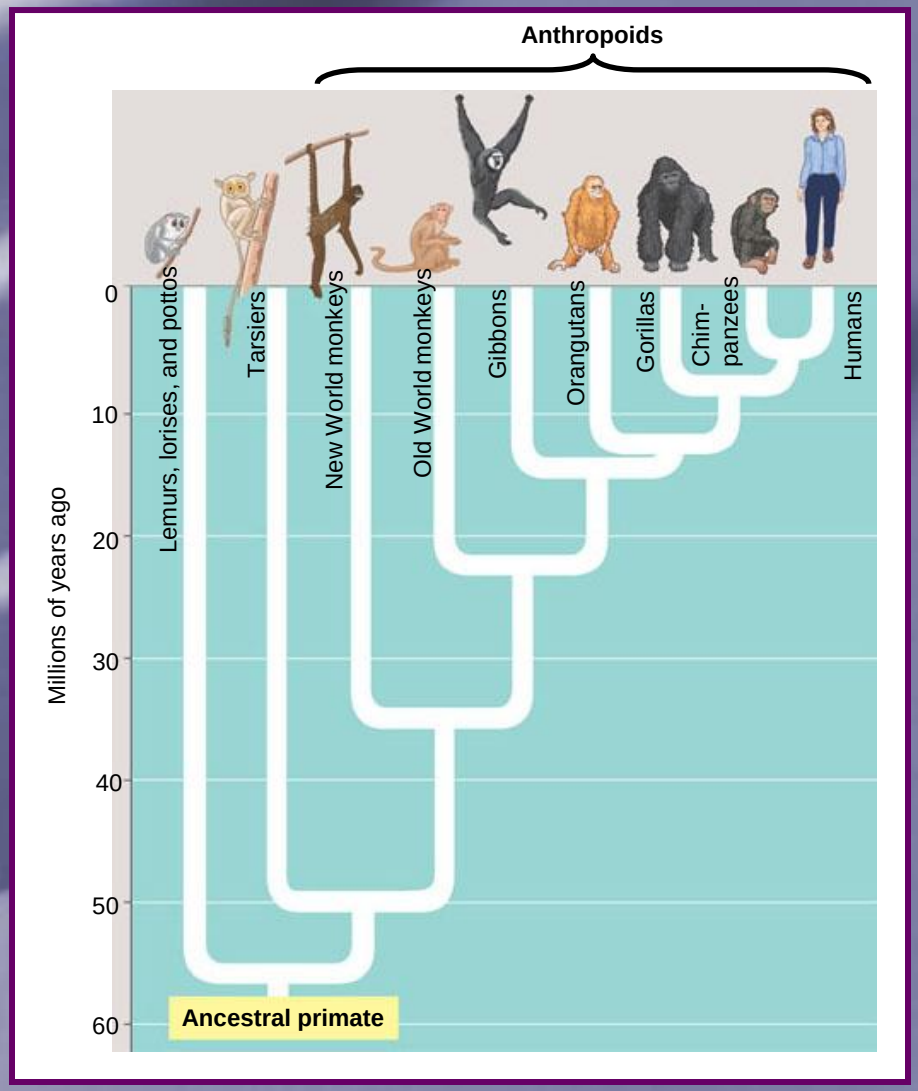
Living Primates

- The tarsiers of Southeast Asia
- The anthropoids, which include monkeys and hominids

  worldwide

The Origin of Primates

- The oldest known anthropoid fossils, about 45 million years old
  - Indicate that tarsiers are more closely related to anthropoids



The Origin of Primates

- The fossil record indicates that monkeys
  - First appeared in the New World (South America) during the Oligocene
- The first monkeys
  - Evolved in the Old World (Africa and Asia)
- New World and Old World monkeys
  - Underwent separate adaptive radiations during their many millions of years of separation

New World and Old World Monkeys

(a) New World monkeys, such as spider monkeys (shown here), squirrel monkeys, and capuchins, have a prehensile tail and nostrils that open to the sides.

(b) Old World monkeys lack a prehensile tail, and their nostrils open downward. This group includes macaques (shown here), mandrills, baboons, and rhesus monkeys.

Hominoids

- The other group of anthropoids, the hominoids
  - Consists of primates informally called apes

(a) Gibbons, such as this Muller's gibbon, are found only in southeastern Asia. Their very long arms and fingers are adaptations for brachiation.

(b) Orangutans are shy, solitary apes that live in the rain forests of Sumatra and Borneo. They spend most of their time in trees; note the foot adapted for grasping and the opposable thumb.

(c) Gorillas are the largest apes: some males are almost 2 m tall and weigh about 200 kg. Found only in Africa, these herbivores usually live in groups of up to about 20 individuals.

(d) Chimpanzees live in tropical Africa. They feed and sleep in trees but also spend a great deal of time on the ground. Chimpanzees are intelligent, communicative, and social.

(e) Bonobos are closely related to chimpanzees but are smaller. They survive today only in the African nation of Congo.

Hominoids

- Diverged from monkeys about 20-25 mya
- Non-human hominoids are found exclusively in the tropical parts of the world
- Generally larger than monkeys, have long arms, short legs, and no tail
- Very intelligent and social
- Behavior is more flexible than in mokeys

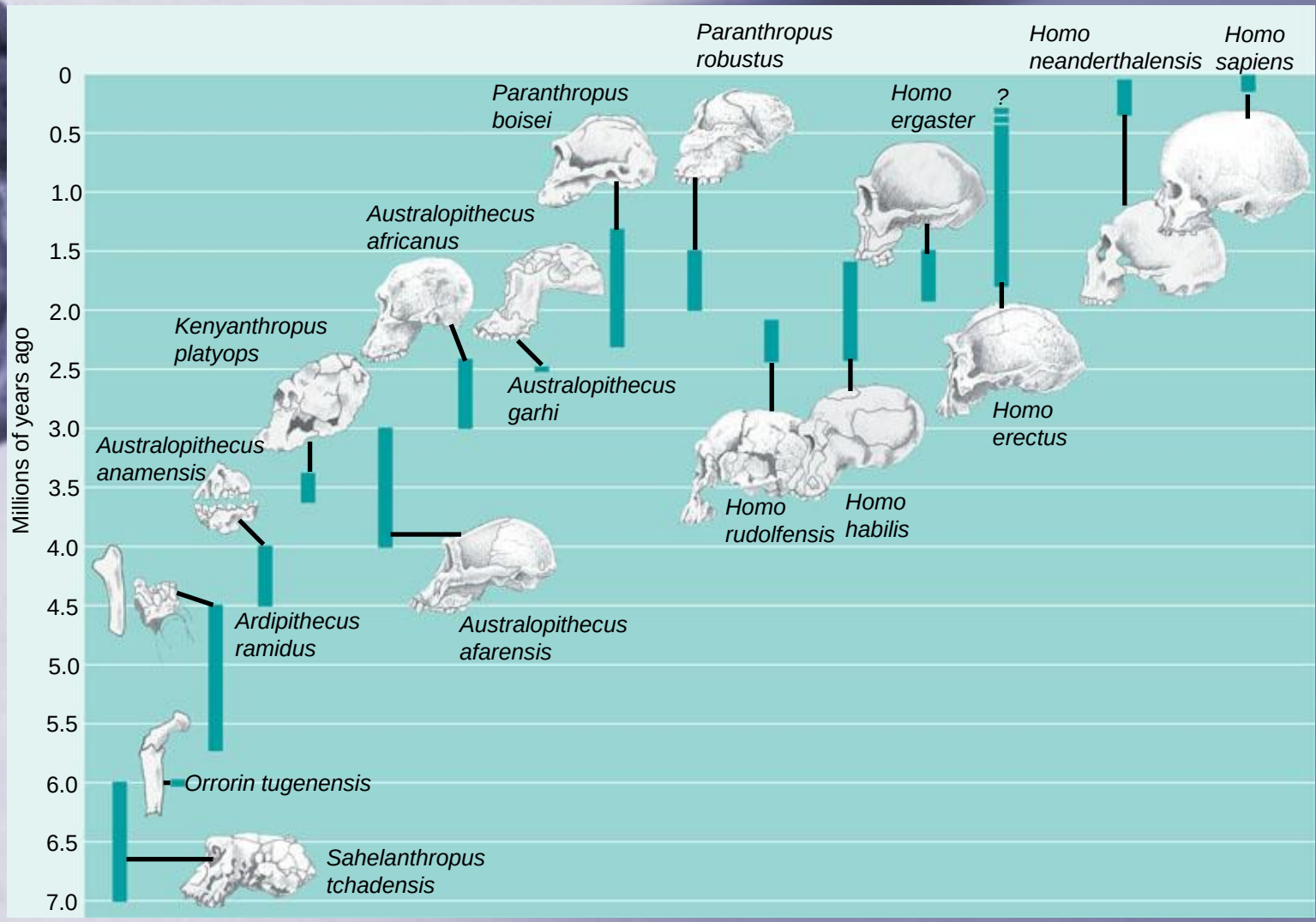
Humans

- *Homo sapiens* is about 160,000 years old
  - Which is very young considering that life has existed on Earth for at least 3.5 billion years
- Derived characters of humans include:
  - Upright posture and bipedal locomotion
  - Larger brains
  - Language capabilities
  - Symbolic thought
  - The manufacture and use of complex tools
  - Shortened jaw

The Earliest Hominoids

- Paleoanthropologists have discovered fossils of approximately 20 species of extinct hominoids
  - That are more closely related to humans than to chimpanzees
  - These species are known as hominids
- Hominids originated in Africa
  - Approximately 6–7 million years ago
- Early hominids
  - Had a small brain, but probably walked upright, exhibiting mosaic evolution

The Earliest Hominoids



The Earliest Hominoids

- Two common misconceptions of early hominids include
  - Thinking of them as chimpanzees
  - Imagining human evolution as a ladder leading directly to *Homo sapiens*
- Australopiths are a paraphyletic assemblage of hominids
  - That lived between 4 and 2 million years ago
- Some species walked fully erect
  - And had human-like hands and teeth

Australopithecus afarensis

(a) Lucy, a 3.24-million-year-old skeleton, represents the hominid species *Australopithecus afarensis.*

(b) The Laetoli footprints, more than 3.5 million years old, confirm that upright posture evolved quite early in hominid history.

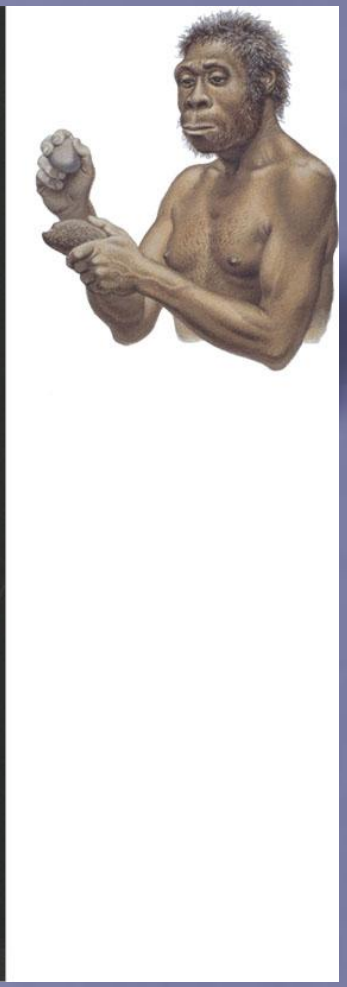
(c) An artist's reconstruction of what *A. afarensis* may have looked like.

Early Homo

- The earliest fossils that paleoanthropologists place in our genus *Homo*
  - Are those of the species *Homo habilis*, ranging in age from about 2.4 to 1.6 million years
- Stone tools have been found with *H. habilis*
  - Giving this species its name, which means “handy man”

Early Homo

- *Homo ergaster*
  - Was the first fully bipedal, large-brained hominid
  - Existed between 1.9 and 1.6 million years
  - Larger brain than *Homo habilis*
  - Short fingers and smaller teeth



Early Homo

- *Homo ergaster* shows a marked difference in the size of the different sexes
  - Associated with intense male competition for females
- Neanderthals- Lived in Europe and the Near East from 200,000 to 30,000 years ago
  - Were large, thick-browed hominids
  - Became extinct a few thousand years after the arrival of *Homo sapiens* in Europe

Early Homo

- *Homo sapiens*
  - Appeared in Africa at least 160,000 years ago
- The oldest fossils of *Homo sapiens* outside Africa
  - Date back about 50,000 years ago