Animal Evolution –The Invertebrates

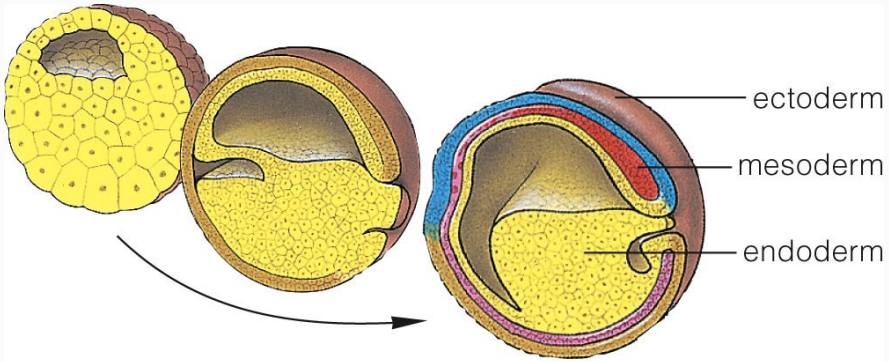
Animal Traits and Body Plans

- **Animals**
  - Multicelled heterotrophs that move about during part or all of the life cycle
  - Body cells do not have a wall and are typically diploid
  - The overwhelming majority are invertebrates

Animal Body Plans: Organization

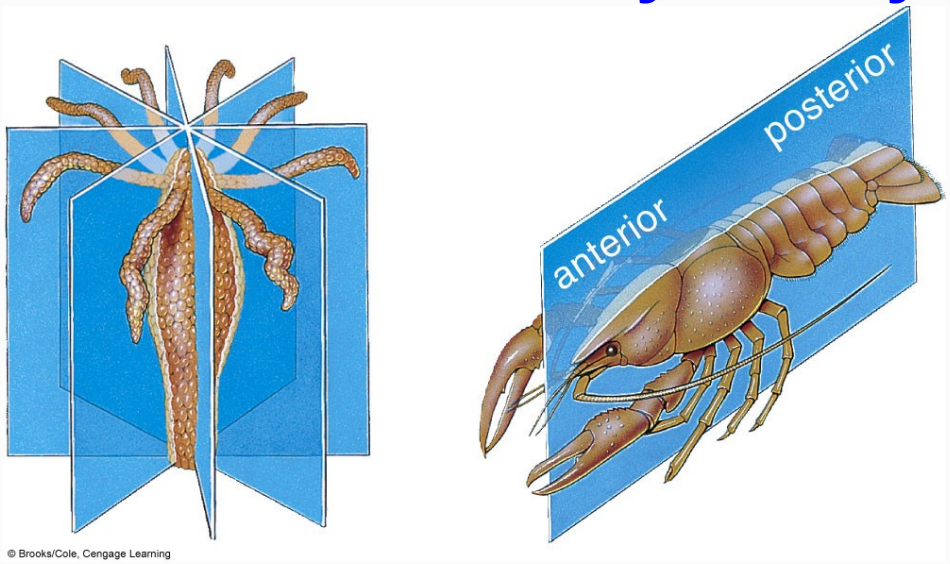
- **Tissues**
  - Cells of a particular type and function, organized in a specific pattern

- Tissue formation begins in an embryo
  - Ectoderm and endoderm
  - Mesoderm
  - Simpler animals don't possess tissues or have fewer layers



Animal Body Plans: Body Symmetry

- Body Symmetry
  - Simplest animals are asymmetrical (sponges)
  - Jellyfish and hydras have **radial symmetry**
  - Most animals have **bilateral symmetry**

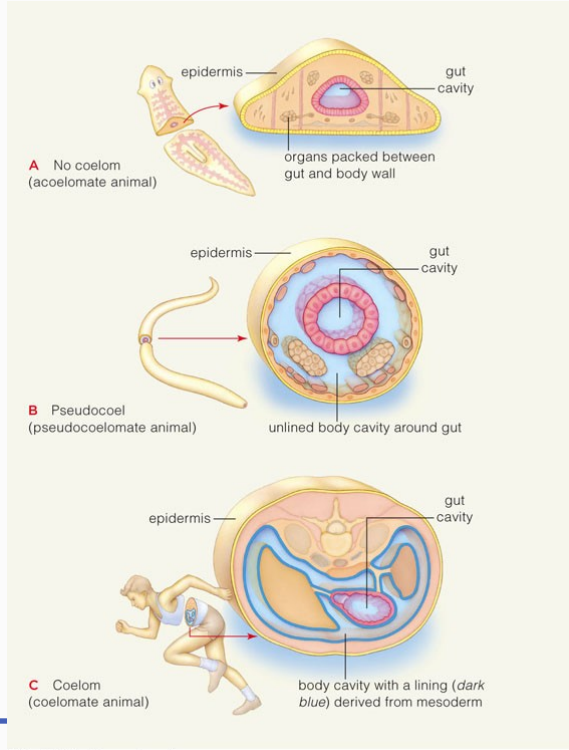


Animal Body Plans: Gut and Body Cavity

- **Gut**
  - Digestive sac (incomplete digestive system) or tube (complete) that opens at the body surface

- Typically, a body cavity surrounds the gut
  - **Coelom**: Cavity lined by tissue
  - **Pseudocoel**: Cavity is partially lined

- **Acoelomates** have no body cavity



Two Lineages of Bilateral Animals

- **Protostomes**
  - First opening in the embryo becomes the mouth
  - Second opening becomes the anus

- **Deuterostomes**
  - First opening in the embryo becomes the anus
  - Second opening becomes the mouth

Variation in Animal Body Plans

Don’t worry as much about circulation!!! Just FYI!

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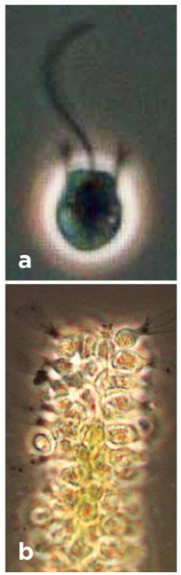
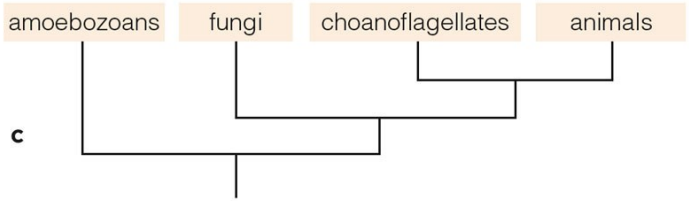
Becoming Multicellular

- Animals probably evolved from a colonial, choanoflagellate-like protist

- **Choanoflagellates** ("collared flagellate")
  - Modern protists most closely related to animals



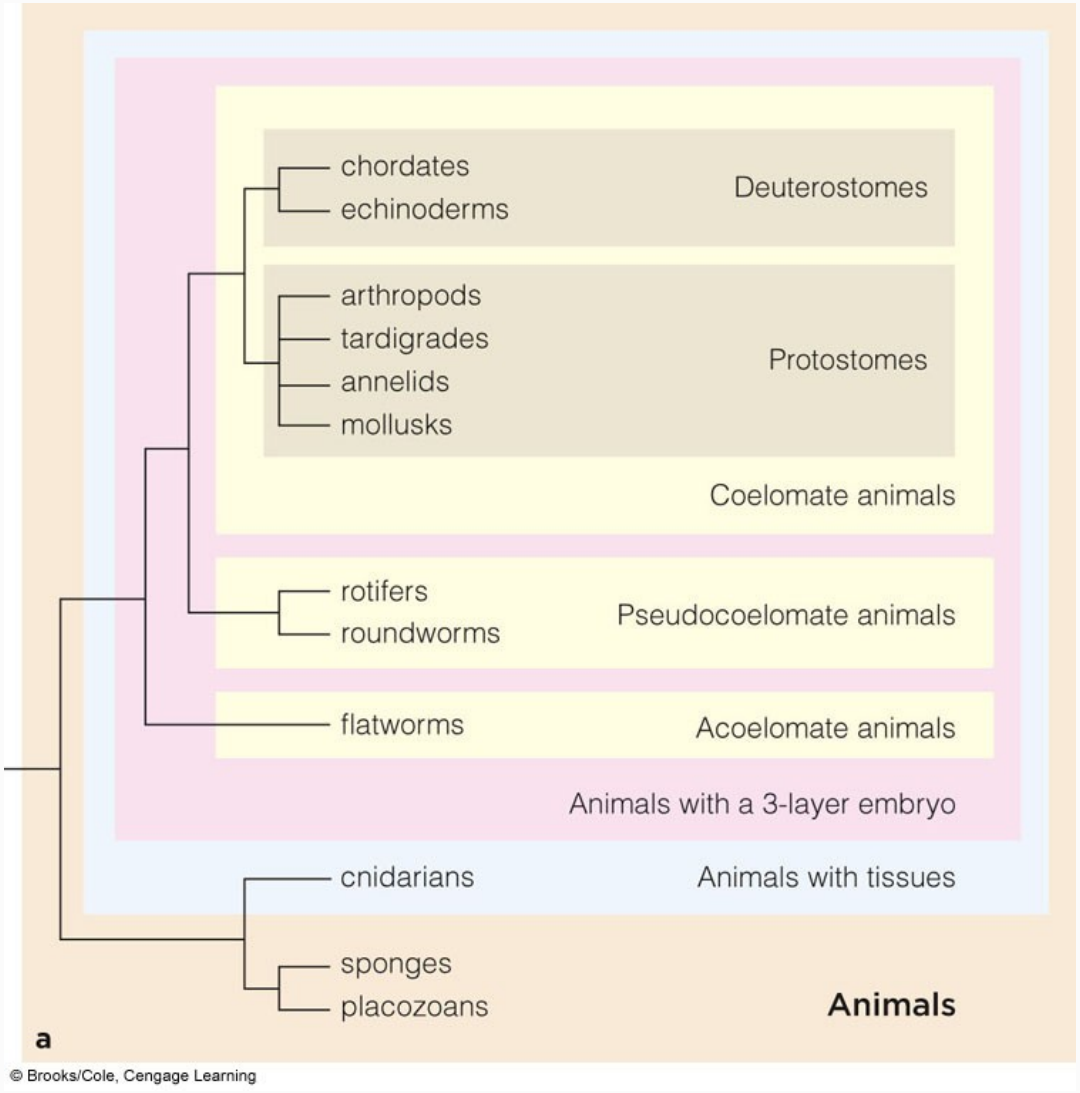


Relationships and Classification

- Animals have traditionally been classified based on morphology and developmental pattern
  - Mainly features of body cavities

- A newer system puts all animals with a three-layer embryo into protostomes or deuterostomes

Relationships and Classification



Variation in Animal Body Plans

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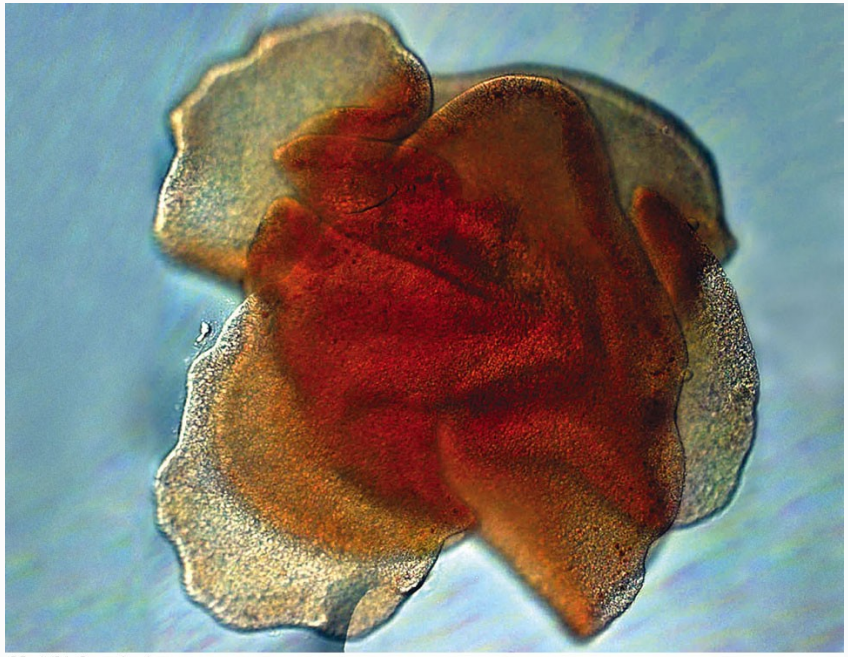
The Simplest Living Animal

- **Placozoans**, the simplest known animals, have no body symmetry, no tissues, and just four different types of cells
  - *Example: Trichoplax adherens*

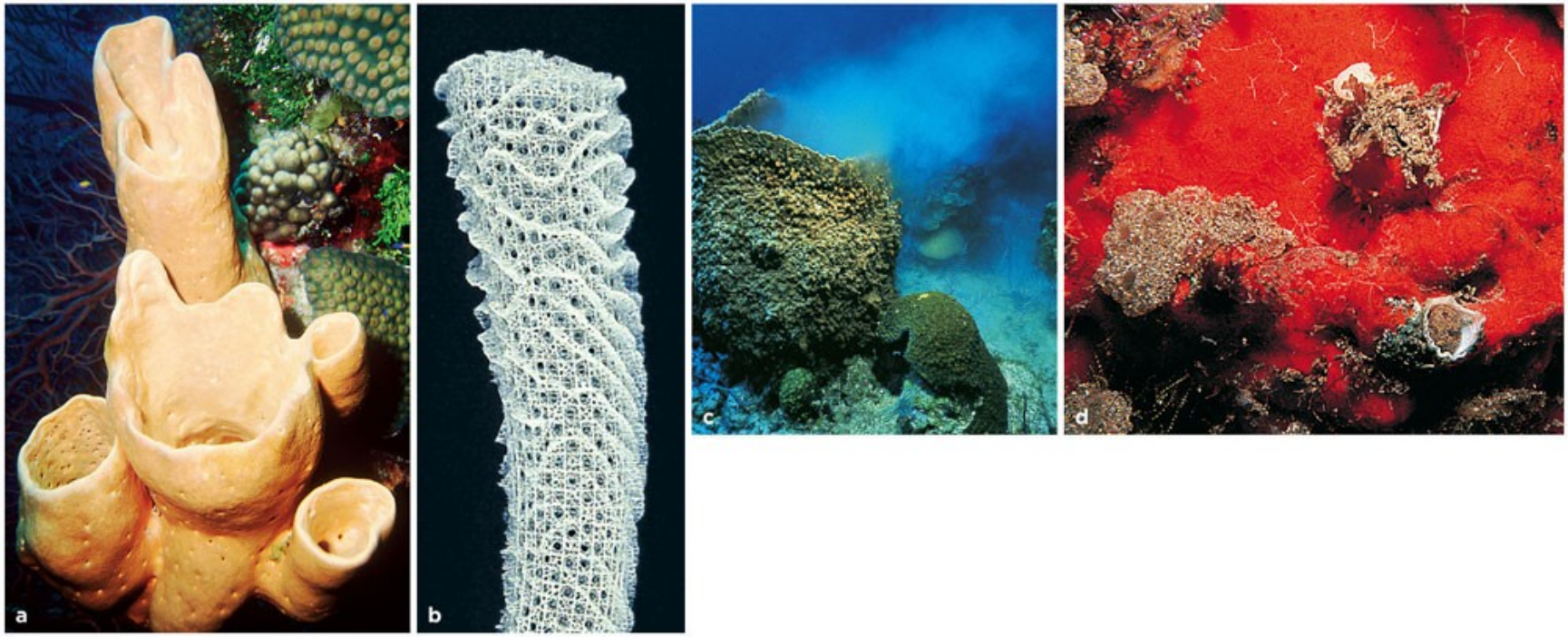


The Sponges

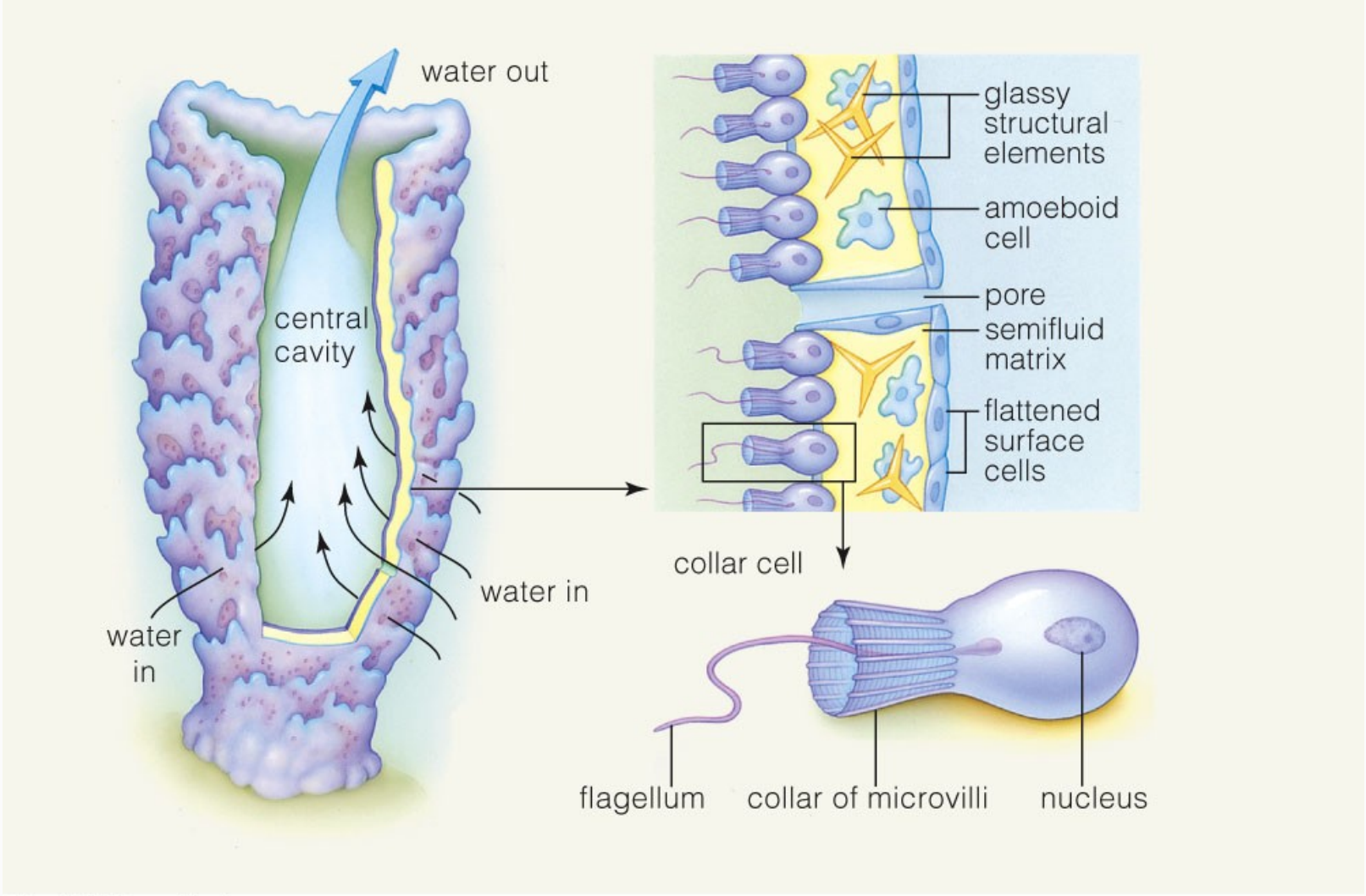
- Sponges are simple but successful

- **Sponges** (phylum Porifera)
  - Attach to seafloor or other surfaces
  - No symmetry, tissues, or organs
  - Pores with flagellated collar cells filter water
  - Sexual or asexual reproduction

Sponges



Sponge Body Plan



Sponge Reproduction and Dispersal

- **Hermaphrodite**
  - Individual that produces both eggs and sperm
  - Sperm are released into water; eggs are retained
  - Zygote develops into ciliated larva

- **Larva**
  - Free-living, sexually immature stage in life cycle
  - Settles and develops into adult

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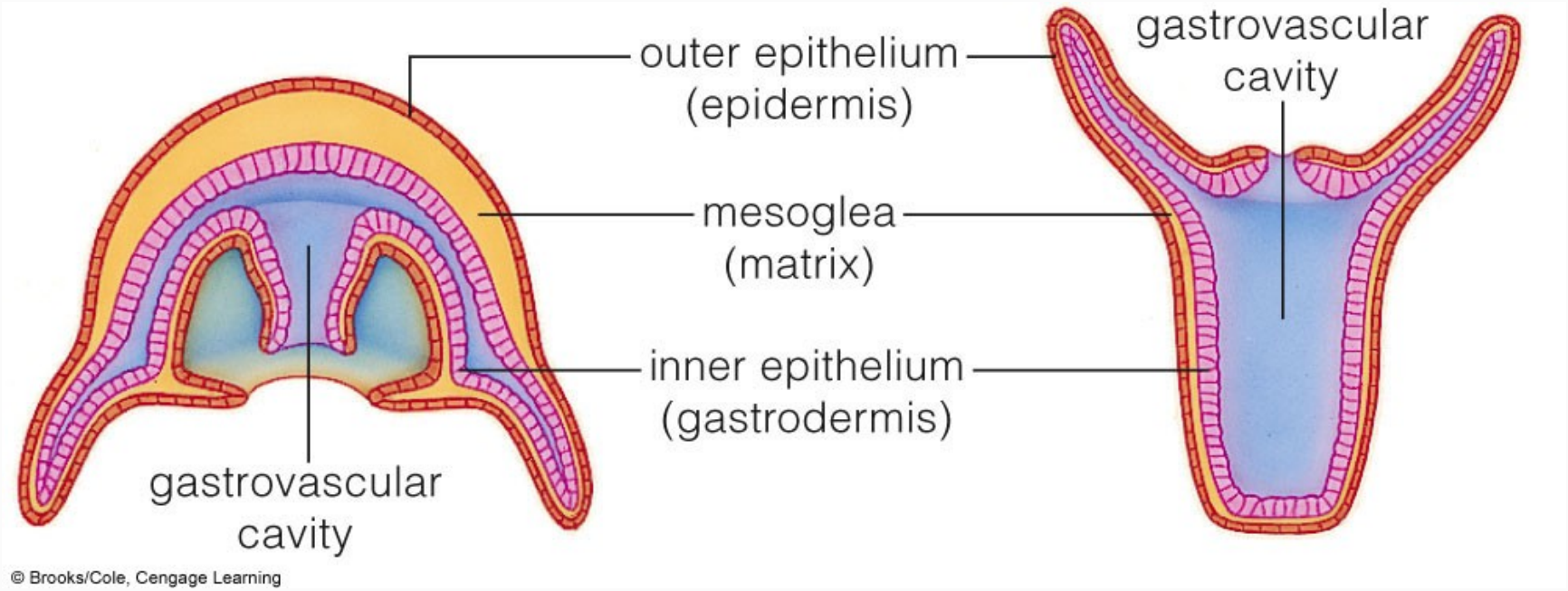
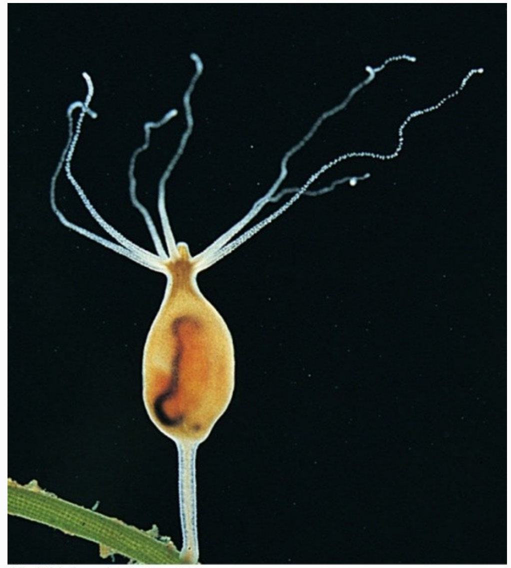
Cnidarians—True Tissues

- **Cnidarians** (phylum Cnidaria)
  - Radial animals with two tissue layers
  - Medusae (jellyfishes) are bell shaped and drift
  - Polyps (sea anemones) are tubular with one end usually attached to a surface

Two Cnidarian Body Plans



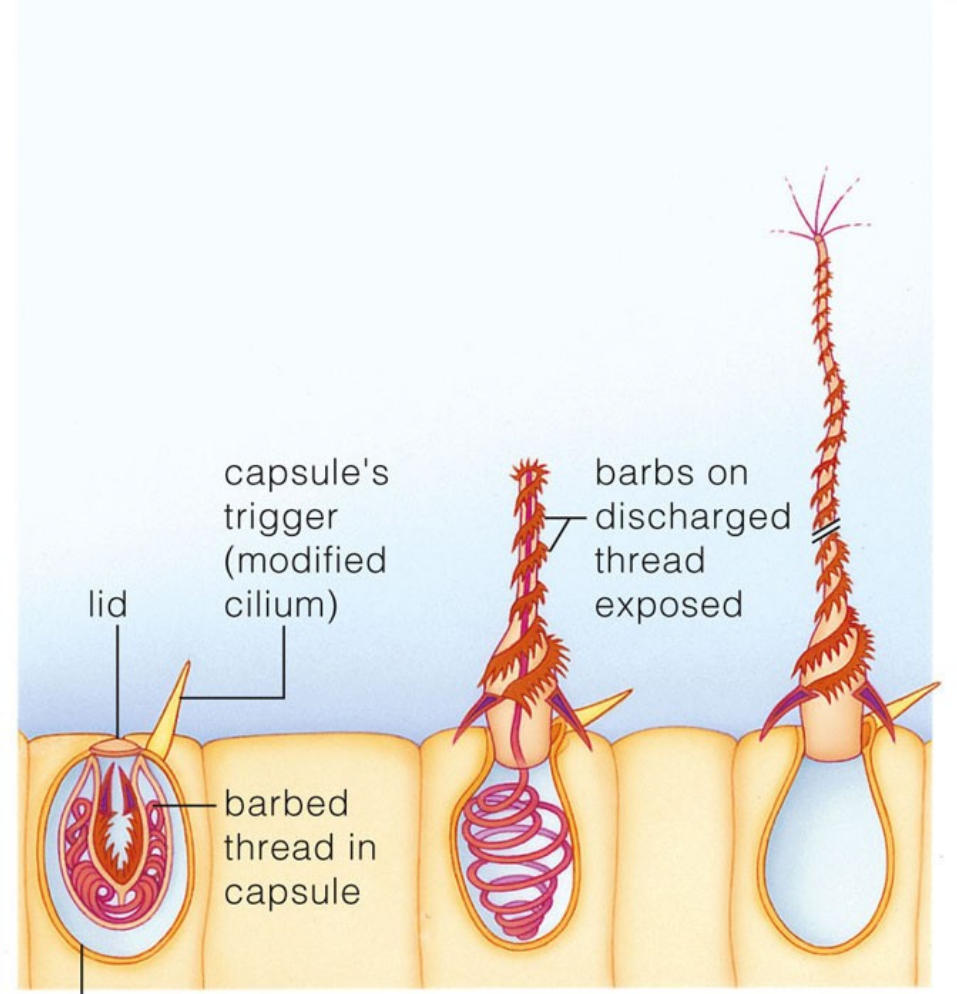
Cnidarian Diversity



General Cnidarian Features

- **Nematocysts**
  - Stinging organelles in tentacle cells, triggered by contact, used in feeding or defense
- **Nerve net**
  - Simple nervous system of interconnecting nerve cells extending through the tissues
- **Hydrostatic skeleton**
  - Fluid-filled structure moved by contractile cells

Nematocyst Action



Key Concepts
The Structurally Simple Invertebrates

- *Placozoans and sponges have no body symmetry or tissues*

- *The radially symmetrical cnidarians such as jellyfish have two tissue layers and unique stinging cells used in feeding and in defense*

Variation in Animal Body Plans

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Flatworms—Simple Organ Systems

- **Flatworms** (phylum Platyhelminthes) have a three-layer embryo that develops into an adult with many organ systems but no coelom

http://www.youtube.com/v/DuwDJ-eZOMc

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Annelids—Segmented Worms

- **Annelids** (phylum Annelida) are bilateral worms with a coelom and a segmented body

Variation in Animal Body Plans

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Mollusks—Animals With a Mantle

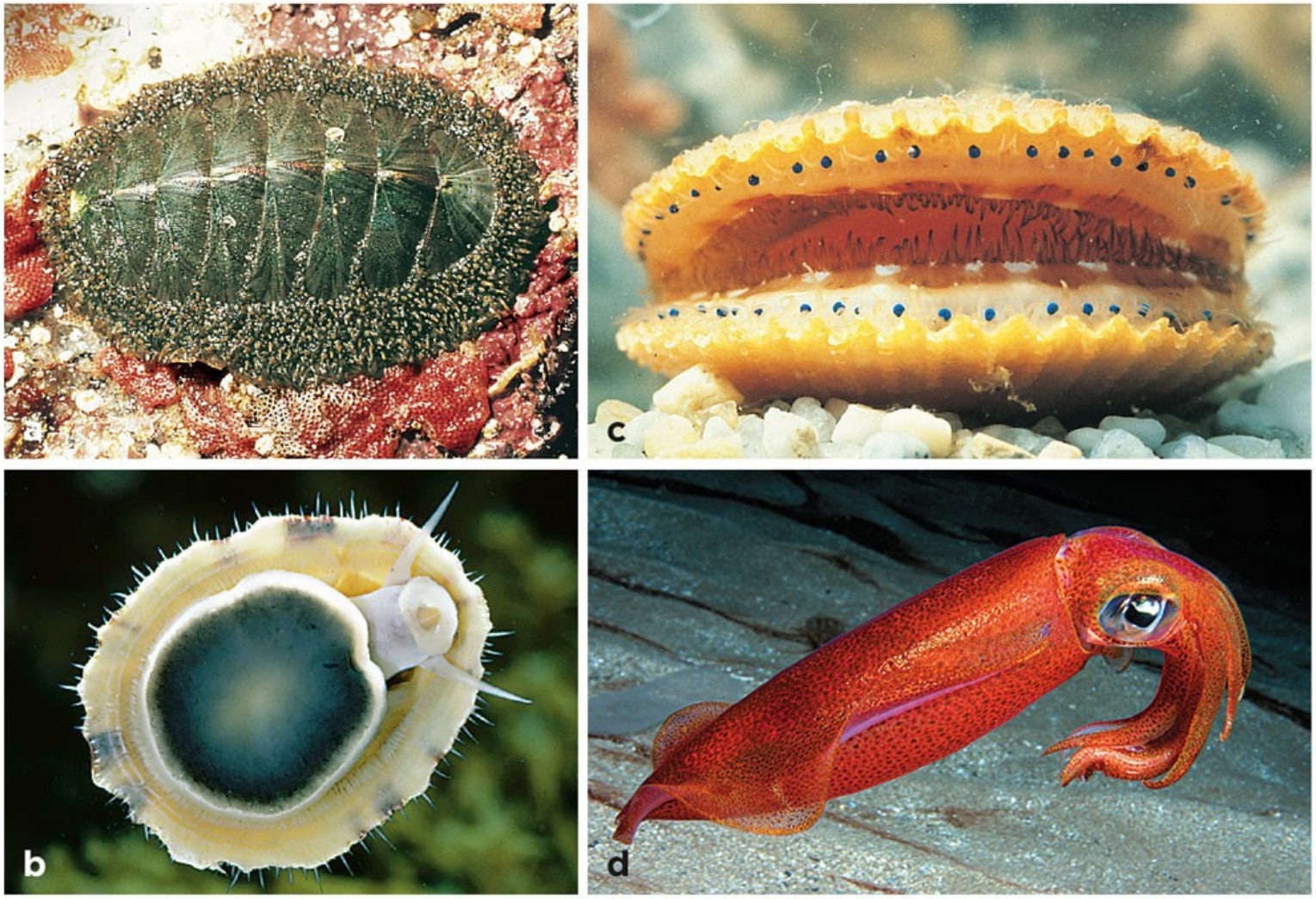
- **Mollusks** (phylum Mollusca)
  - Bilaterally symmetrical with a reduced coelom
  - **Mantle** covers internal organs, secretes a shell
  - Feed using a hard **radula**
  - Have a complete digestive tract
  - **Gills** for respiration in aquatic species

Mollusk Diversity

- **Chitons**
  - Eight overlapping plates
- **Gastropods** (snails, slugs)

  http://www.youtube.com/v/nHVoV0MVwSc
- **Bivalves** (mussels, clams, oysters)
  - Hinged, two-part shell
- **Cephalopods** (squids, octopuses)
  - Large, fast and smart; closed circulatory system

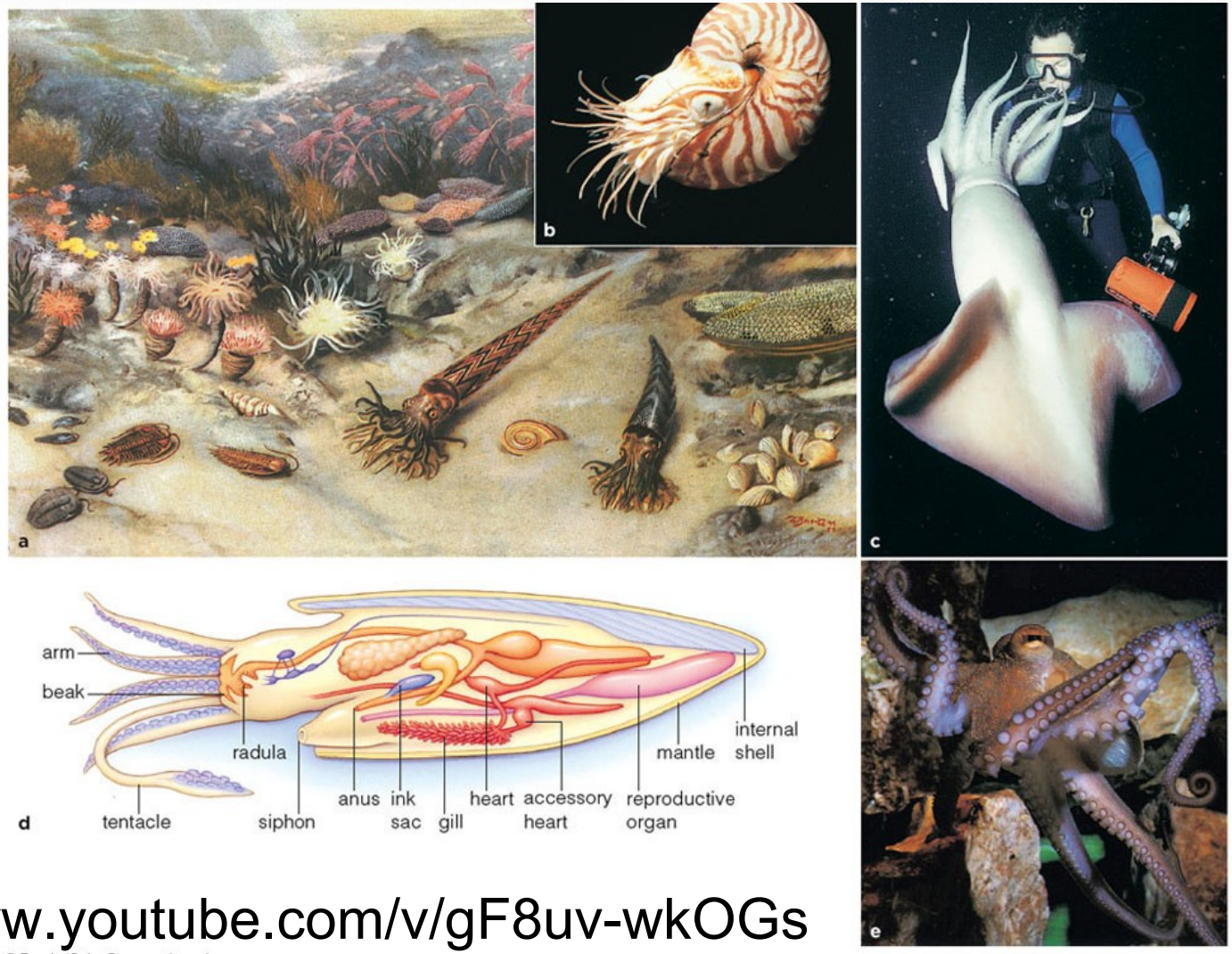
Mollusk Groups



Cephalopods—Fast and Brainy

- Cephalopod (“head foot”)
  - Tentacles attached to the head are evolutionary modifications of the foot; they surround the mouth, which has a hard, horny beak
- Include the fastest (squids), biggest (giant squid), and smartest (octopuses) invertebrates
  - Jet propulsion, complex eyes, closed circulatory system, complex behavior

Cephalopods



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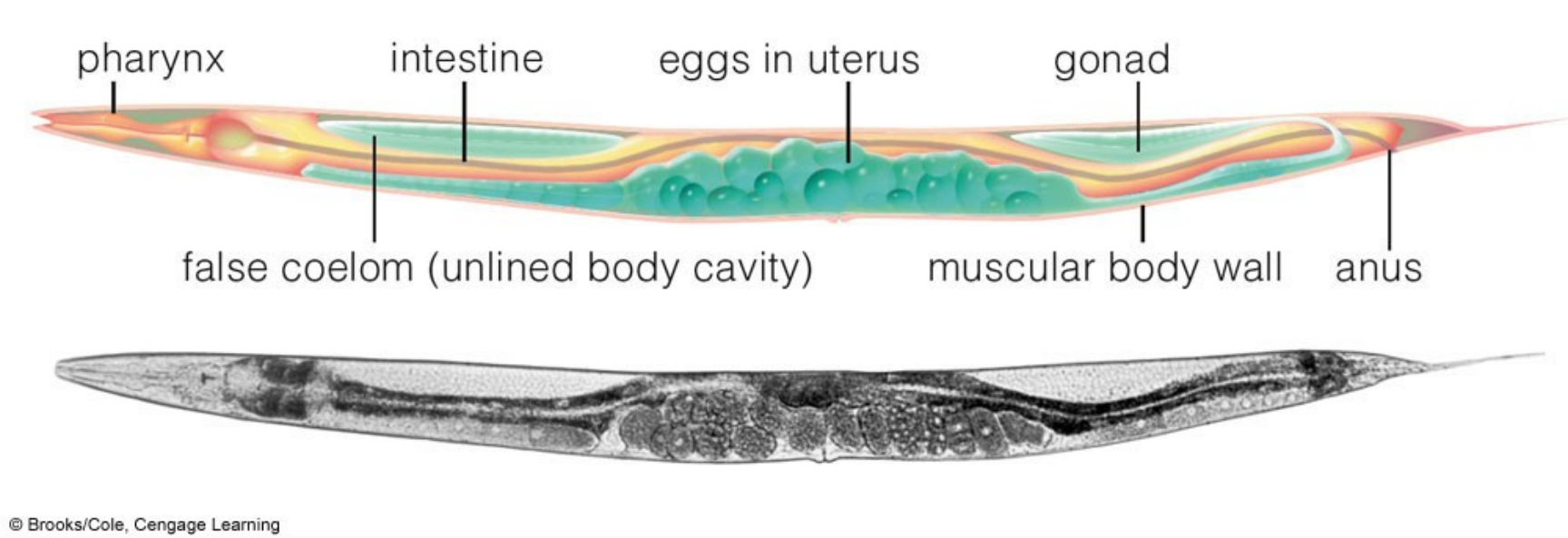
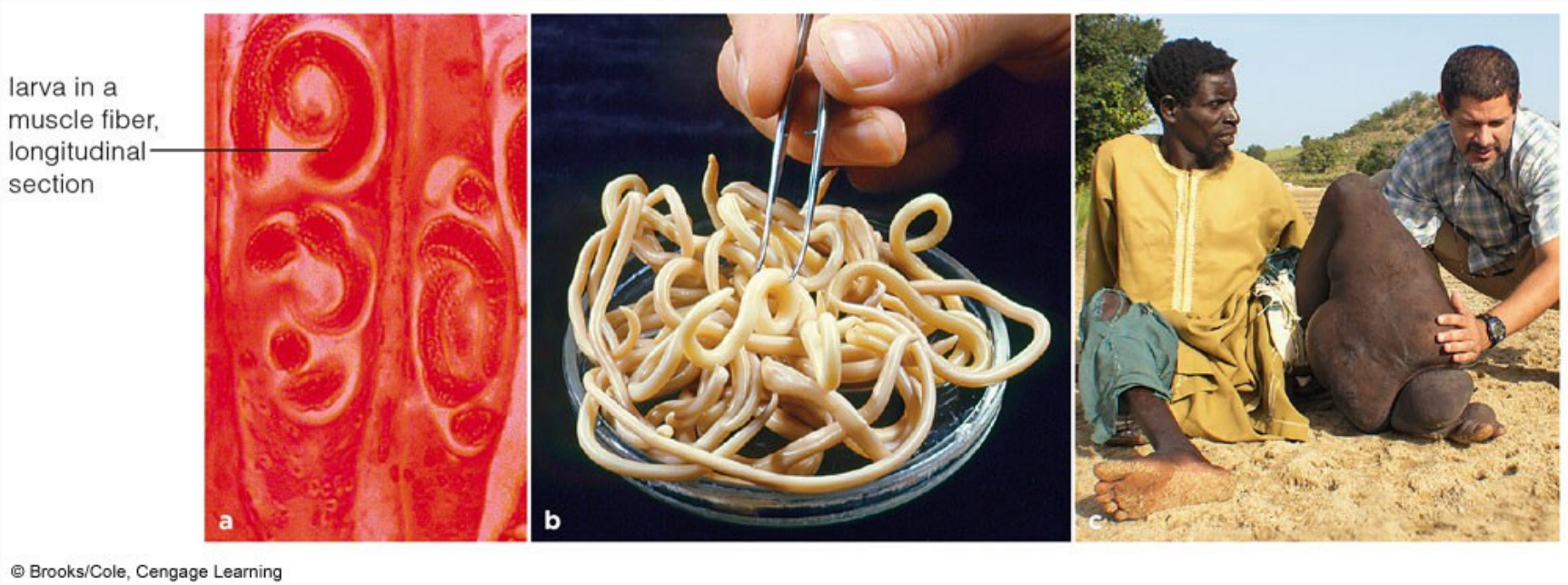
Roundworms— Unsegmented Worms That Molt

- **Roundworms** (phylum Nematoda) are unsegmented, pseudocoelomate worms with a secreted cuticle that is molted
- Most are decomposers, some are parasites

Roundworm Body Plan



Roundworms



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Arthropods—
Animals With Jointed Legs

- **Arthropods** (phylum Arthropoda) are the most diverse animal phylum – with more than a million species
  - Trilobites are an extinct group
  - Modern arthropods include horseshoe crabs, spiders, ticks, crabs, lobsters, centipedes, and insects

Living Arthropod Subgroups

Table 25.2 Living Arthropod Subgroups

Group	Representatives	Named Species
Chelicerates	Horseshoe crabs	4
	Arachnids (scorpions, spiders, ticks, mites)	70,000
Crustaceans	Crabs, shrimp, lobsters, barnacles, pill bugs	42,000
Myriapods	Millipedes and centipedes	2,800
Insects	Beetles, ants, butterflies, flies	>1 million

Chelicerates—
Spiders and Their Relatives

- Chelicerates are arthropods without antennae
  - Marine chelicerates include the oldest living arthropod lineage (horseshoe crabs)
  - All land chelicerates are arachnids, including spiders, scorpions, ticks, and mites

Chelicerates

The Mostly Marine Crustaceans

- Crustaceans are mostly marine arthropods with two pairs of antennae
  - Small crustaceans include krill, copepods, and barnacles
  - Decapod crustaceans include lobsters, crayfish, crabs and shrimps

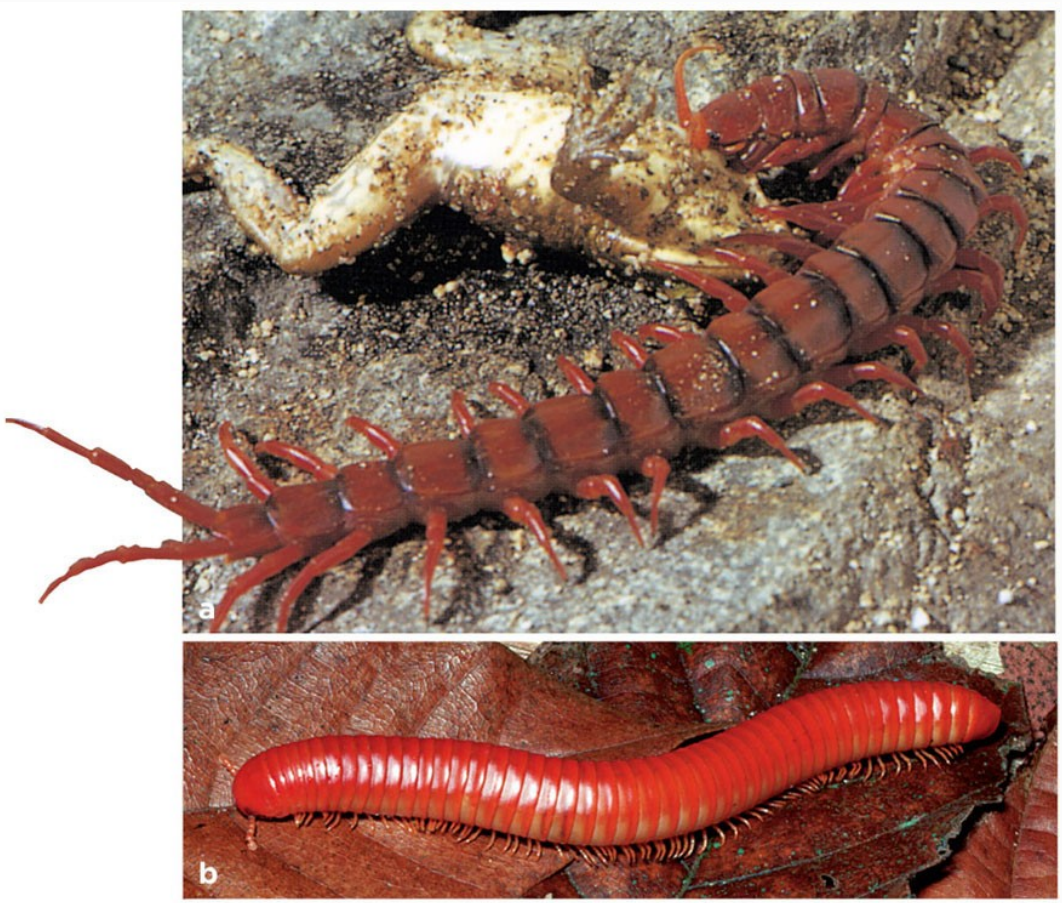
Crustaceans

Myriapods—Lots of Legs

- **Myriapods** (“many feet”) are arthropods with two antennae and many body segments
- Centipedes are predators
- Millipedes are scavengers

Myriapods

- Centipede and millipede



Insects

- Arthropods are the most successful animals, and insects are the most successful arthropods
- 6 legs!
- Development may be direct, or through incomplete or complete metamorphosis

Insect Diversity

http://www.youtube.com/v/a7tga7JPMwg

Key Concepts
The Major Invertebrate Lineages

- *One major lineage of animals with tissues includes the flatworms, annelids, mollusks, nematodes, and arthropods*
- *All are bilaterally symmetrical*
- *The arthropods, which include the insects, are the most diverse of all animal groups*

The Protostome-Deuterostome Split

- So far, all of the animals with a three-layered embryo – from flatworms to arthropods – have been protostomes

- All of the following animals – from echinoderms to vertebrates – are deuterostomes

Variation in Animal Body Plans

Table 25.1 Animal Groups Surveyed in Chapters 25 and 26

Animal Phylum	Representative Groups	Living Species	Organization	Body Symmetry	Digestion	Circulation
Placozoa	Placozoans (*Trichoplax*)	1	Connected cells	None	Extracellular	Diffusion
Porifera	Barrel sponges, encrusting sponges	8,000	Connected cells	None	Intracellular	Diffusion
Cnidaria	Sea anemones, jellyfishes, corals	11,000	2 tissue layers	Radial	Saclike gut	Diffusion
Platyhelminthes	Planarians, tapeworms, flukes	15,000	3 tissue layers, organs	Bilateral	Saclike gut	Diffusion
Annelida	Polychaetes, earthworms, leeches	15,000	3 tissue layers, organs	Bilateral	Complete gut	Closed system
Mollusca	Snails, slugs, clams, octopuses	110,000	3 tissue layers, organs	Bilateral	Complete gut	Open in most, closed in some
Rotifera	Rotifers	2,150	3 tissue layers, organs	Bilateral	Complete gut	Diffusion
Tardigrada	Water bears	950	3 tissue layers, organs	Bilateral	Complete gut	Diffusion
Nematoda	Pinworms, hookworms	20,000	3 tissue layers, organs	Bilateral	Complete gut	Closed system
Arthropoda	Spiders, crabs, millipedes, insects	1,113,000	3 tissue layers, organs	Bilateral	Complete gut	Open system
Echinodermata	Sea stars, sea urchins	6,000	3 tissue layers, organs	Larvae bilateral; adults radial	Complete gut	Open system
Chordata	Invertebrate chordates	2,100	3 tissue layers, organs	Bilateral	Complete gut	Closed system
	Vertebrates (fishes, amphibians, reptiles, birds, mammals)	4,500	3 tissue layers, organs	Bilateral	Complete gut	Closed system

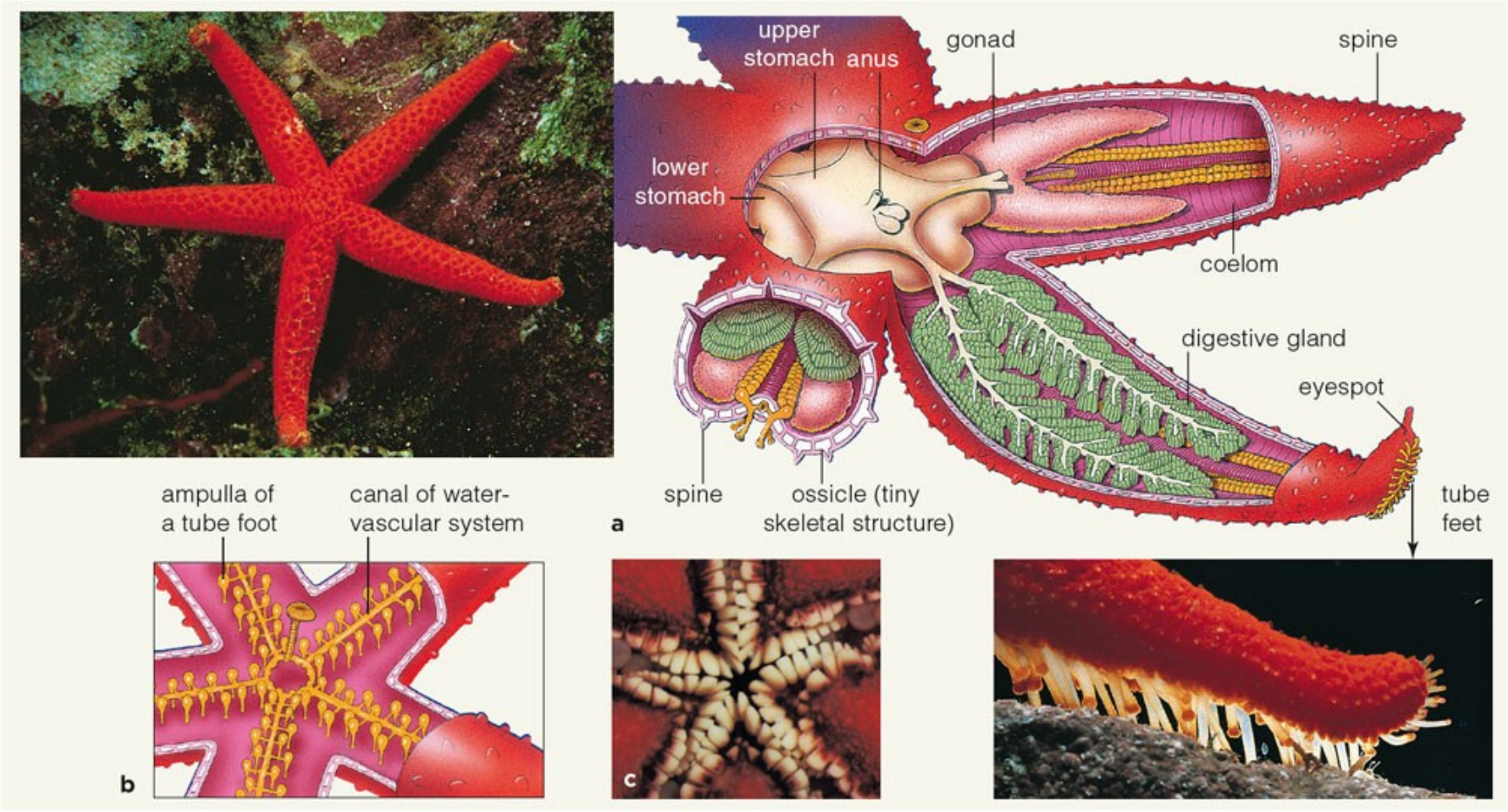
The Spiny-Skinned Echinoderms

- Echinoderms (phylum Echinodermata) have “spiny skins” embedded with interlocking spines and plates of calcium carbonate
- They begin life as bilateral larvae and develop into spiny-skinned, radial adults
- They are brainless and have a unique **water-vascular system** for locomotion

Video: Water vascular system

http://www.youtube.com/v/AC5F6yEcBG4

Echinoderm Body Plan: Sea Star

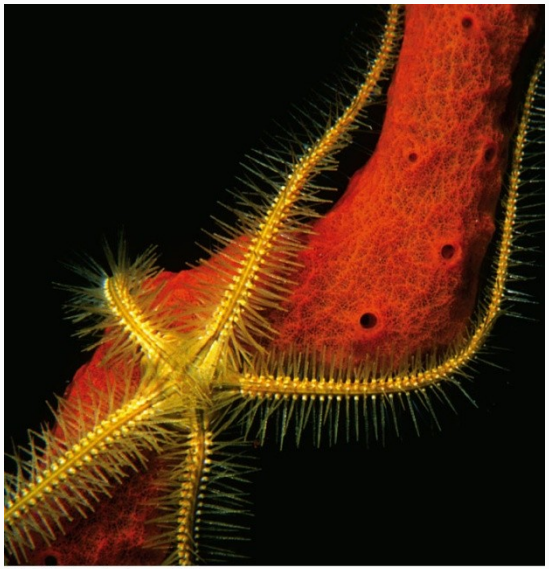


Echinoderm Diversity

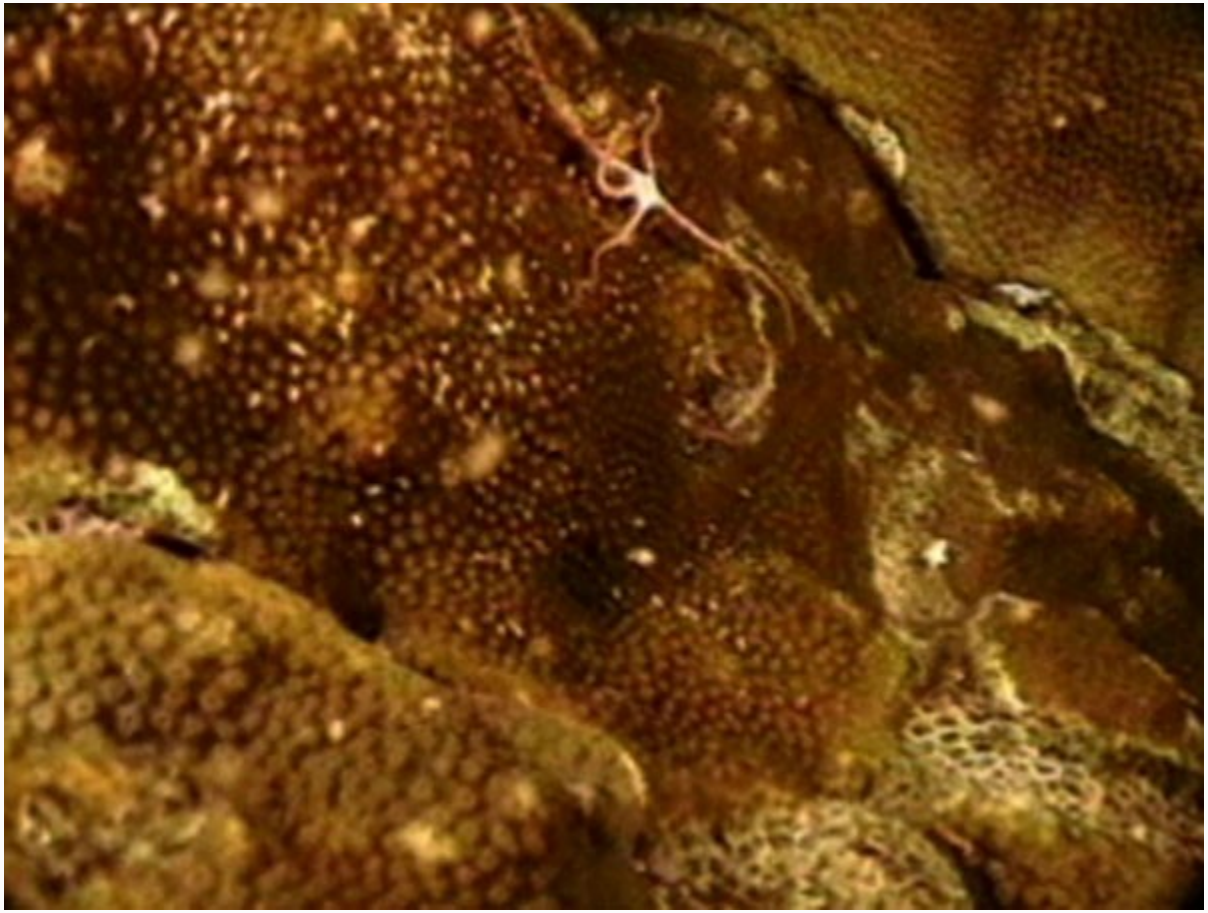
- Echinoderms include about 6,000 marine invertebrates such as sea stars, brittle stars, sea urchins, and sea cucumbers

- Echinoderms can regenerate lost body parts; any portion of a sea star with some of the central disc can regrow missing parts

Echinoderms



Video: Brittle star



http://www.youtube.com/v/E1t-Dz4u4u0

Key Concepts
On the Road to Vertebrates

- *Echinoderms are on the same branch of the animal family tree as the vertebrates*

- *They are invertebrates with bilateral ancestors, but adults now have a decidedly radial body plan*

Animal Evolution – The Chordates

The Chordate Heritage

- **Chordates**
  - Most diverse lineage of deuterostomes
  - Some are invertebrates; most are **vertebrates**
  - Bilateral and coelomate
  - Cephalized and segmented
  - Complete digestive system
  - Closed circulatory system
  - Classified by embryonic characteristics

Modern Chordate Groups

Table 26.1 Modern Chordate Groups

Group	Named Species
Invertebrate chordates:	
Lancelets	30
Tunicates	2,150
Craniates:	
Hagfishes (jawless fishes)	60
Vertebrates:	
Lampreys (jawless fishes)	41
Jawed fishes:	
Cartilaginous fishes	1,160
Bony fishes	26,000
Amphibians	4,900
Reptiles	8,200
Birds	8,600
Mammals	4,500

For details of chordate classification, see Appendix I.

Embryonic Chordate Characteristics

- Four characteristics of chordate embryos may not persist in adults
  - **Notochord** of stiff connective tissue that extends the length of the body and supports it
  - Dorsal, hollow nerve cord parallels the notochord
  - Gill slits across the wall of the pharynx
  - Tail that extends beyond the anus

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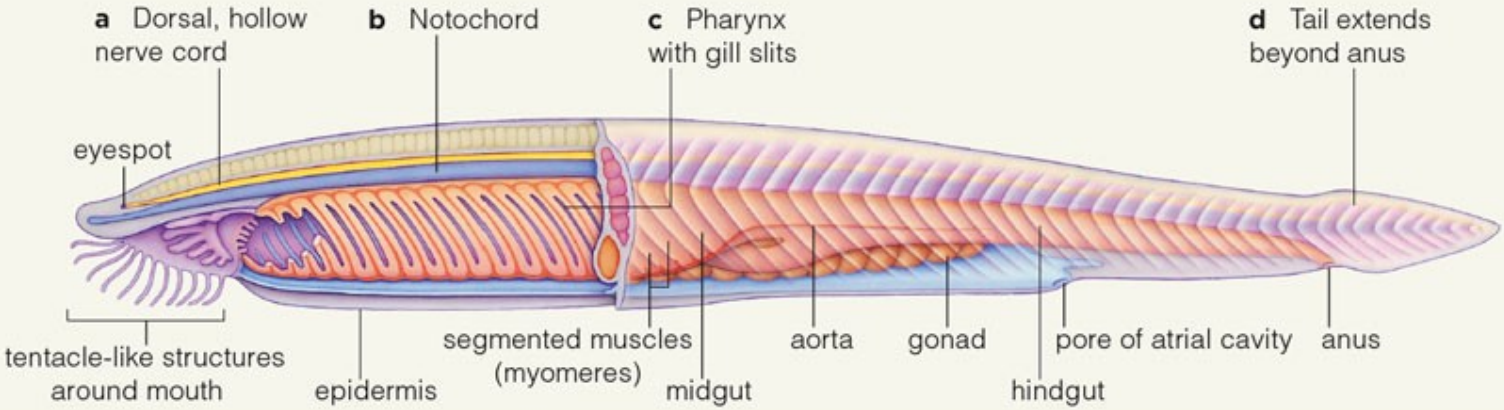
For details of chordate classification, see Appendix I.

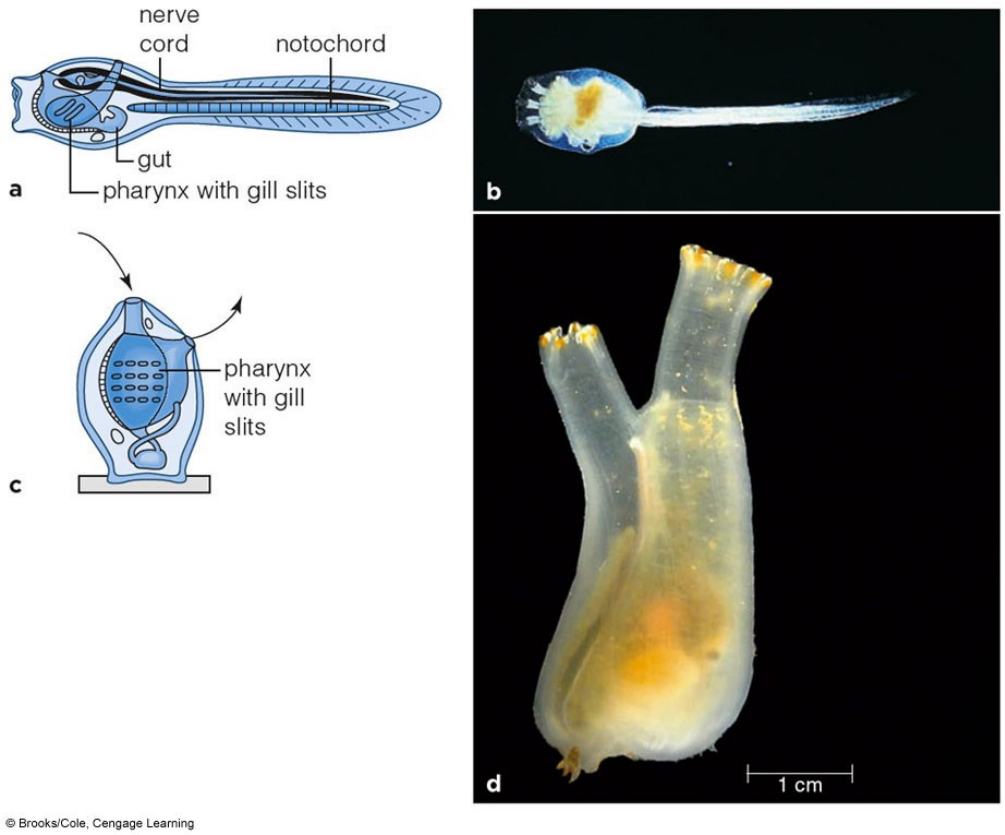
Invertebrate Chordates

- **Lancelets** are the only group of chordates that retains all chordate characteristics as adults



Invertebrate Chordates

- **Tunicates** have typical chordate larvae, but adults retain only the pharynx with gill slits



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For details of chordate classification, see Appendix I.

Craniates

- **Craniates** have a braincase of cartilage or bone (cranium) that encases the brain, paired eyes, and other sensory structures on the head
- Craniates includes fishes, amphibians, reptiles, birds, and mammals
- Hagfishes are the only modern craniates that are not vertebrates

Hagfishes

- Soft bodied, boneless fishes

Key Concepts
Characteristics of Chordates

- *Four traits characterizes the chordates:*
  - *A supporting rod (notochord)*
  - *A hollow, dorsal nerve cord*
  - *A pharynx with gill slits in the wall*
  - *A tail extending past an anus*

- *Certain invertebrates and all vertebrates belong to this group*

Subphylum Vertebrata

Modern Chordate Groups

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Mammals	4,500

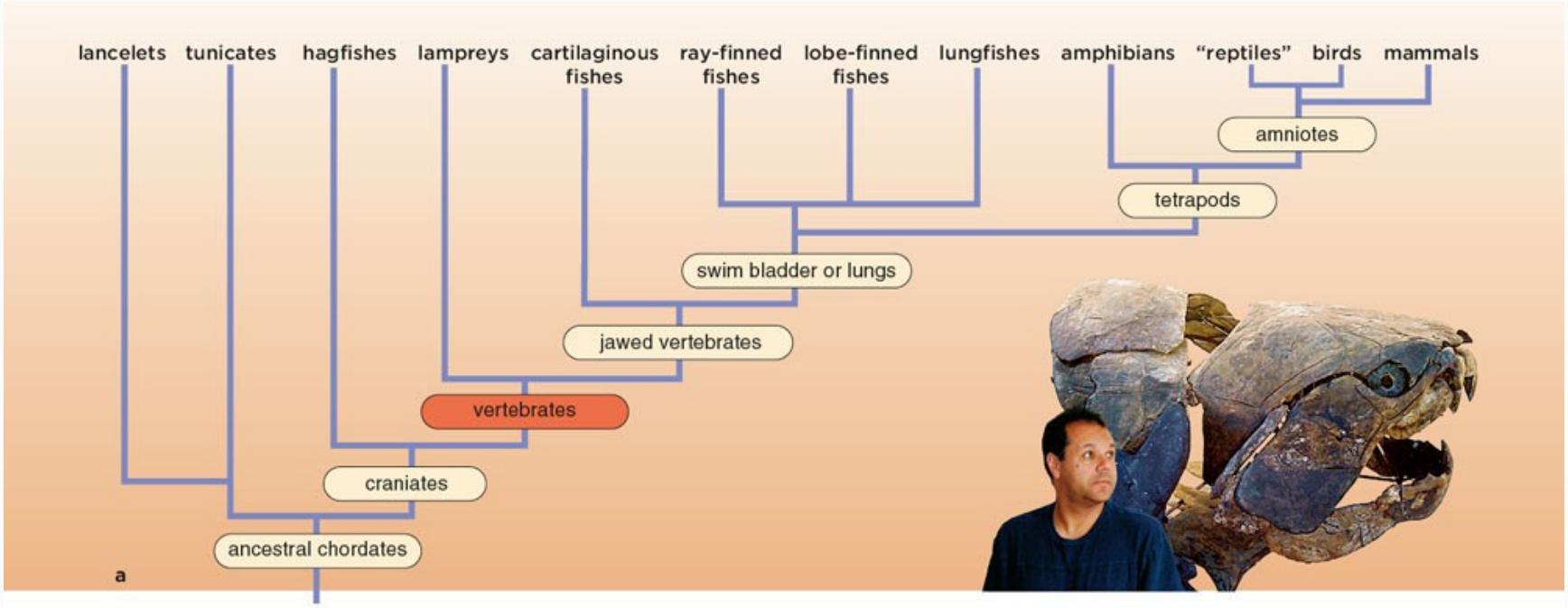
For details of chordate classification, see Appendix I.

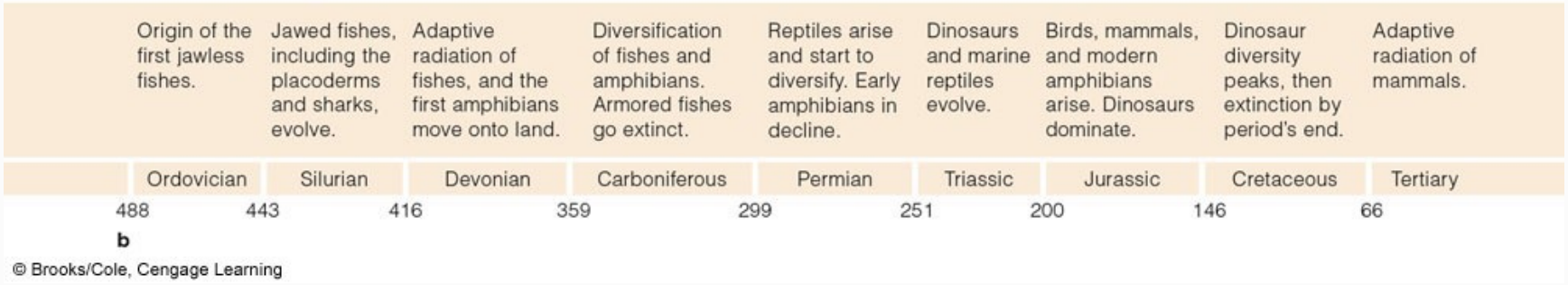
Vertebrate Traits and Trends

- **Vertebrates** are chordates with an internal skeleton (**endoskeleton**) of cartilage or bone with a supportive backbone (**vertebral column**) made up of individual **vertebrae**

- Modern vertebrates (except lampreys) have **jaws** derived from gill-supporting structures

Chordate Family Tree





Modern Chordate Groups – we stopped here!

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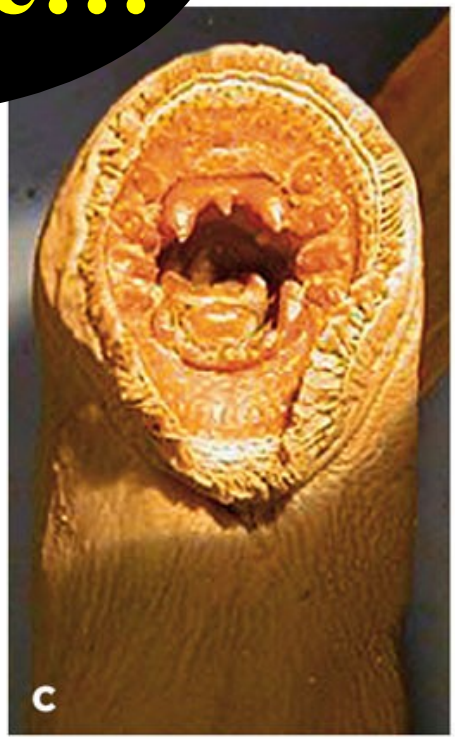
Mammals	4,500

For details of chordate classification, see Appendix I.

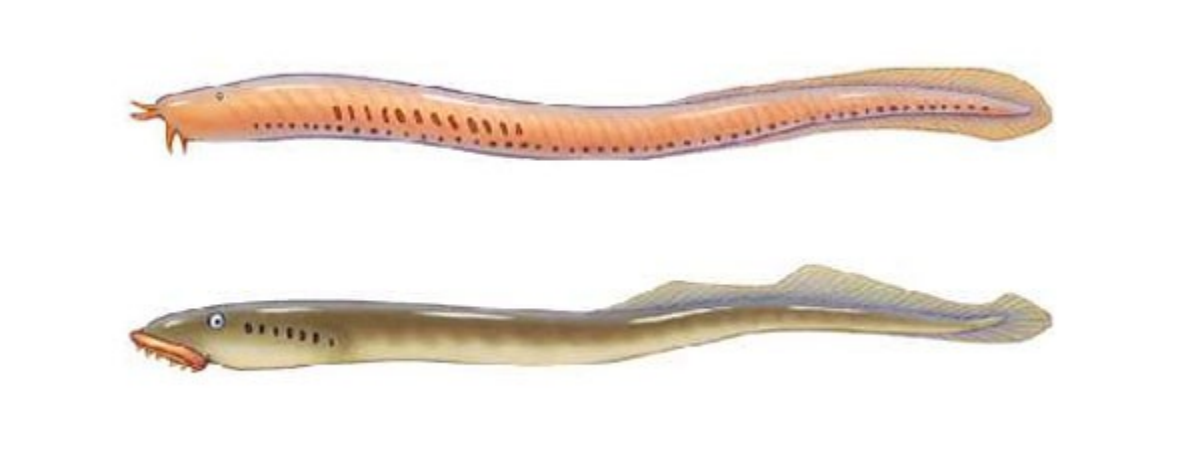
The Jawless Lampreys

- Lampreys have no jaws or paired fins; they undergo metamorphosis, and many are parasites of other fishes

Hi everyone!!!



Animation: Hagfish & Lampreys



http://www.youtube.com/v/jYBesqhG8bE

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For details of chordate classification, see Appendix I.

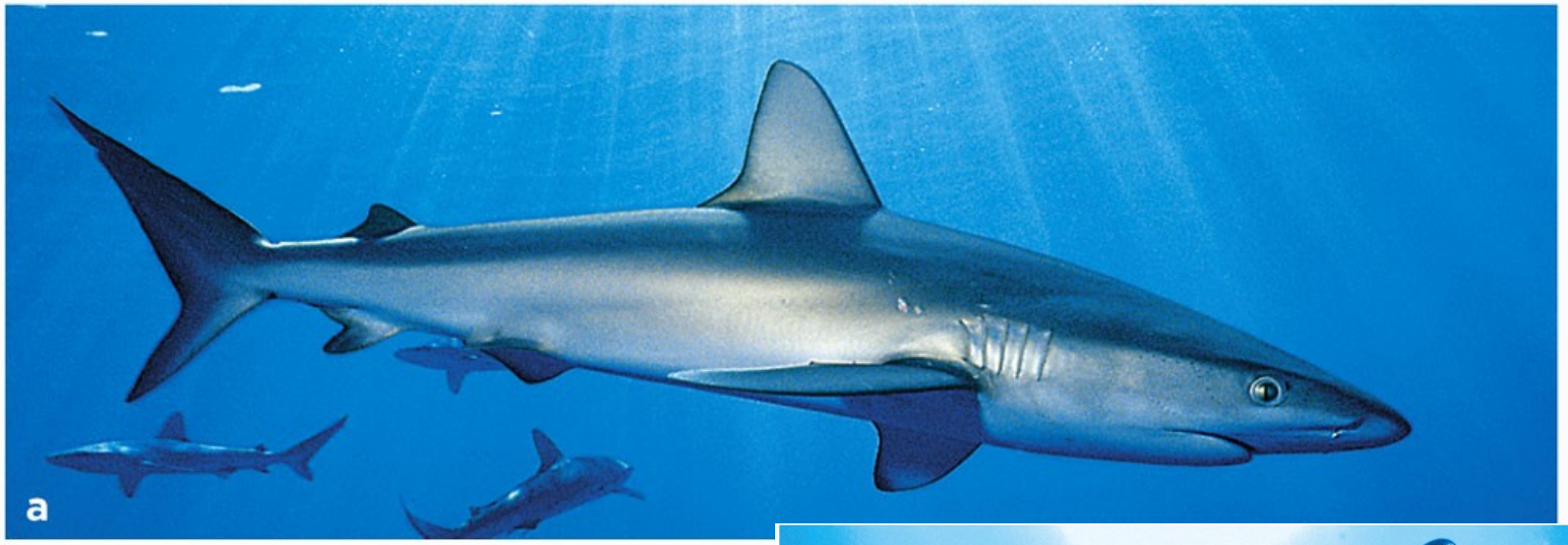
The Jawed Fishes

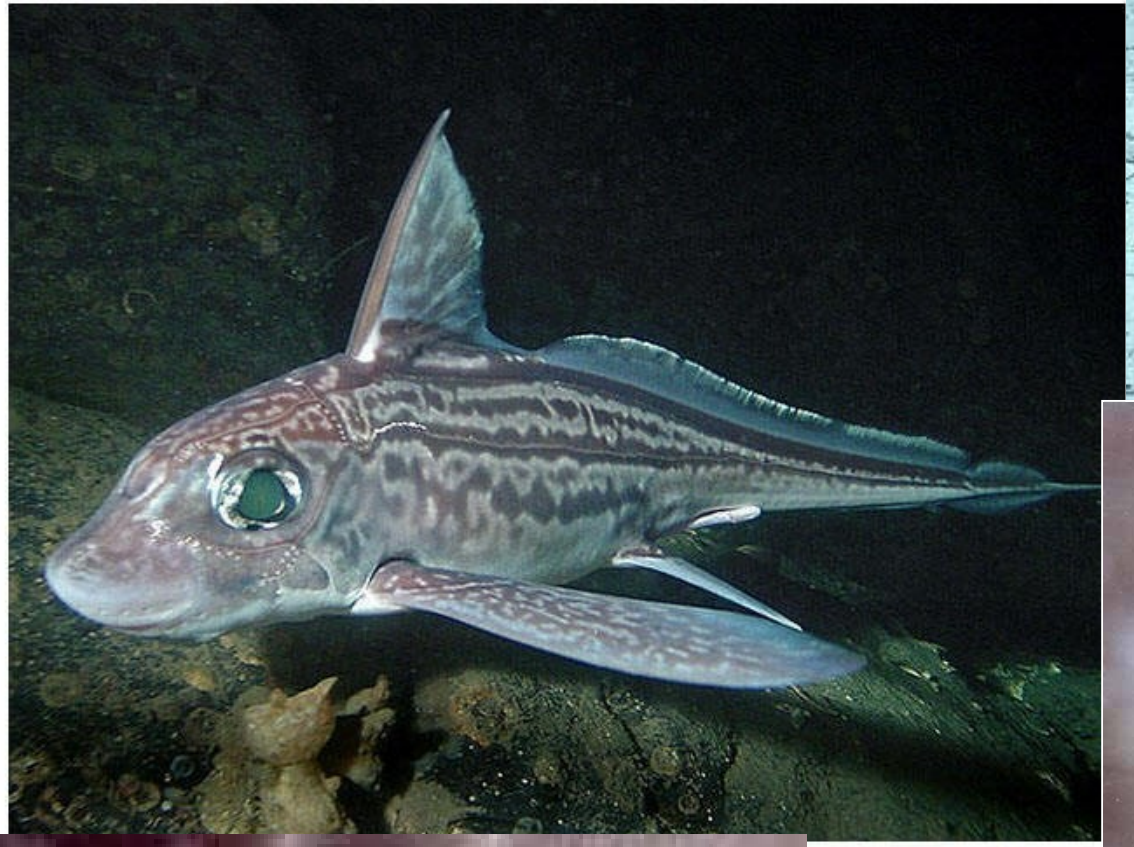
- Jawed fishes typically have paired fins and a body covered with scales

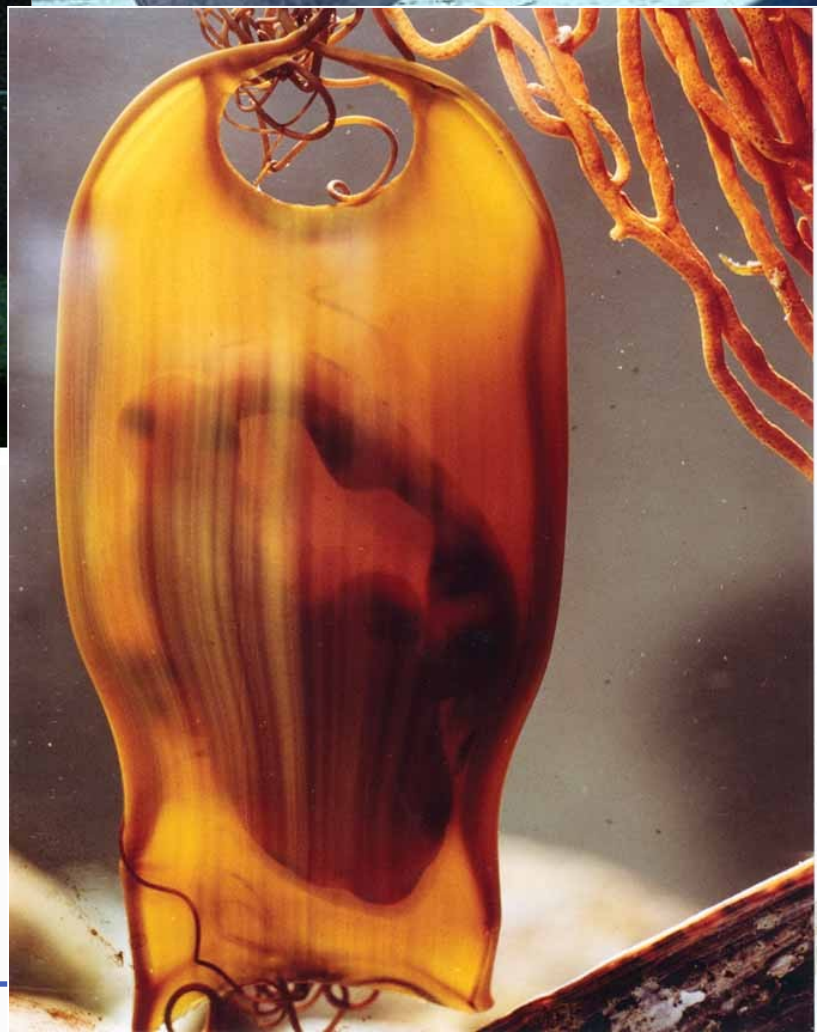
- **Cartilaginous fishes** (Chondrichthyes) have a cartilage skeleton, gill slits, and teeth that shed
  - Sharks and rays

- **Bony fishes** (Osteichthyes) have a bony skeleton, gill covers, and a **swim bladder**
  - Ray-finned fishes.
  - Lungfishes, coelacanth (lobe-finned fishes)

Cartilaginous Fishes

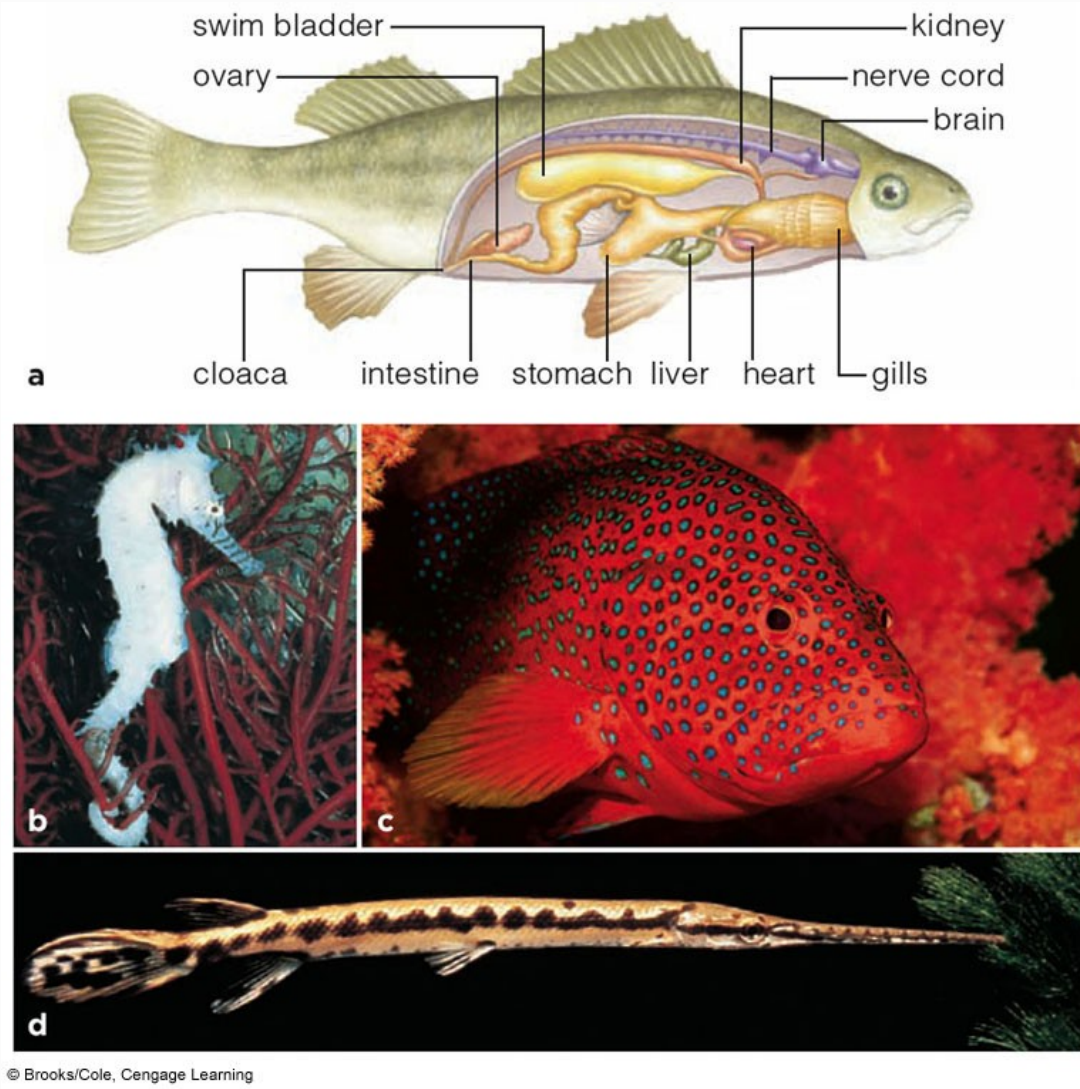






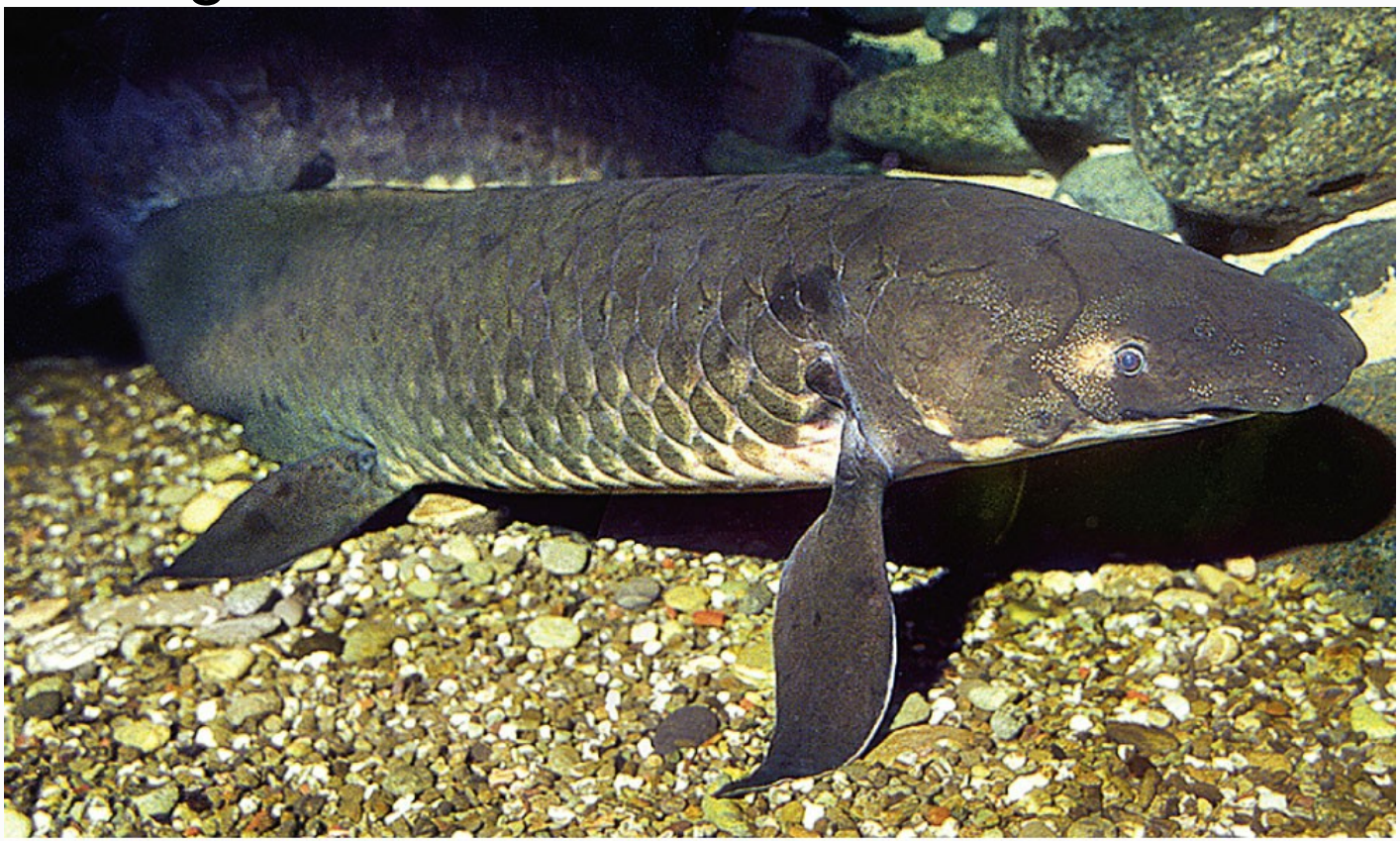
Ray-Finned Bony Fishes

- **Bony fishes** (Osteichthyes) have a bony skeleton, gill covers, and a **swim bladder**
  - Ray-finned fishes.
  - Lungfishes, coelacanth (lobe-finned fishes)



Lungfish

- Lungfishes have gills and lunglike sacs for breathing air



Coelacanth

- A modern lobe-finned fish; closely related to amphibians

Modern Chordate Groups

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Birds	8,600
Mammals	4,500

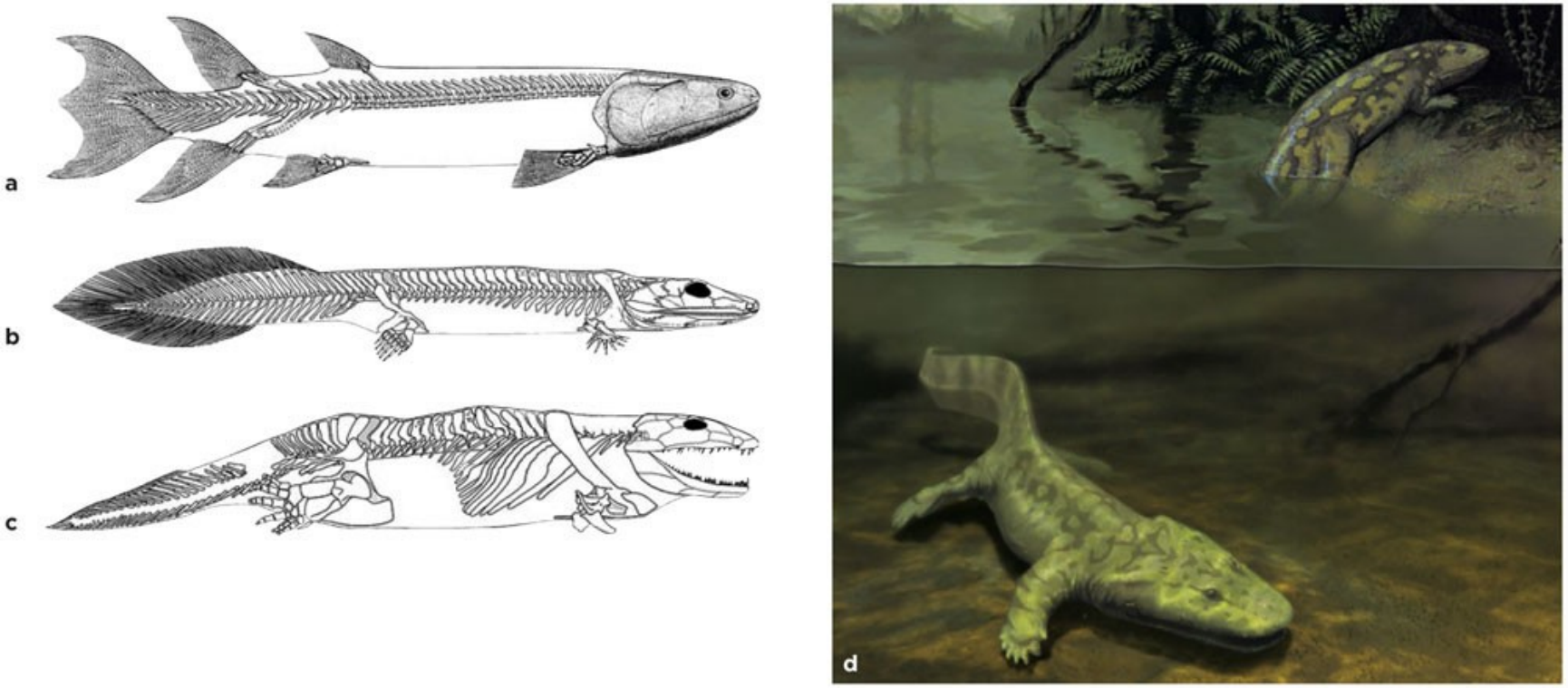
For details of chordate classification, see Appendix I.

Amphibians—
First Tetrapods on Land

- **Tetrapods** (four-legged walkers)
  - Branched from lobe-finned fishes

- **Amphibians**
  - Land-dwelling vertebrates that return to water to breed, undergo metamorphosis, and have a three-chambered heart

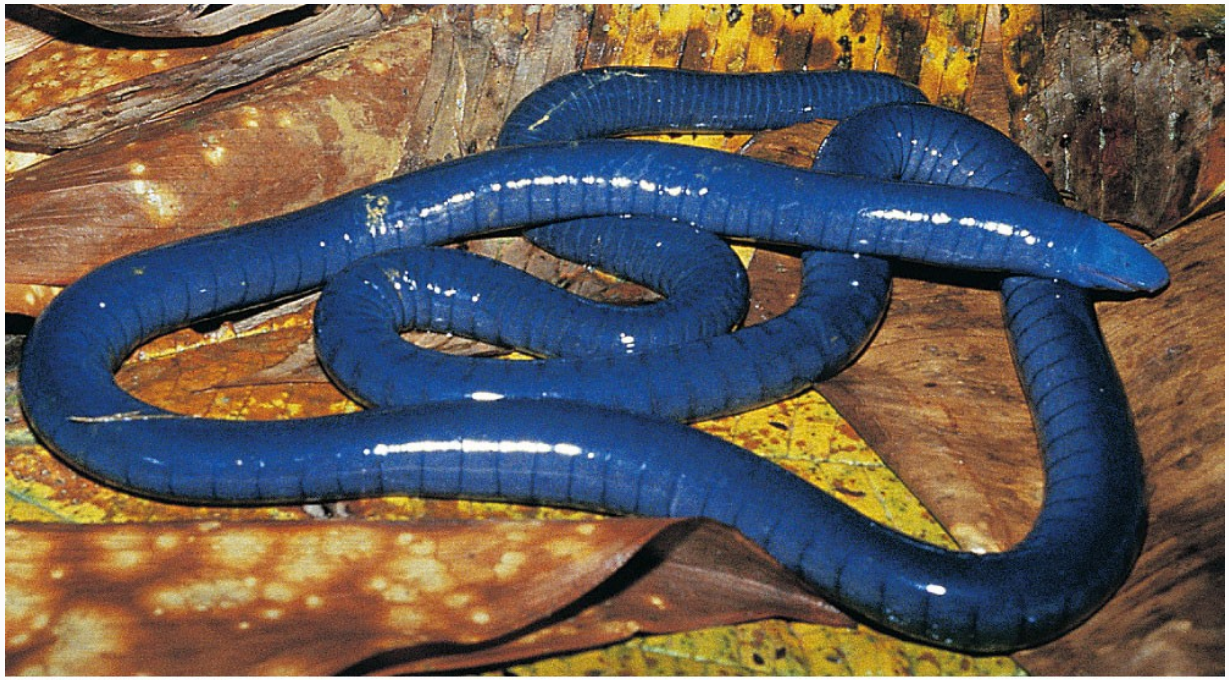
Adapting to Life on Land



Modern Amphibians

- Salamanders and newts
  - Body form most like early tetrapods, side-to-side walking motion
- Caecilians
  - Includes many limbless, blind burrowers
- Frogs and toads
  - Tailless adults with long, muscular hind legs

Salamander and Caecilian



http://www.youtube.com/v/6K6szXrBHwM

Key Concepts
Transition from Water to Land

- *Vertebrates evolved in the seas, where cartilaginous and bony fishes still live*
- *Of all vertebrates, modern bony fishes are most diverse*
- *One group gave rise to aquatic tetrapods (four-legged walkers), the descendants of which moved onto dry land*

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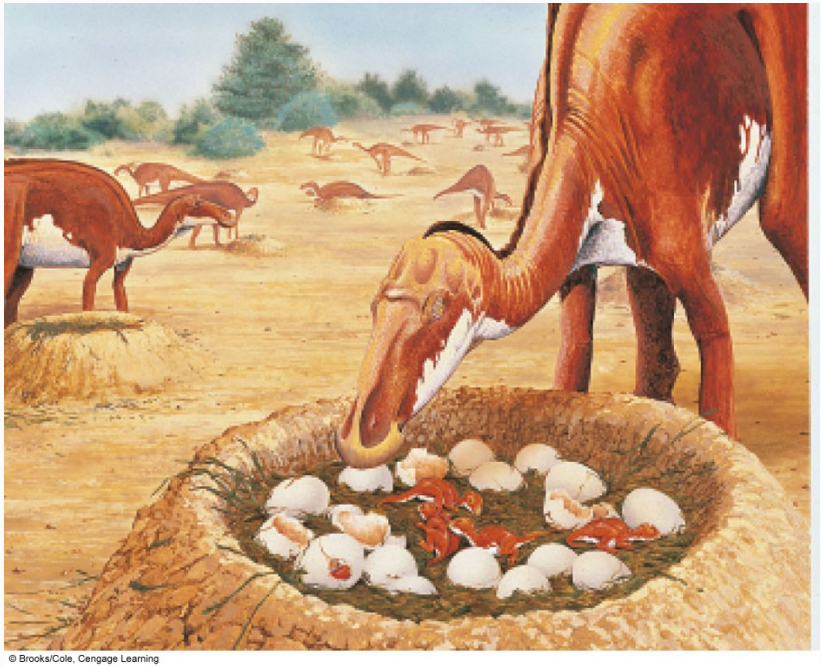
For details of chordate classification, see Appendix I.

The Rise of Amniotes

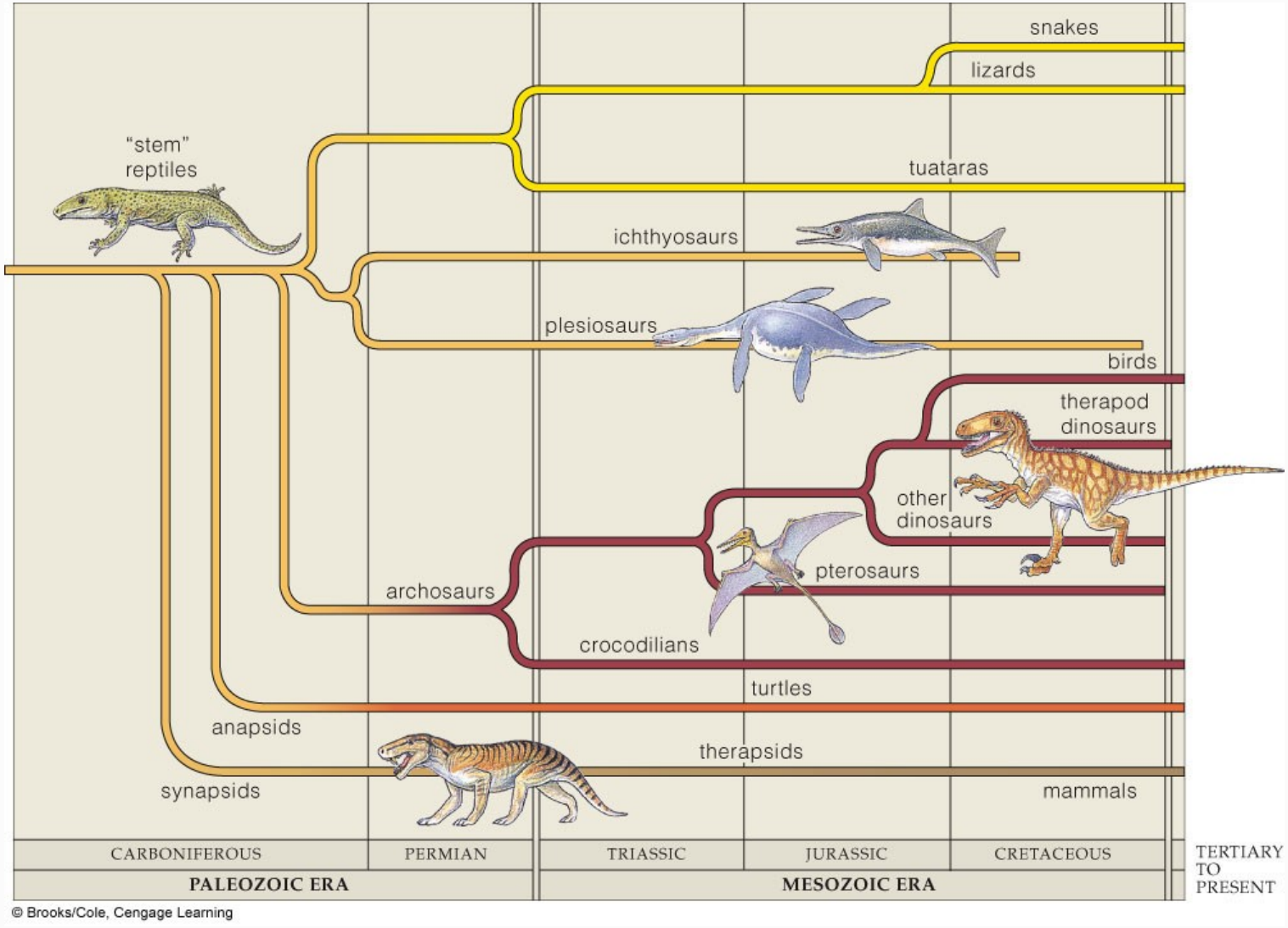
- **Amniotes** are animals with embryos that develop inside a waterproof egg; their waterproof skin and highly efficient kidneys make them well adapted to dry habitats



Amniotes

- Four branches of amniotes lead to mammals, turtles, lizards and snakes, and crocodiles and birds
- **Reptiles** are an artificial group referring to amniotes other than bird or mammals
- **Dinosaurs** are extinct amniotes; birds are their descendents

Amniote Phylogeny



So Long, Dinosaurs

- **K-T asteroid impact hypothesis**
  - Asteroid impacts changed life on Earth, defining the Cretaceous-Tertiary (K-T) boundary
  - Most dinosaurs became extinct

Modern Reptiles

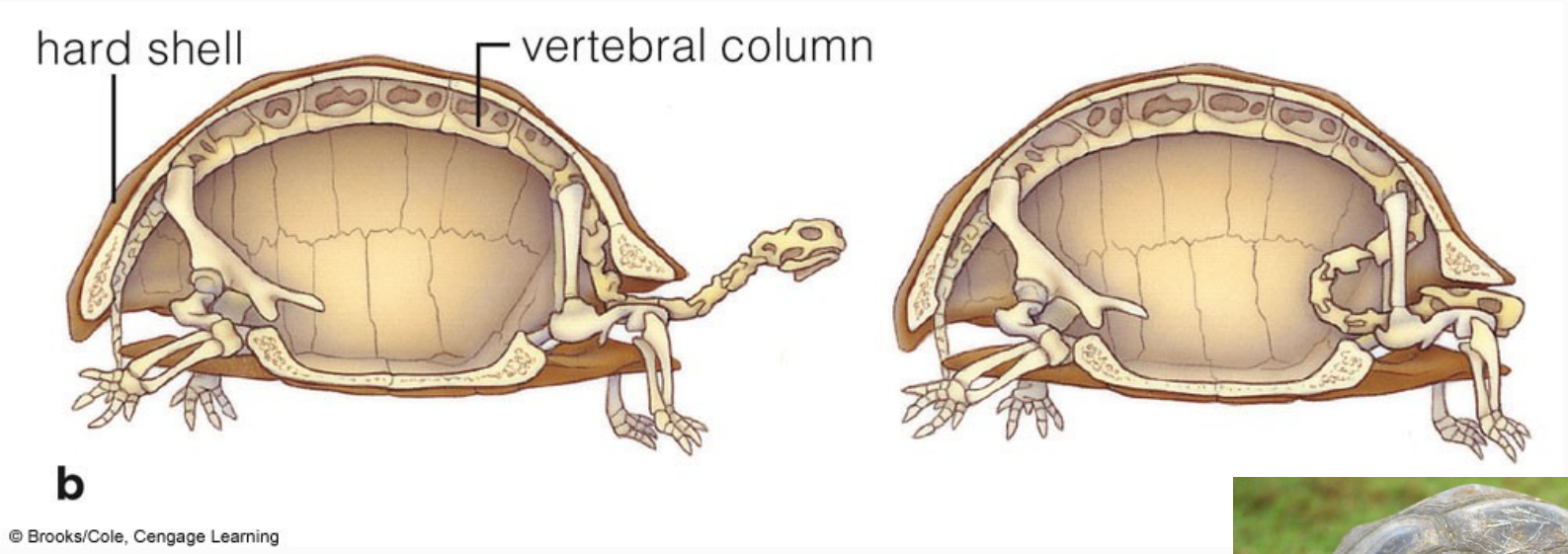
- Major Groups
  - Turtles (shell attached to skeleton)
  - Lizards (the most diverse reptiles)
  - Snakes (limbless)
  - Tuataras (some amphibian-like traits; third eye)
  - Crocodilians (closest relatives of birds)

Diversity of Modern Reptiles

- Reptile characteristics
  - Scale-covered body
  - **Cloaca** for waste disposal
  - Four approximately equal limbs (except snakes)
  - Internal fertilization
  - Body temperature determined by surroundings (**ectotherms**)

Turtles and Tortoises

- **Turtles** and tortoises have a bony, scale-covered shell attached to the backbone



Lizards

- **Lizards**, the most diverse reptiles, have many interesting defenses

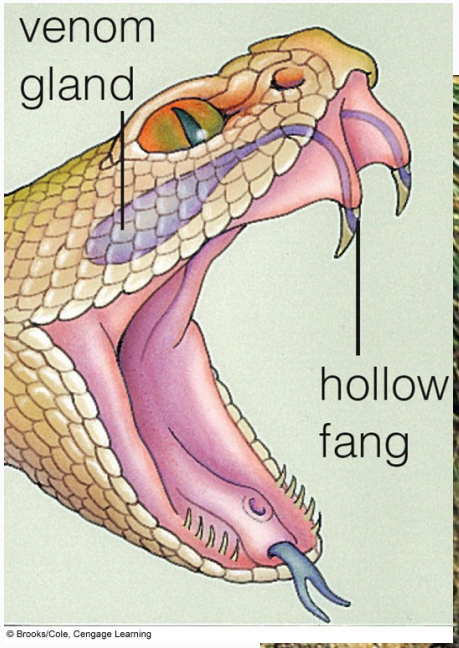
Tuataras

- The two remaining species of **tuataras** have a third eye under the skin of the forehead

http://www.youtube.com/v/RyNivqawzHY

Snakes

- **Snakes** are legless, but some have bony remnants of hindlimbs



Crocodilians

- Crocodilians, close relatives of birds, are the only reptiles with a four-chambered heart (like birds and mammals)

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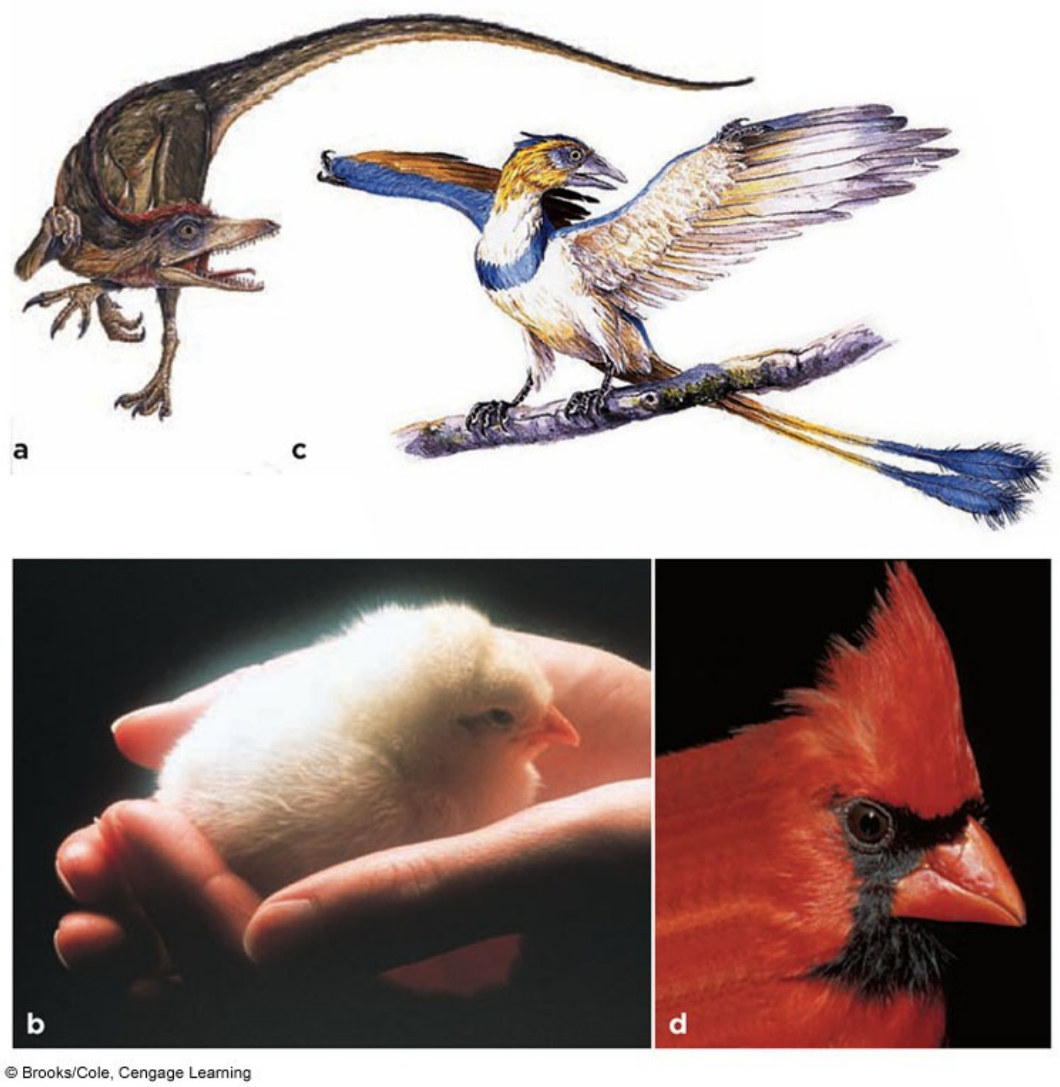
For details of chordate classification, see Appendix I.

Birds—The Feathered Ones

- Birds are the only animals with feathers
  - Descendants of flying dinosaurs in which scales became modified as feathers
  - Long feathers are adapted for flight
  - Downy feathers provide insulation

Dinosaurs and Feathers



Bird Adaptations

- Bird characteristics
  - Eggs
  - No teeth
  - Produce body heat (**endotherms**)
  - Lightweight skeleton, strong muscles, and efficient circulation and respiration for flight
  - Wings with flight feathers

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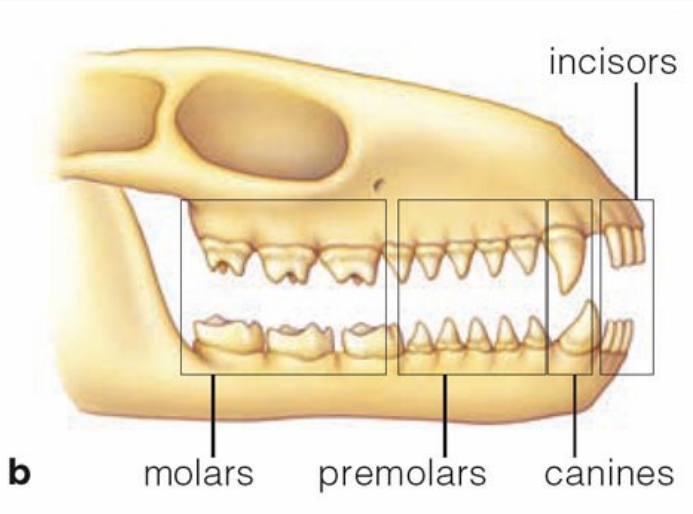
For details of chordate classification, see Appendix I.

The Rise of Mammals

- **Mammals** are animals that nourish young with milk and have hair or fur; four kinds of teeth allow them to eat many kinds of food

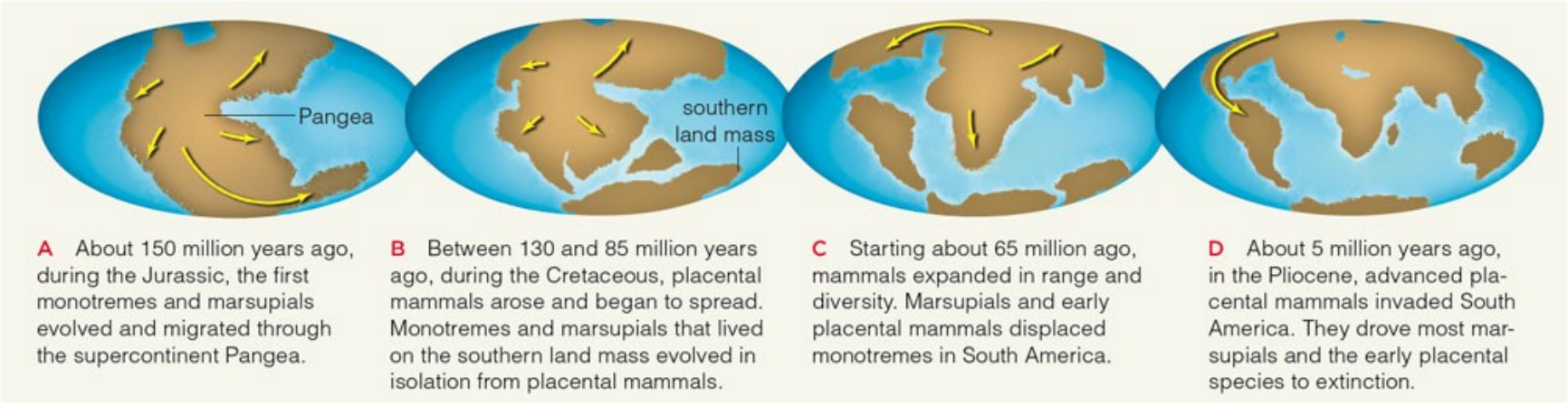


Mammalian Evolution

- **Monotremes** (egg-laying mammals) and **marsupials** (pouched mammals) evolved during the Jurassic

- **Placental mammals** (mammals with a **placenta** that exchanges materials between the mother and embryo inside the body) evolved later

Distribution of Mammalian Lineages



A About 150 million years ago, during the Jurassic, the first monotremes and marsupials evolved and migrated through the supercontinent Pangea.

B Between 130 and 85 million years ago, during the Cretaceous, placental mammals arose and began to spread. Monotremes and marsupials that lived on the southern land mass evolved in isolation from placental mammals.

C Starting about 65 million ago, mammals expanded in range and diversity. Marsupials and early placental mammals displaced monotremes in South America.

D About 5 million years ago, in the Pliocene, advanced placental mammals invaded South America. They drove most marsupials and the early placental species to extinction.

Key Concepts
The Amniotes

- *Amniotes—reptiles, birds, and mammals—have waterproof skin and eggs, highly efficient kidneys, and other traits that adapt them to a life that is typically lived entirely on land*

- *Reptiles and birds belong to one amniote lineage, and mammals to another*

Modern Mammalian Diversity

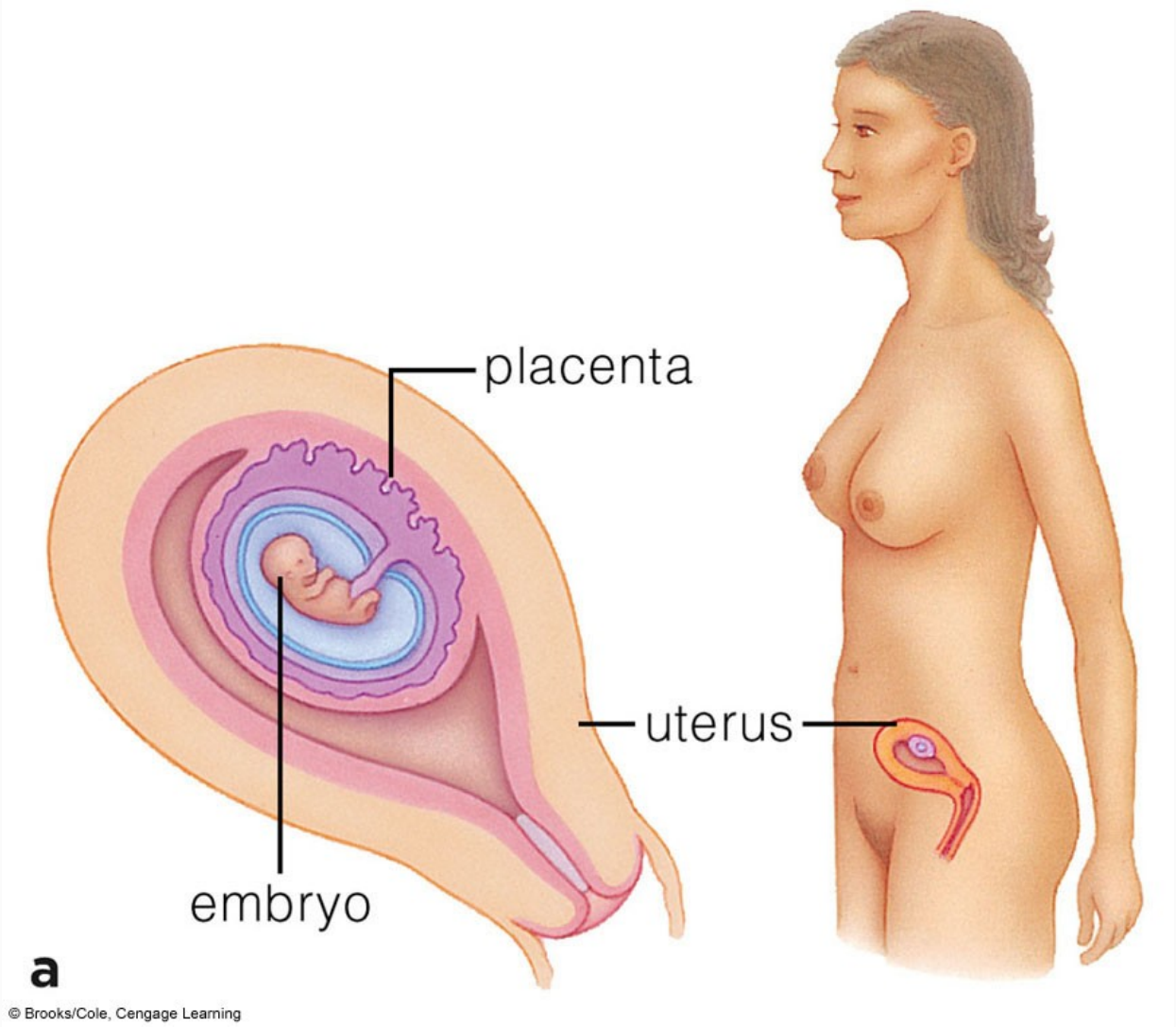
- Egg-laying monotremes lay leathery eggs
  - Spiny anteaters, platypus
- Pouched marsupials develop in a pouch
  - Kangaroos, koala, opossum, Tasmanian devil
- Placental mammals include most living mammals
  - Rodents and bats are the most diverse groups

Monotremes: Platypus

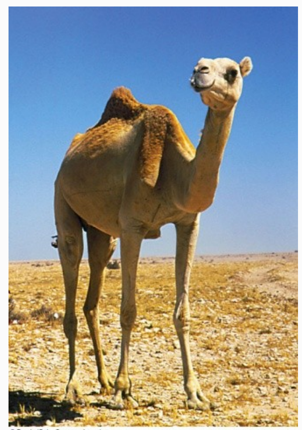
http://www.youtube.com/v/DvB0WT2Id0U

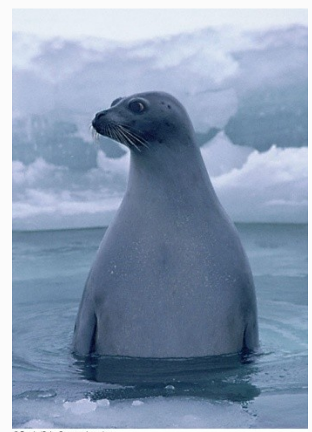
Marsupials

Placental Mammals: The Placenta



Placental Mammals





From Early Primates to Hominids

- **Primates**: Mammalian subgroup including humans, apes, monkeys, and prosimians (primates that aren't monkeys or apes or humans – i.e. lemurs)
- **Anthropoids**: Humans, apes, and monkeys
- **Hominids**: Humans and apes

Primates

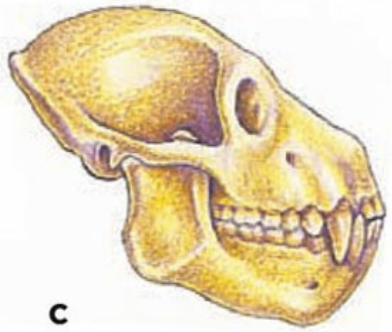
Origins and Early Divergences

- 65 mya: First primates (shrewlike)
- 36 mya: Tree dwelling anthropoids
- 23-18 mya: First hominoids (early apes)
- 6 mya: Hominids

Early Primates

a

b



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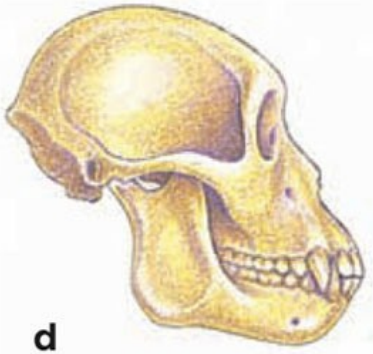


d

http://www.youtube.com/v/W5QJaznkqjM

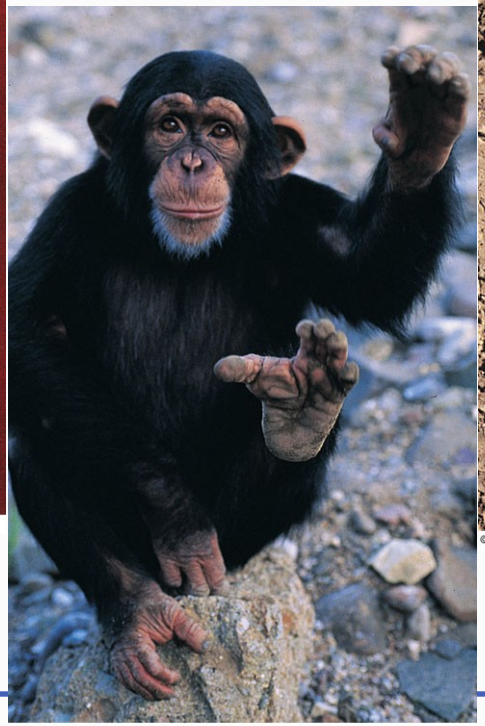
Emergence of Early Humans

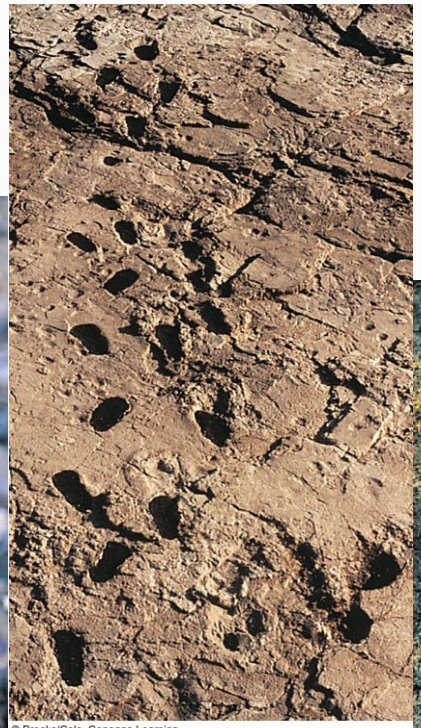
- 6-8 mya: Early hominids from Africa

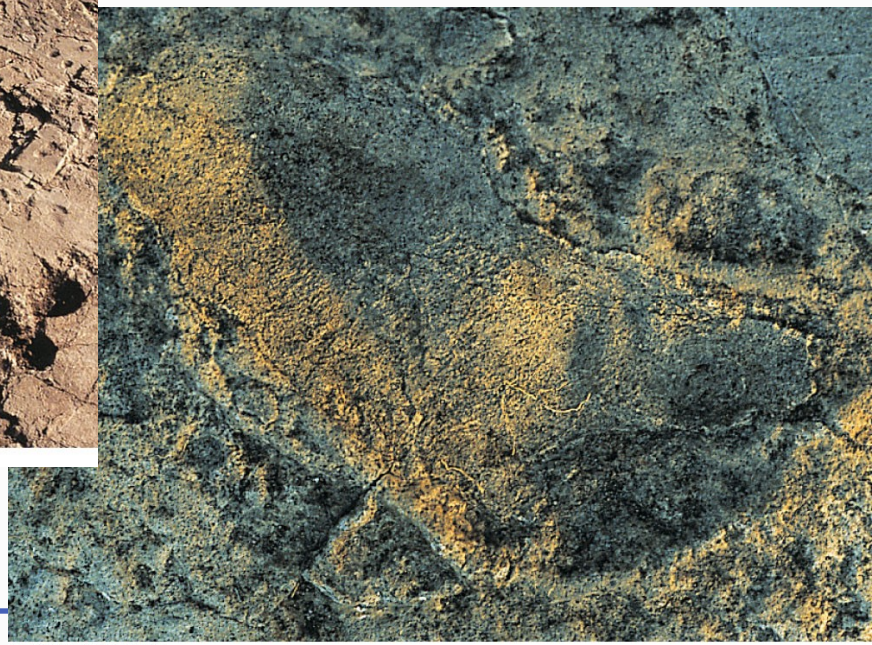
Sahelanthropus tchadensis	*Australopithecus africanus*	*Paranthropus boisei*	*Homo habilis*	*Homo erectus*
6 million years ago	3.2–2.3 million years ago	2.3–1.2 million years ago	1.9–1.6 million years ago	1.9 million to 53,000 years ago

Australopiths

- The first bipedal hominids (*Australopithacus*) were probably human ancestors

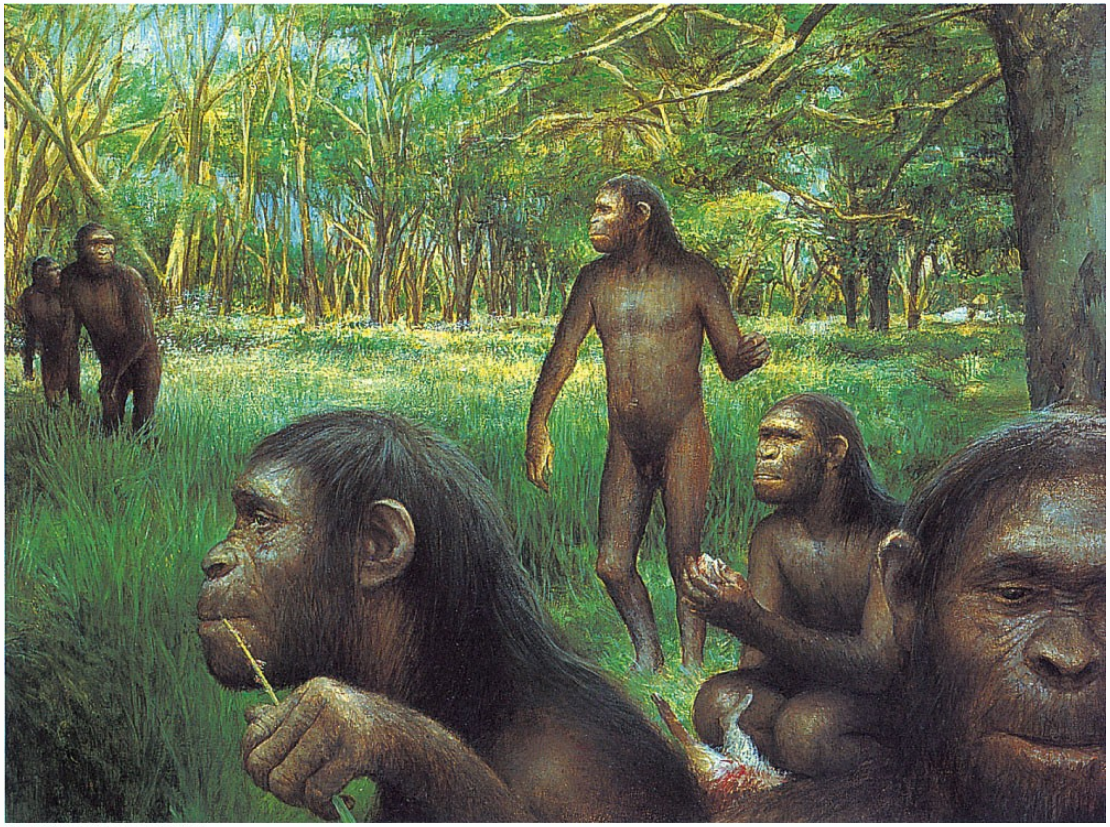






Early Humans

- **Humans** are members of the genus *Homo*
  - *Homo habilis* emerged 1.9 mya



Early Humans

- In Africa 1.8 mya, *Homo erectus* had a larger brain, used simple stone tools and built fires

Emergence of Modern Humans

- *H. erectus* evolved in Africa and spread throughout the world

- *H. neanderthalensis, H. floresiensis,* and modern *H. sapiens* evolved from *H. erectus*

Two Models for the Origin of *H. sapiens*

- **Multiregional model**
  - *H. erectus* in Africa and other regions evolved slowly into *H. sapiens* (based on fossil record)

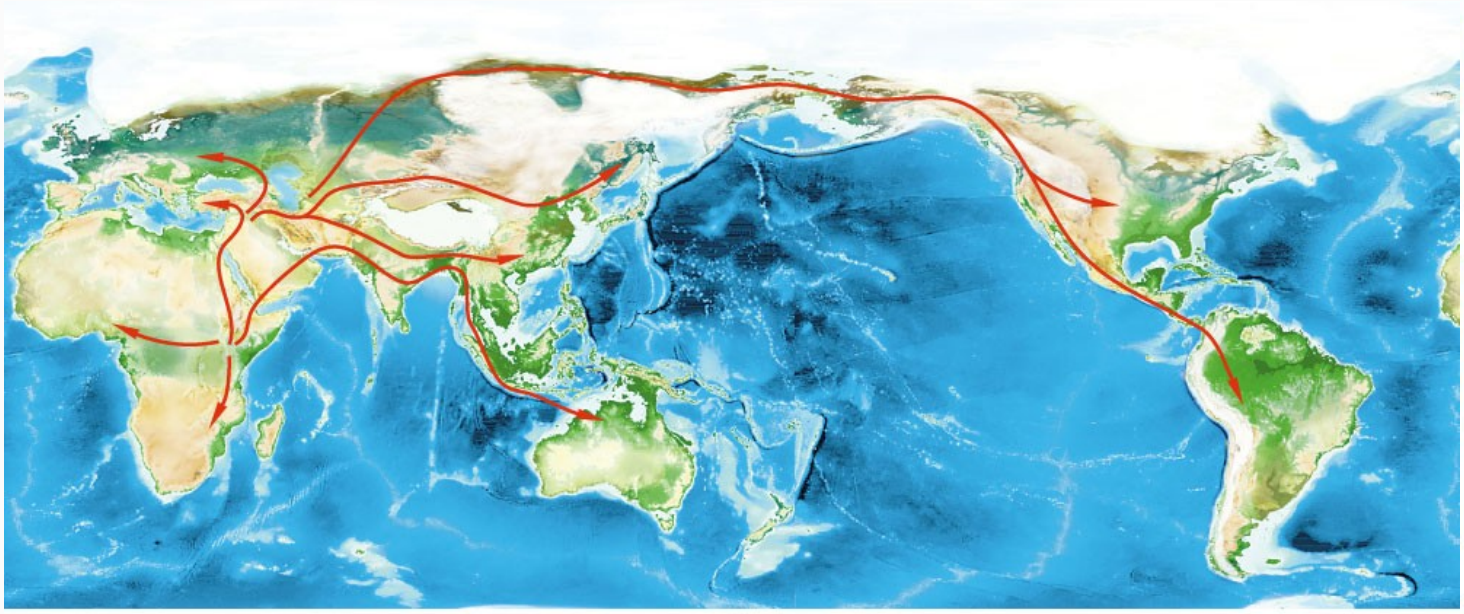
- **Replacement model**
  - *H. sapiens* arose from a single African population of *H. erectus* and drove all other populations to extinction (based on genetics)

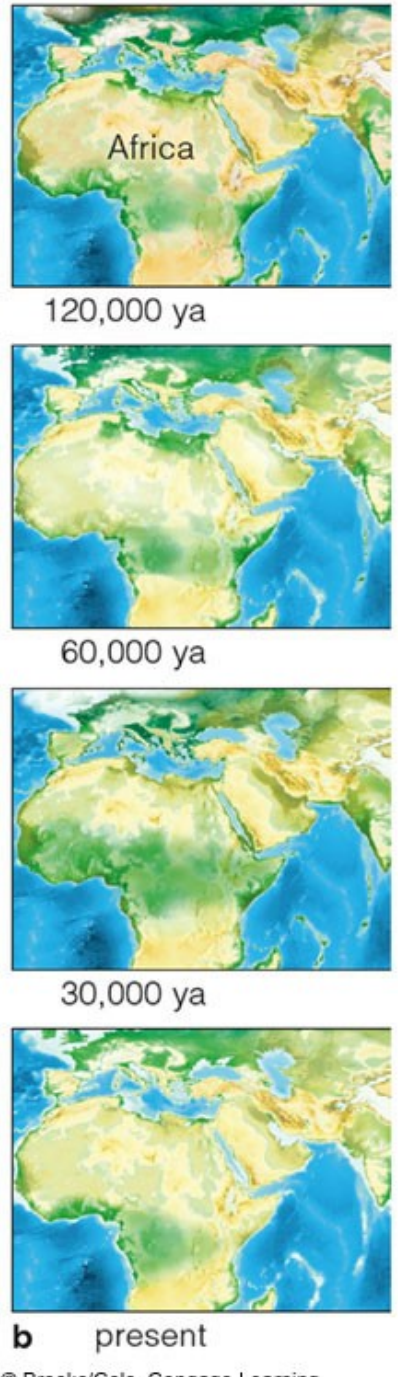
Leaving Home

- Starting 120,000 years ago, long-term shifts in global climate drove humans from Africa into the Middle East, Africa, Australia and Eurasia

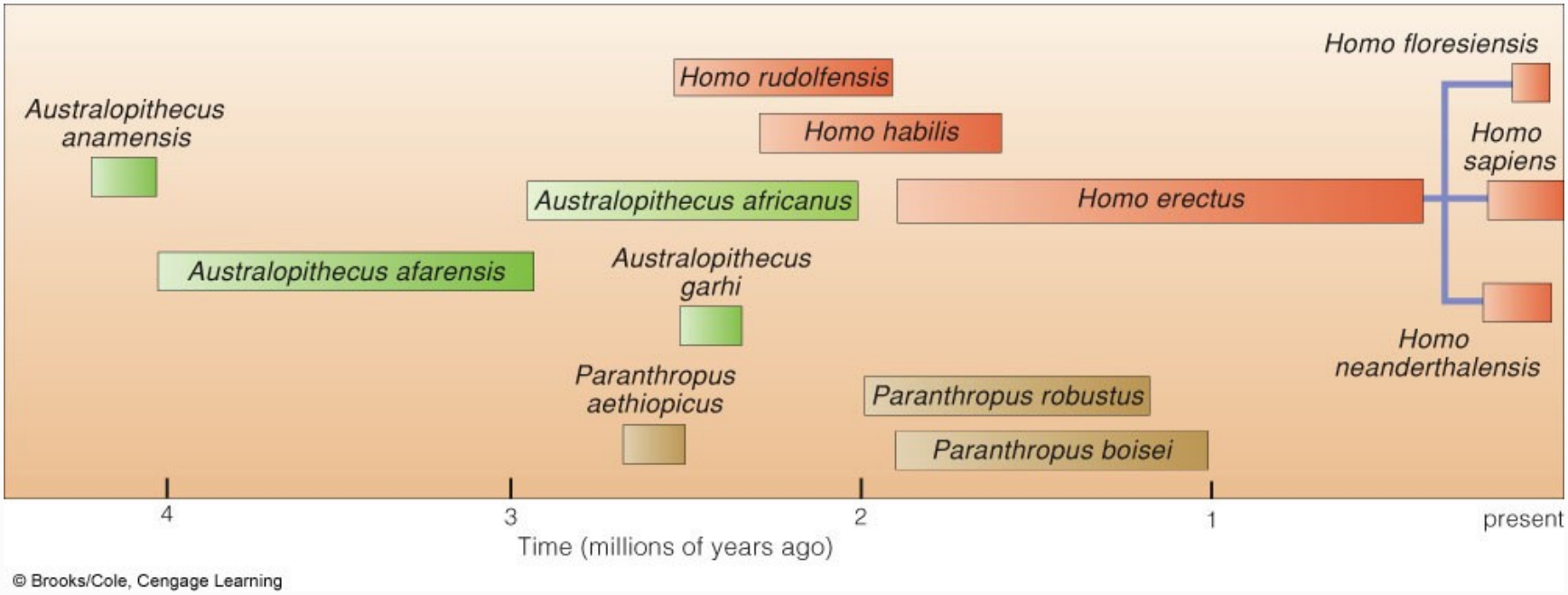
- 15,000 years ago, humans crossed a land bridge from Siberia to North America

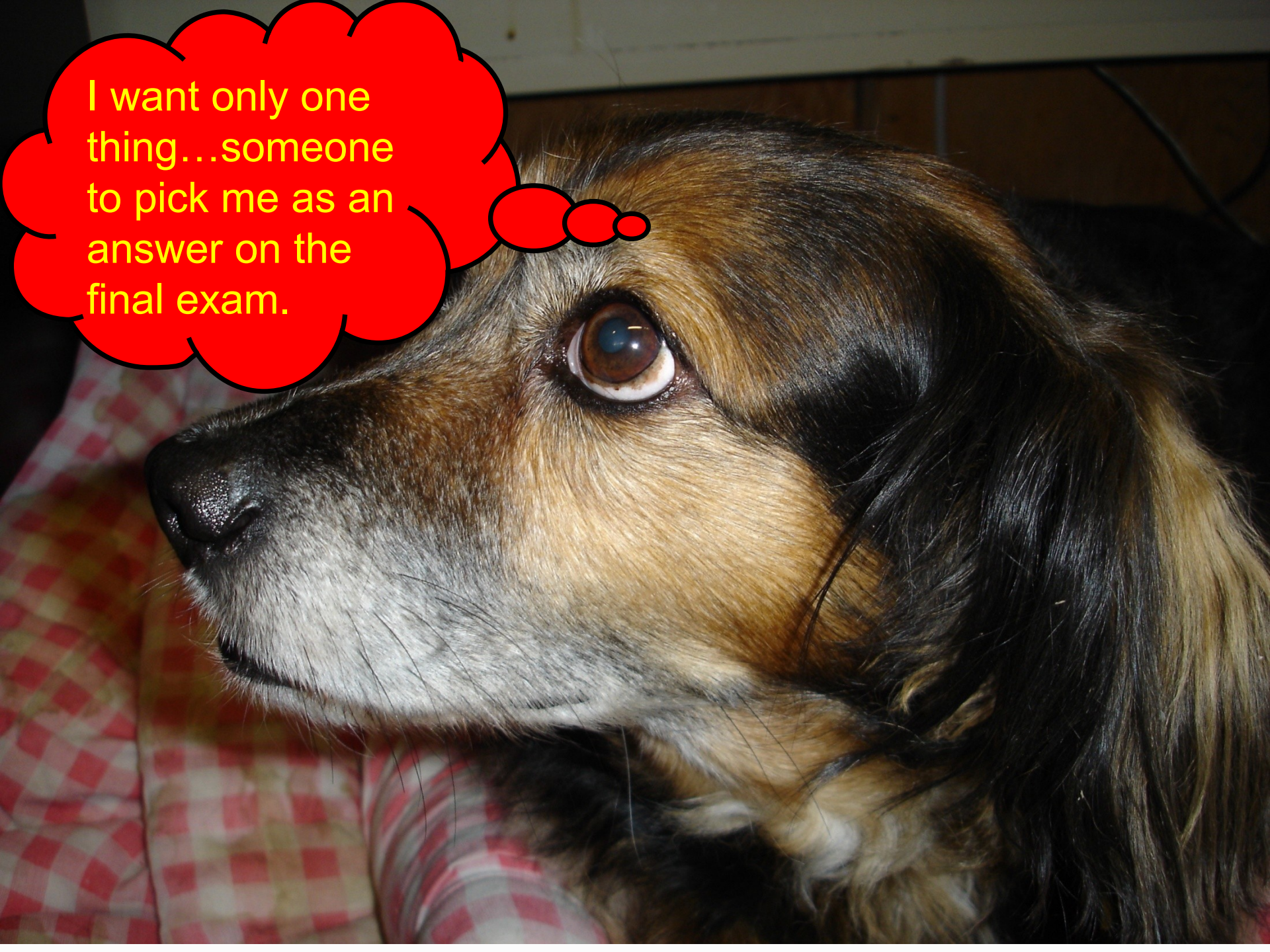
Dispersal Routes of *H. sapiens*





Origins and Extinctions of Hominid Genera




I want only one thing…someone to pick me as an answer on the final exam.