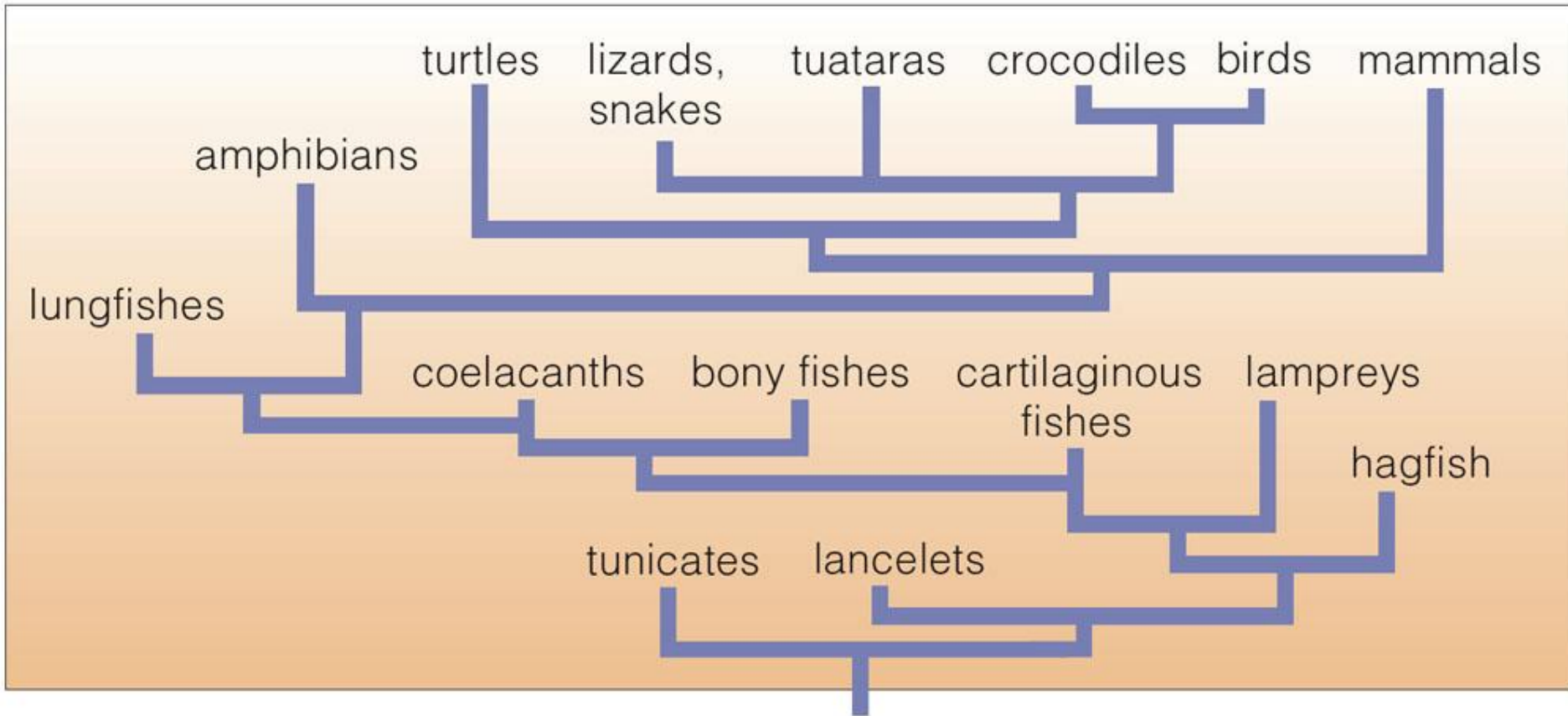


Chapter 26: The Vertebrates



Chordate Features

- **Deuterostomes**
- All share four features:
 - **Notochord supports body**
 - **Nervous system develops from dorsal nerve cord**
 - **Embryos have pharynx with slits**
 - **Embryos have tail that extends past anus**

Tunicates (Urochordates)

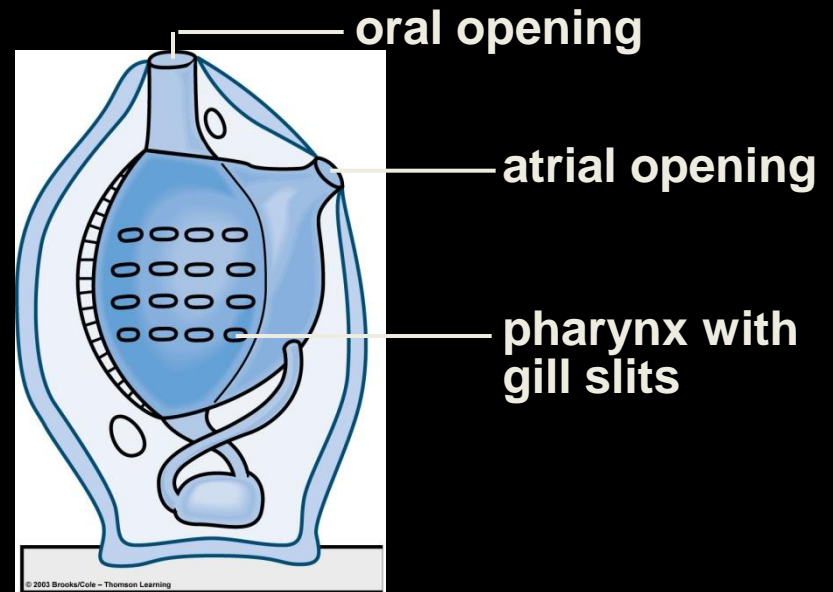
- Larva is free-swimming
- Adult is sessile and baglike with no coelom
- Both stages are filter feeders
- Pharynx serves in both feeding and respiration



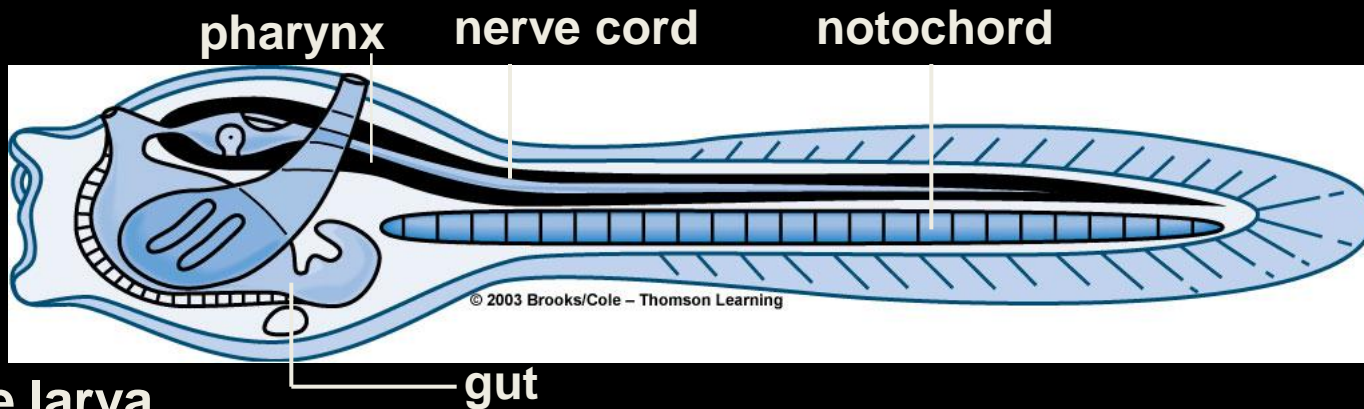
Fig. 26-3a, p.434

Tunicate Life History

Larva undergoes metamorphosis to adult form



Tunicate adult



Tunicate larva

Lancelets (Cephalochordates)

- **Fish-shaped filter feeders**
- Simple brain
- Segmented muscles
- **Chordate characteristics of adult:**
 - Notochord lies under dorsal nerve cord
 - Pharynx has gill slits
 - Tail extends past anus

Lancelet Body Plan

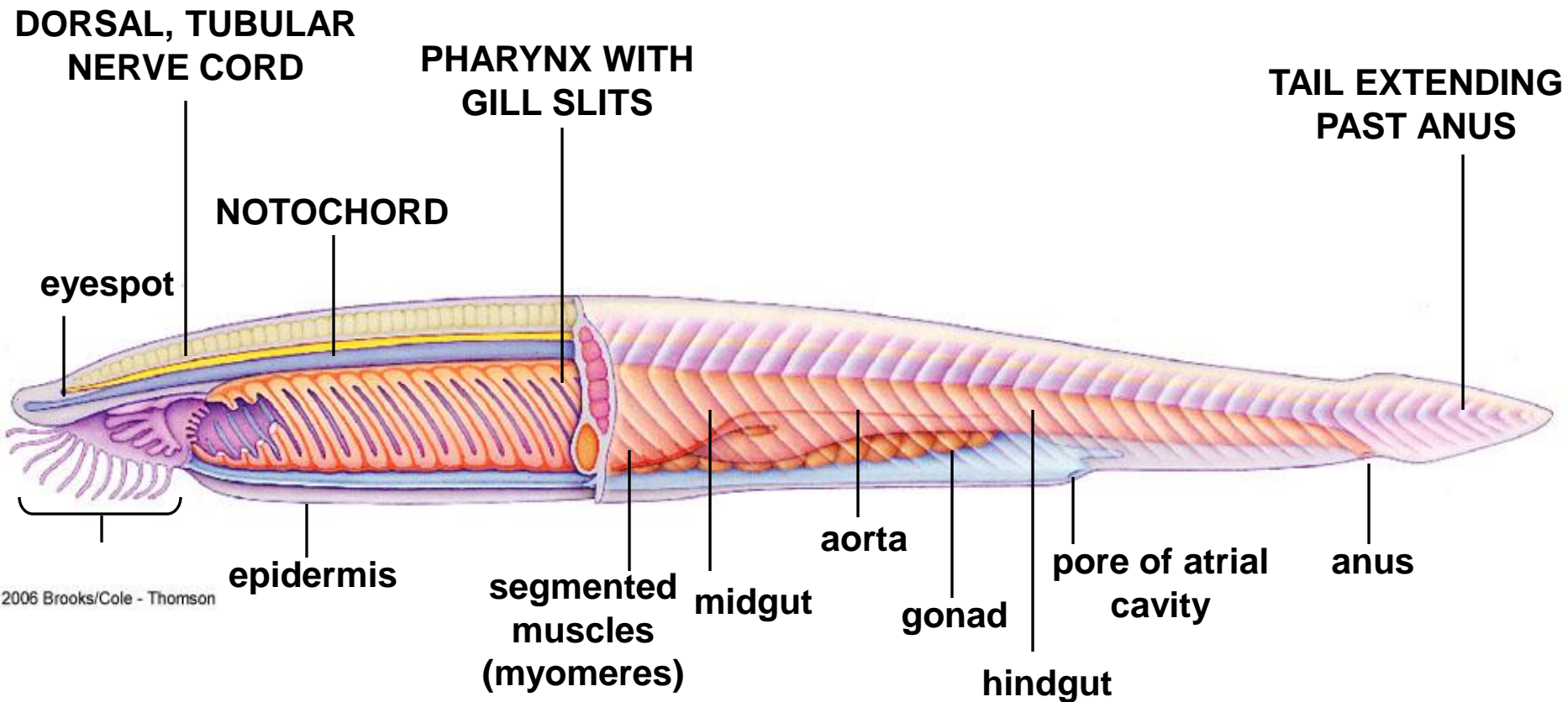


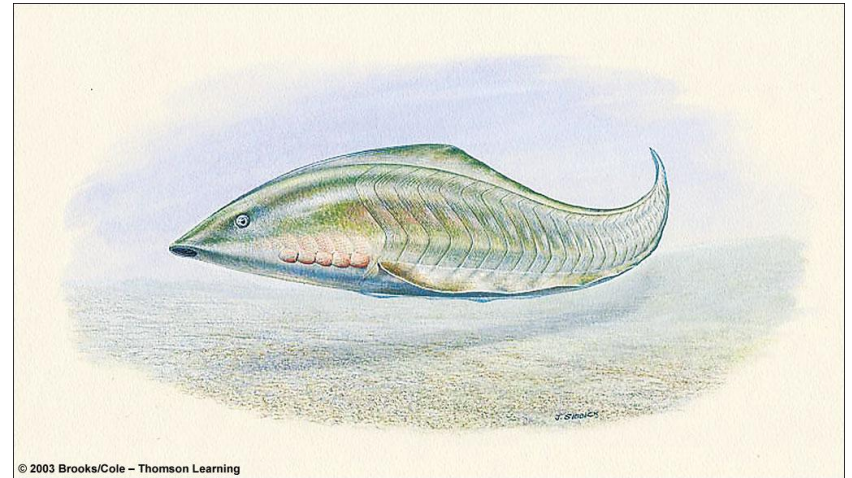
Fig. 26-4, p.435



Fig. 26-5b, p.435

Early Craniates

- Brain inside chamber of cartilage or bone
- Arose before 530 million years ago
- Resemble lancelets, lamprey larva



Reconstruction of one of the earliest known craniates



Fig. 26-5c, p.435

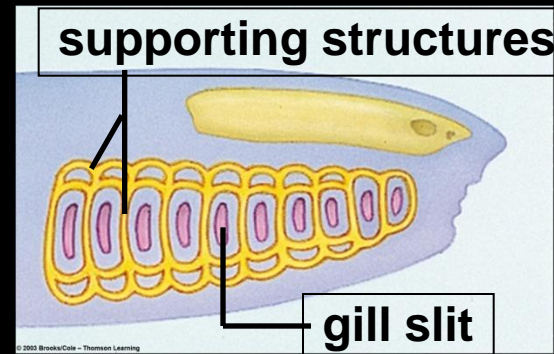


Trends in the Evolution of Vertebrates

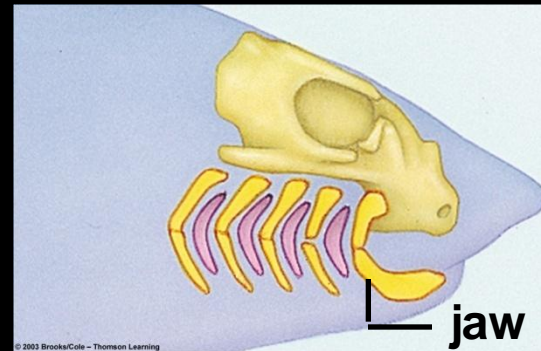
- **Shift from notochord to vertebral column**
- **Nerve cord expanded into brain**
- **Evolution of jaws**
- Paired fins evolved, gave rise to limbs
- Gills evolved, gave rise to lungs

Evolution of Jaws

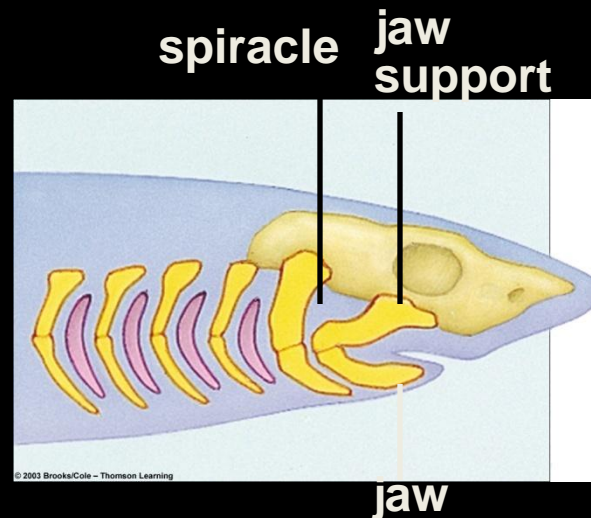
- First fishes lacked jaws
- Jaws are modifications of anterior gill supports



Early jawless fish (agnathan)



Early jawed fish (placoderm)



Modern jawed fish (shark)

Jawed Fishes

- **Most diverse and numerous group of vertebrates**
- **Two classes:**
 - **Chondrichthyes (cartilaginous fishes)**
 - **Osteichthyes (bony fishes)**

Cartilaginous Fishes:

Class Chondrichthyes

- **Most are marine predators**
- **Cartilaginous skeleton**
- **Main groups:**
 - **Skates and rays**
 - **Sharks**
 - **Chimaeras (ratfishes)**

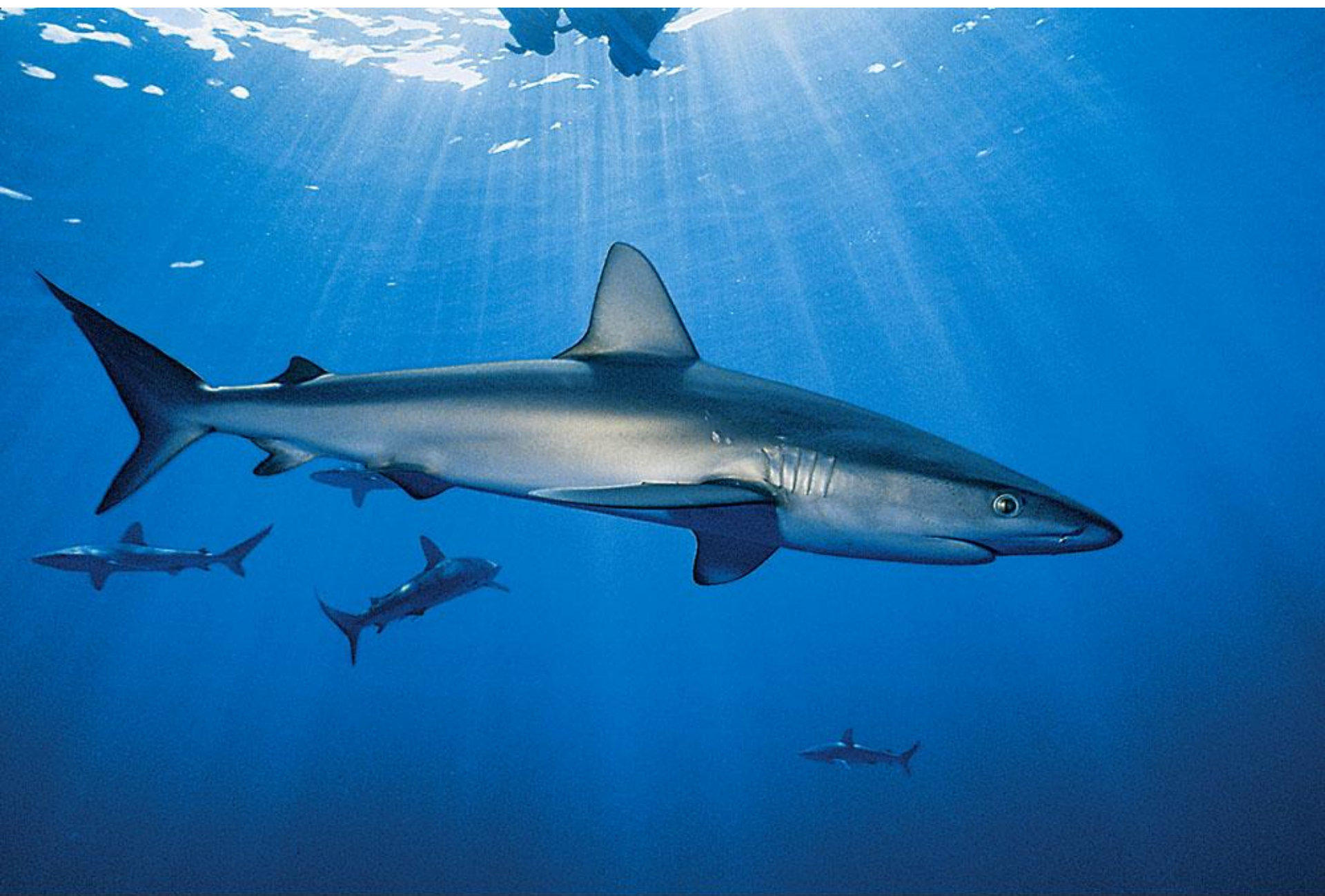


Fig. 26-9a, p.438

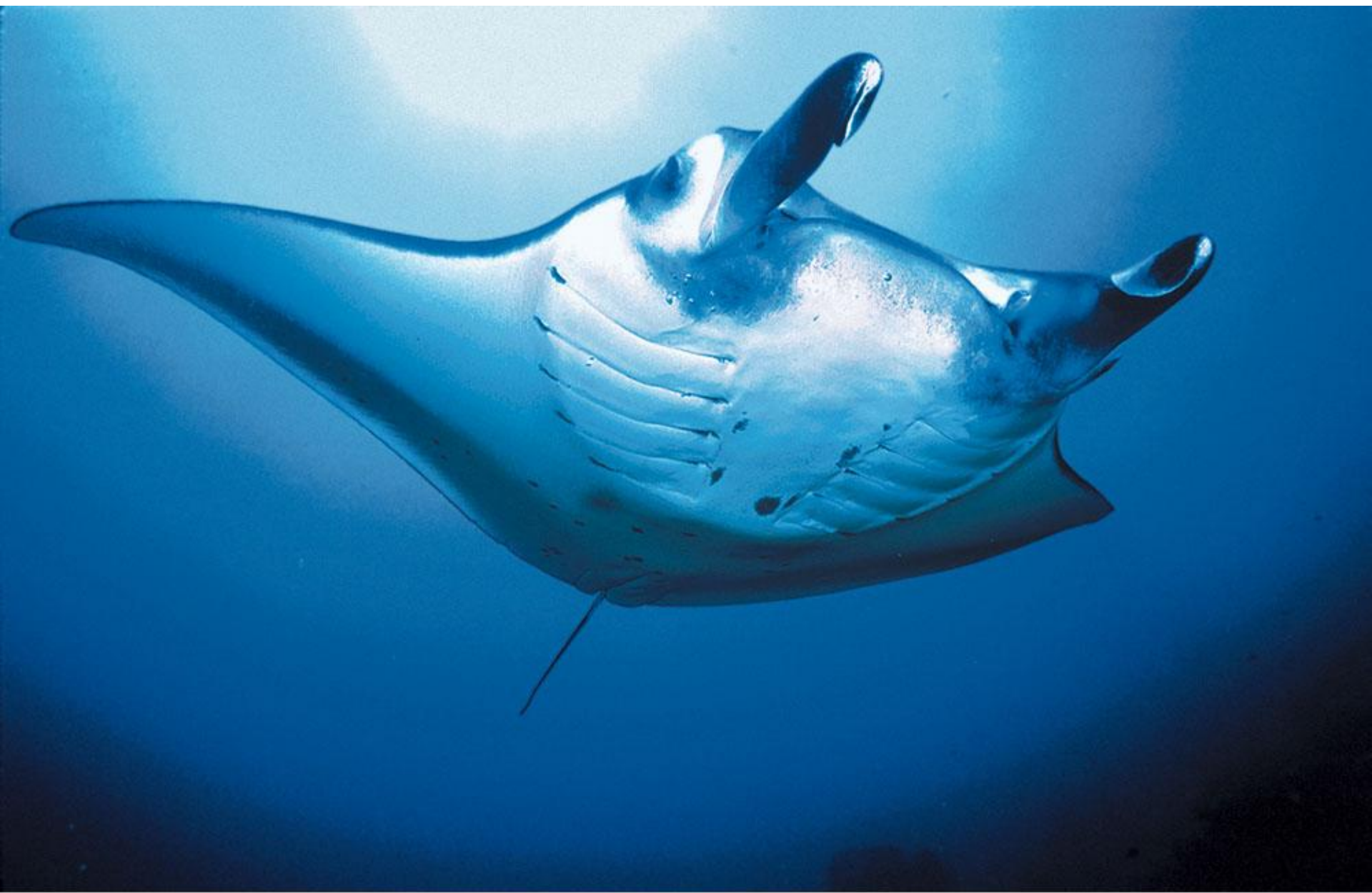


Fig. 26-9b, p.438



Bony Fishes:

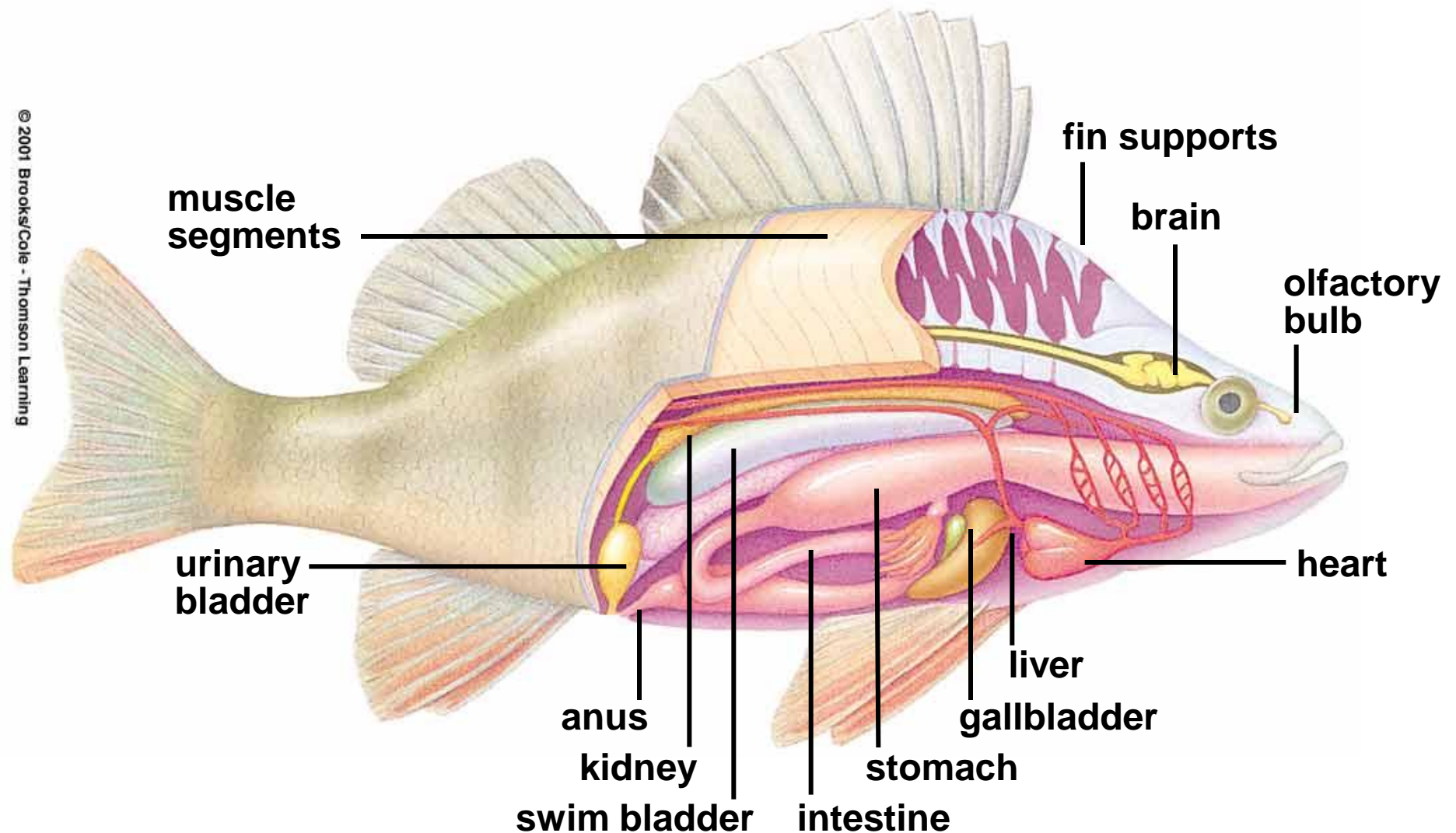
Class Osteichthyes

- Includes 96 percent of living fish species
- Three subclasses:
 - Ray-finned fishes
 - Lobe-finned fishes
 - Lung fishes



Fig. 26-9e, p.438

Body Plan of a Bony Fish



Lungfishes

- Have gills and one lung or a pair
- Must surface to gulp air



Fig. 26-10b, p.439



Fig. 26-10a, p.439

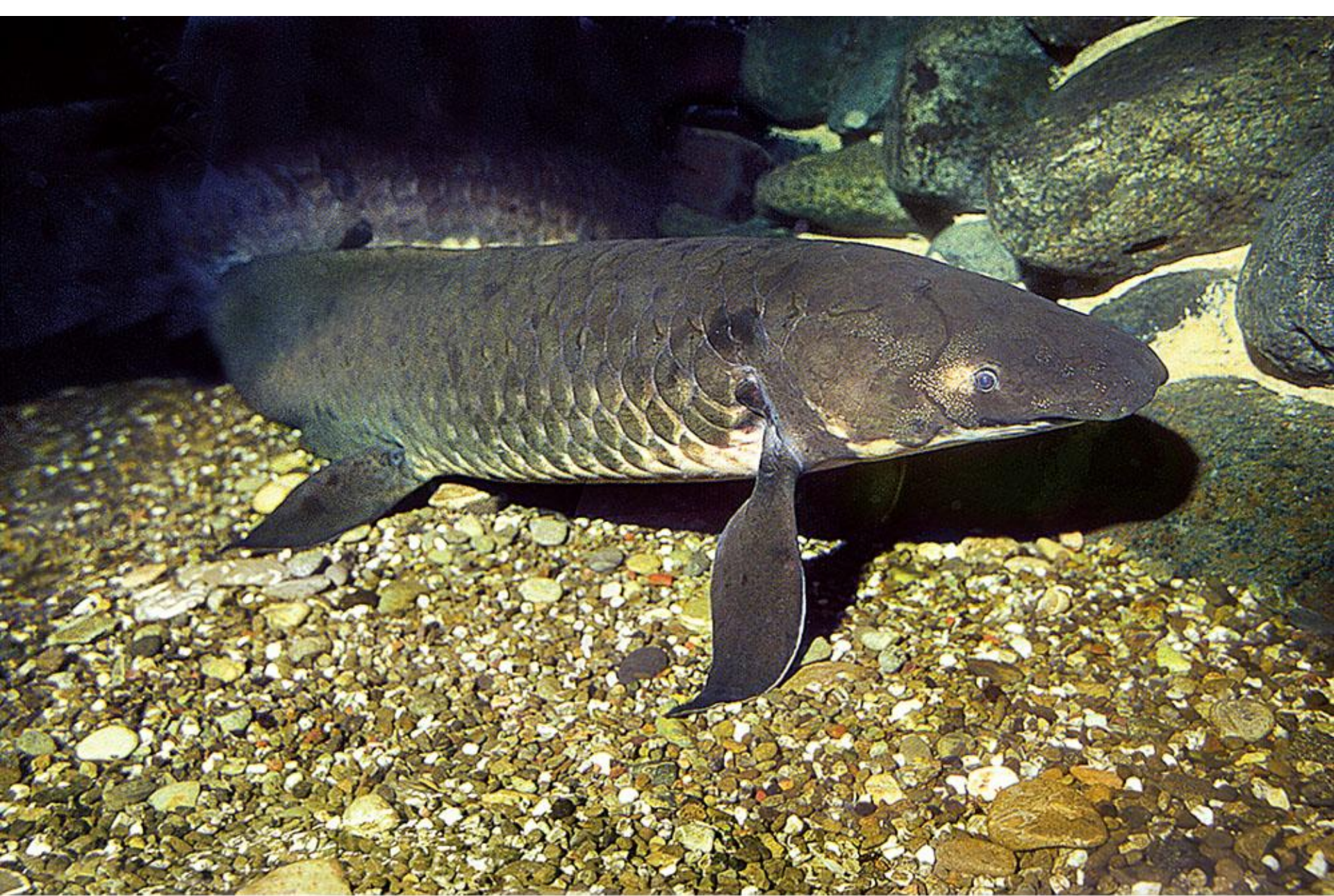
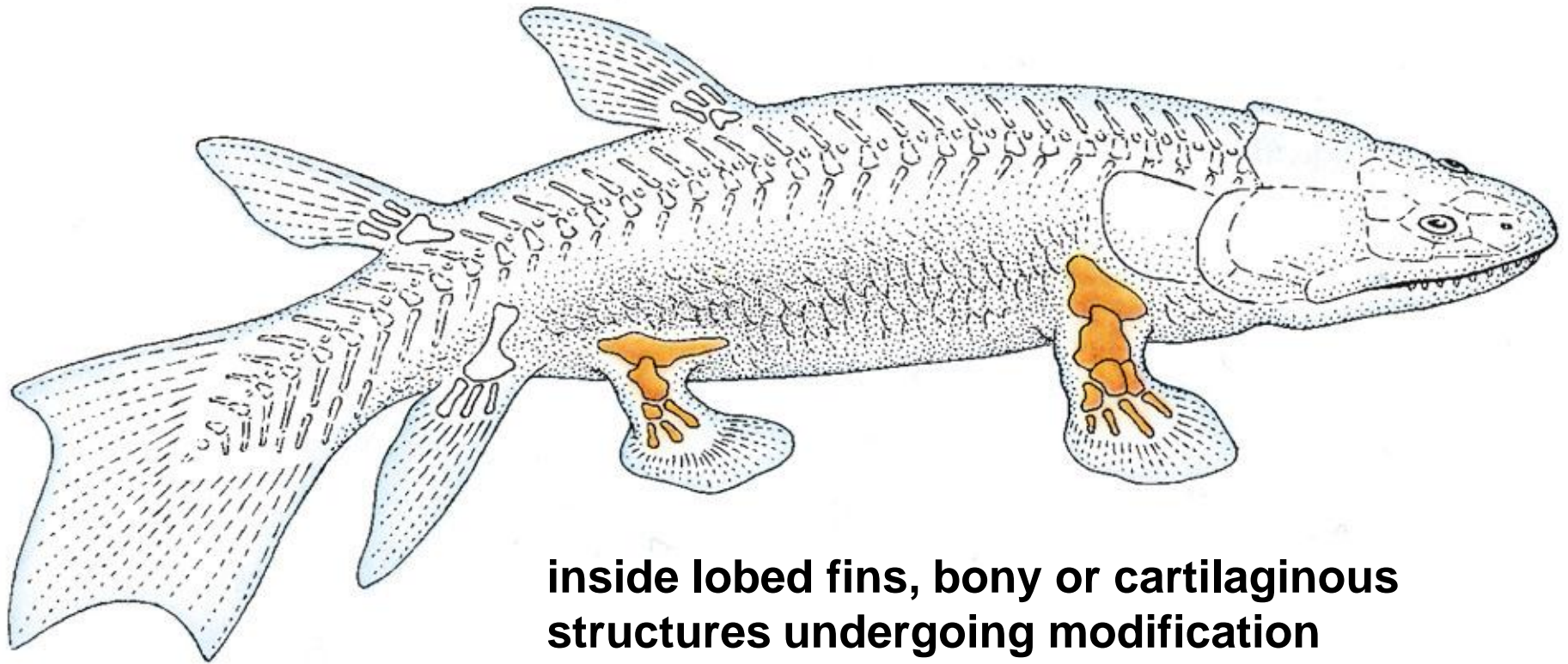


Fig. 26-10b, p.439



**inside lobed fins, bony or cartilaginous
structures undergoing modification**

Early Amphibians

- Fishlike skull and tail
- Four limbs with digits
- Short neck

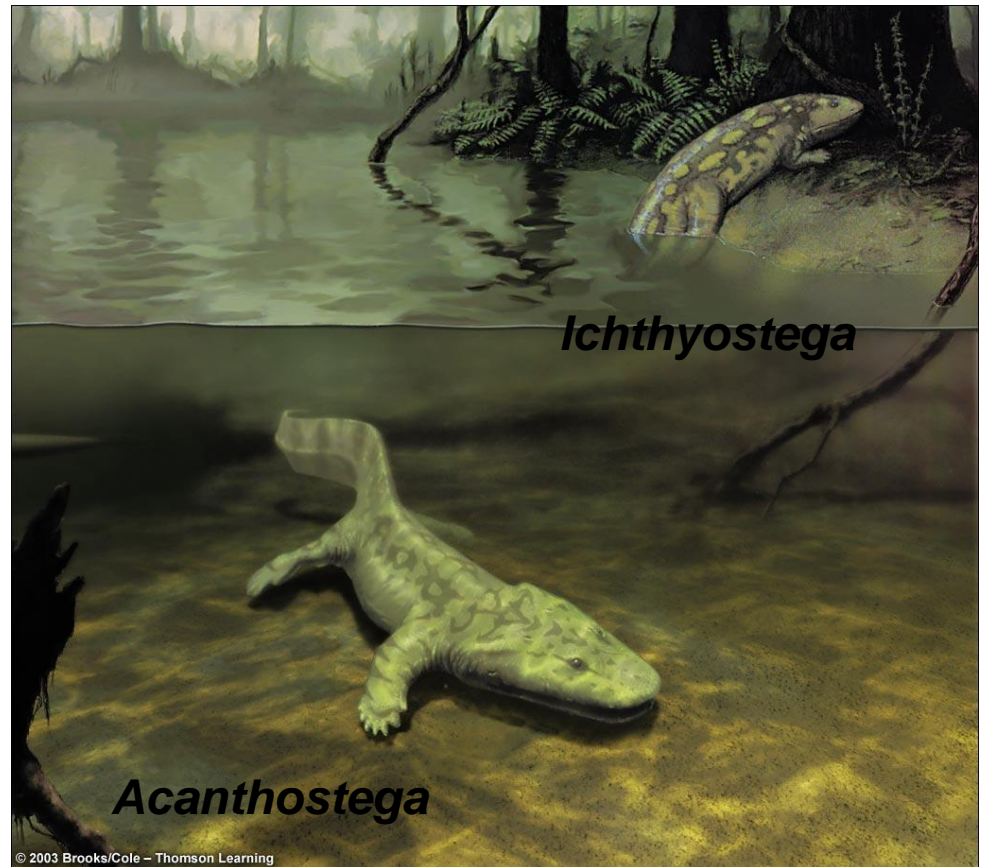


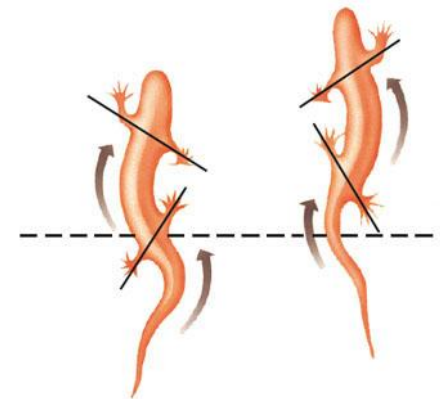
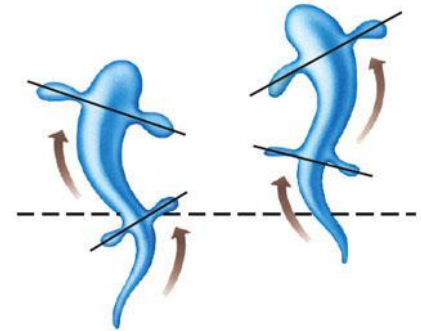
Fig. 26-10c, p.439

Modern Amphibians

- All require water at some stage in the life cycle; most lay eggs in water
- Lungs are less efficient than those of other vertebrates
- Skin serves as respiratory organ

From Fins to Limbs

- Genetic enhancer controls genes involved in formation of digits on limb bones
- Change in a single master gene can drastically alter morphology



Living Amphibian Groups

- Frogs and toads
- Salamanders
- Caecilians

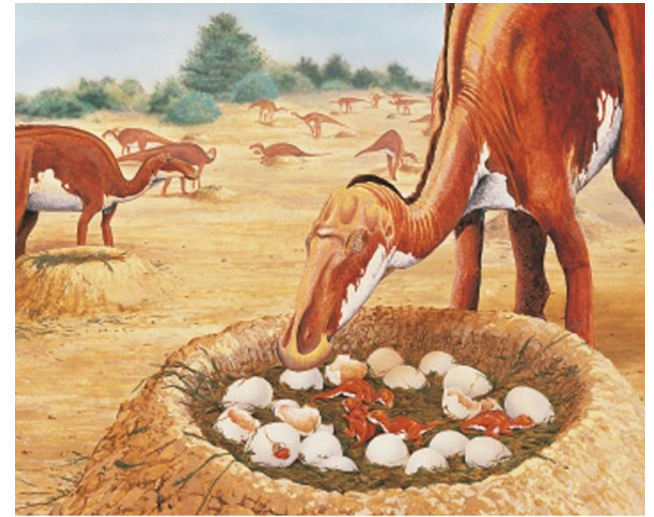






Rise of Amniotes

- **Adaptations to life on land**
 - Tough, scaly skin
 - Internal fertilization
 - Amniote eggs
 - Water-conserving kidneys



© 2008 Brooks/Cole - Thomson

Living Reptiles

Crocodilians

Turtles

Tuataras

Snakes and lizards

Evolutionary History of Amniotes

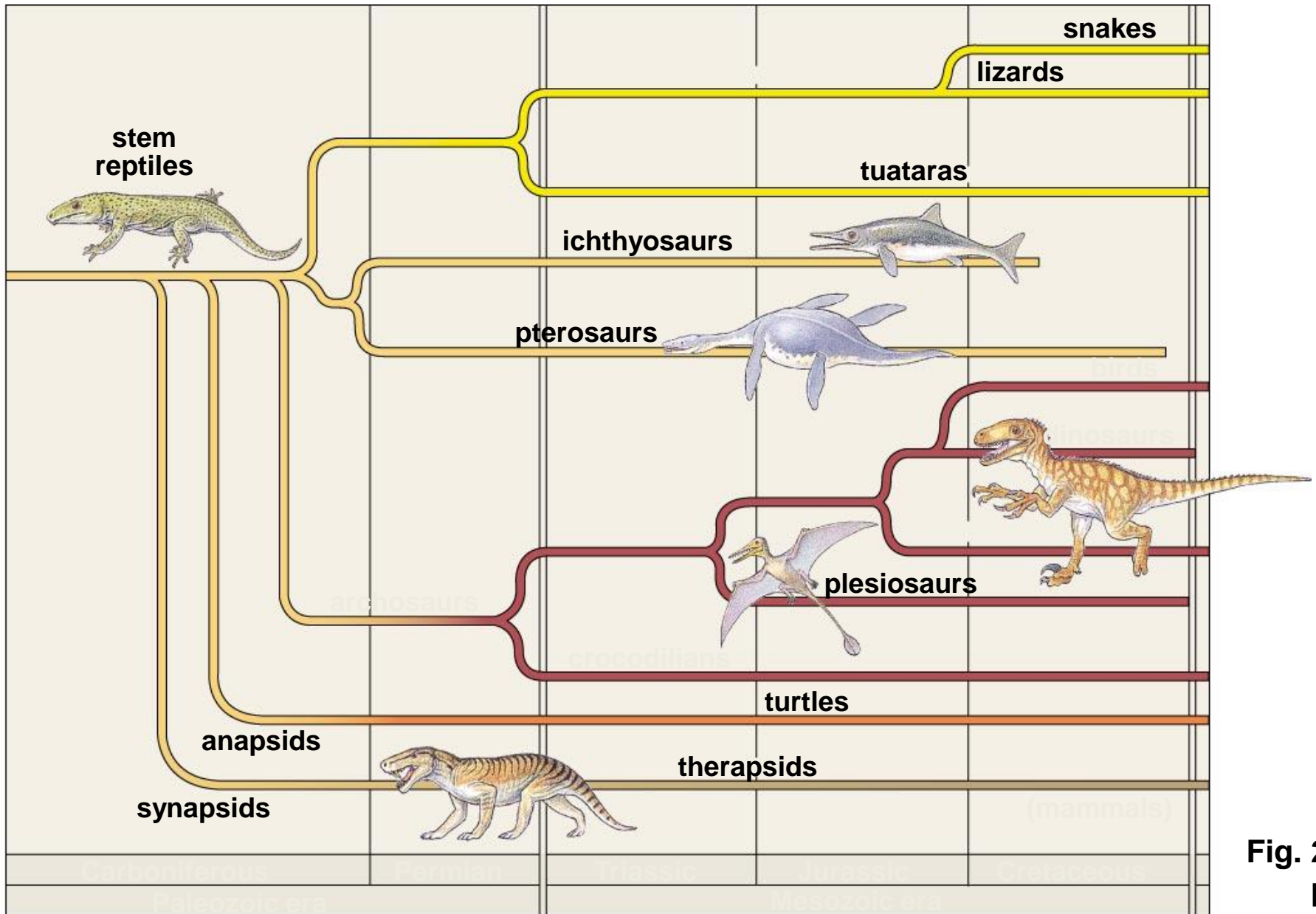
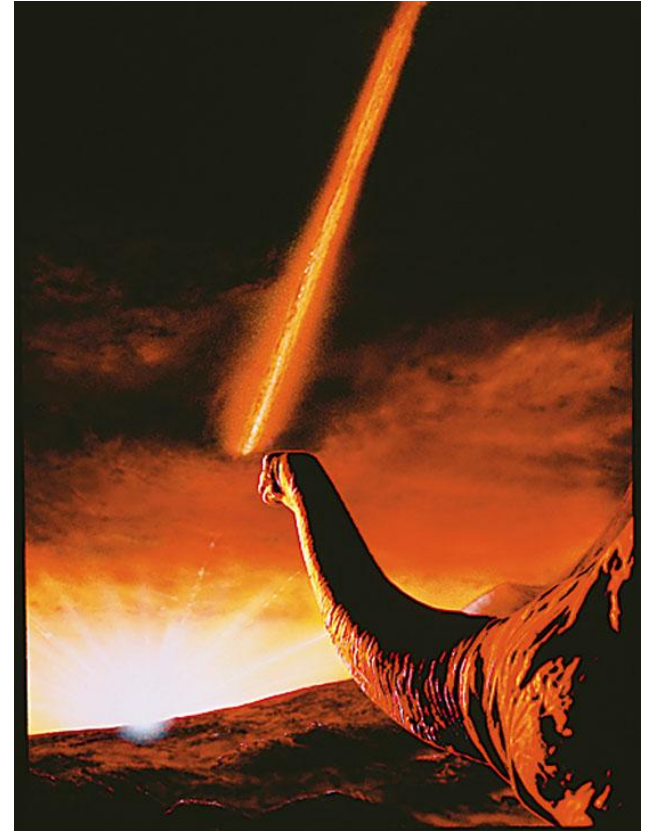


Fig. 26-14
p.442

So Long, Dinosaurs

- Mass extinction between the Cretaceous-Tertiary boundary
- K-T asteroid impact theory
- Global broiling hypothesis



© 2006 Brooks/Cole - Thomson

Crocodile Body Plan

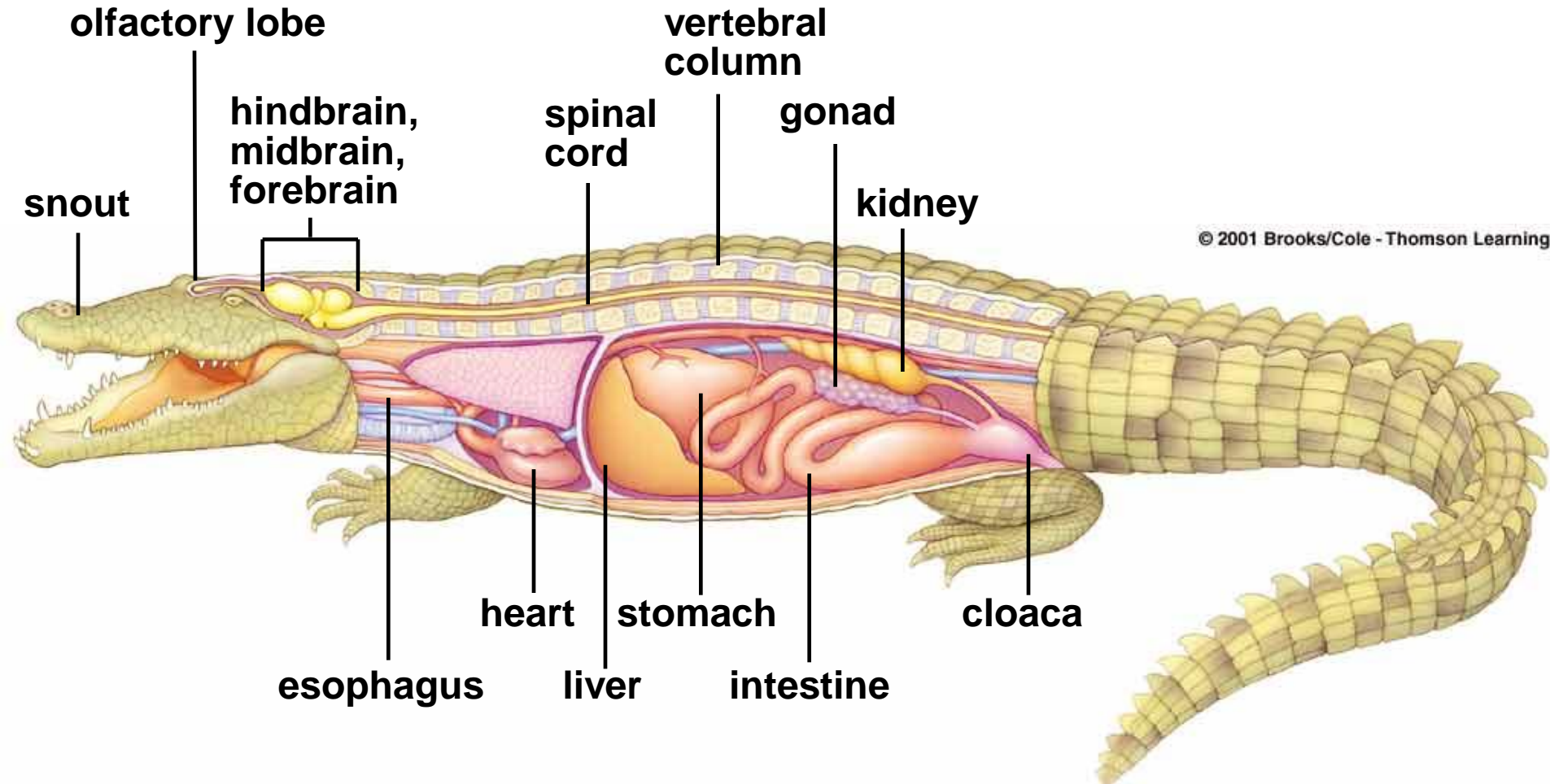
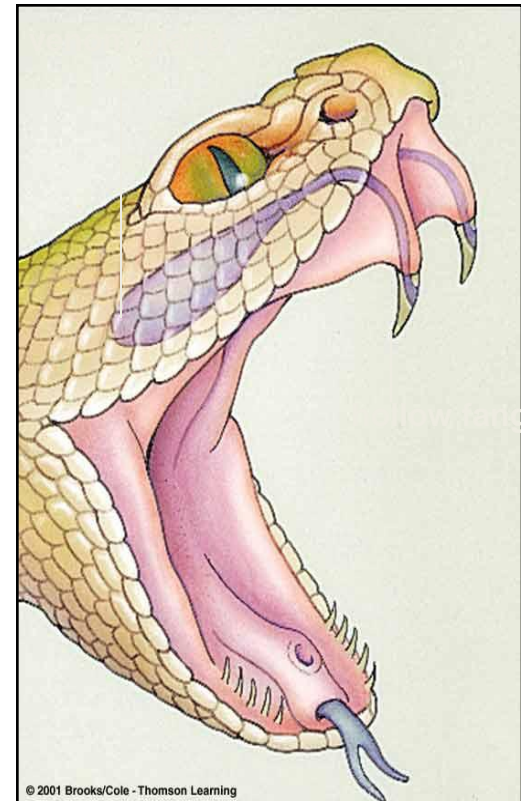


Fig. 26.16, p. 454



Lizards and Snakes

- Largest order (95 percent of living reptiles)
- Most lizards are insectivores with small peglike teeth
- All snakes are carnivores with highly movable jaws



Lizards



Lizards



Snakes





© 2006 Brooks/Cole - Thomson

Fig. 26-17e, p.445

Amniote Egg

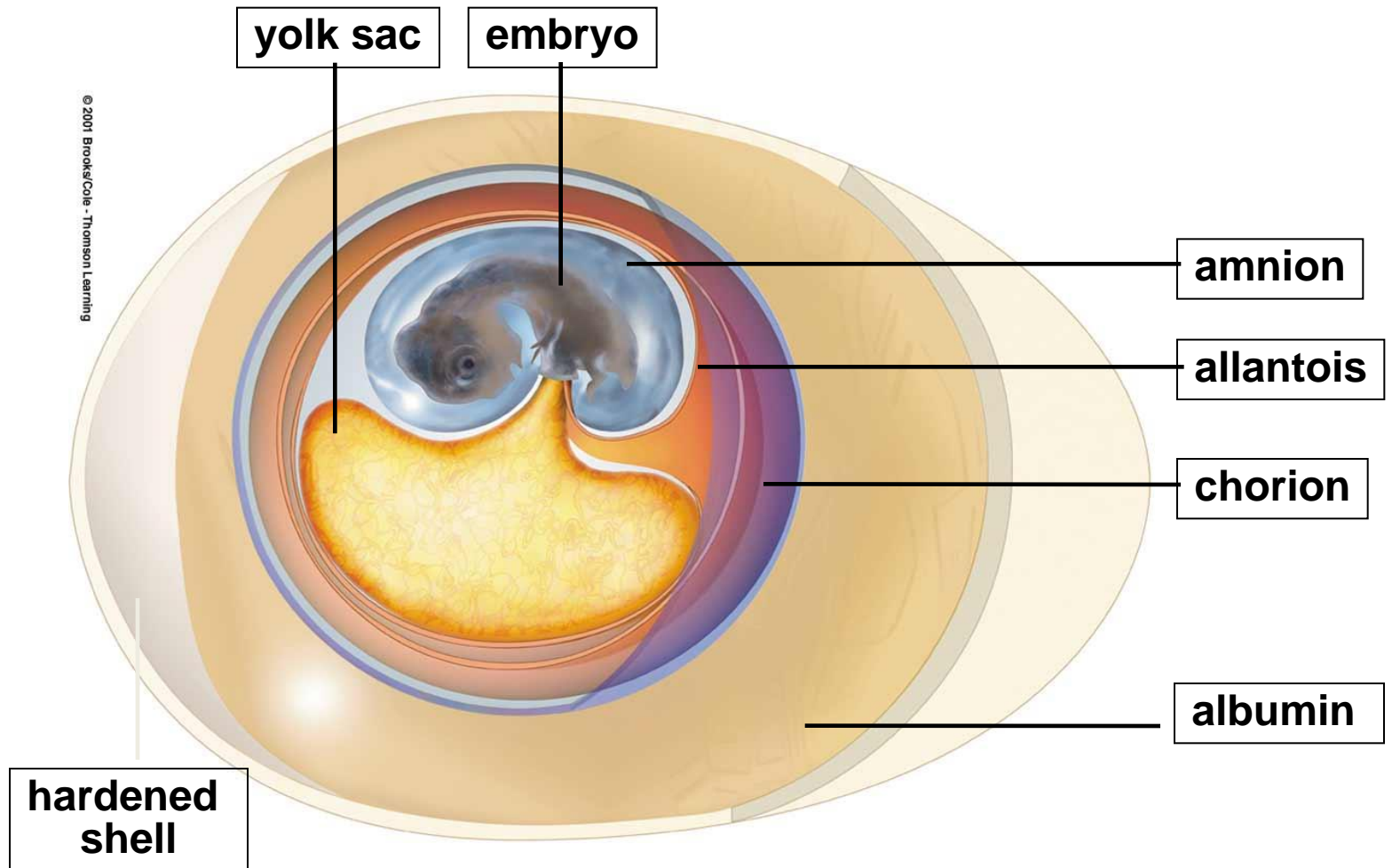


Fig. 26-20, p.446

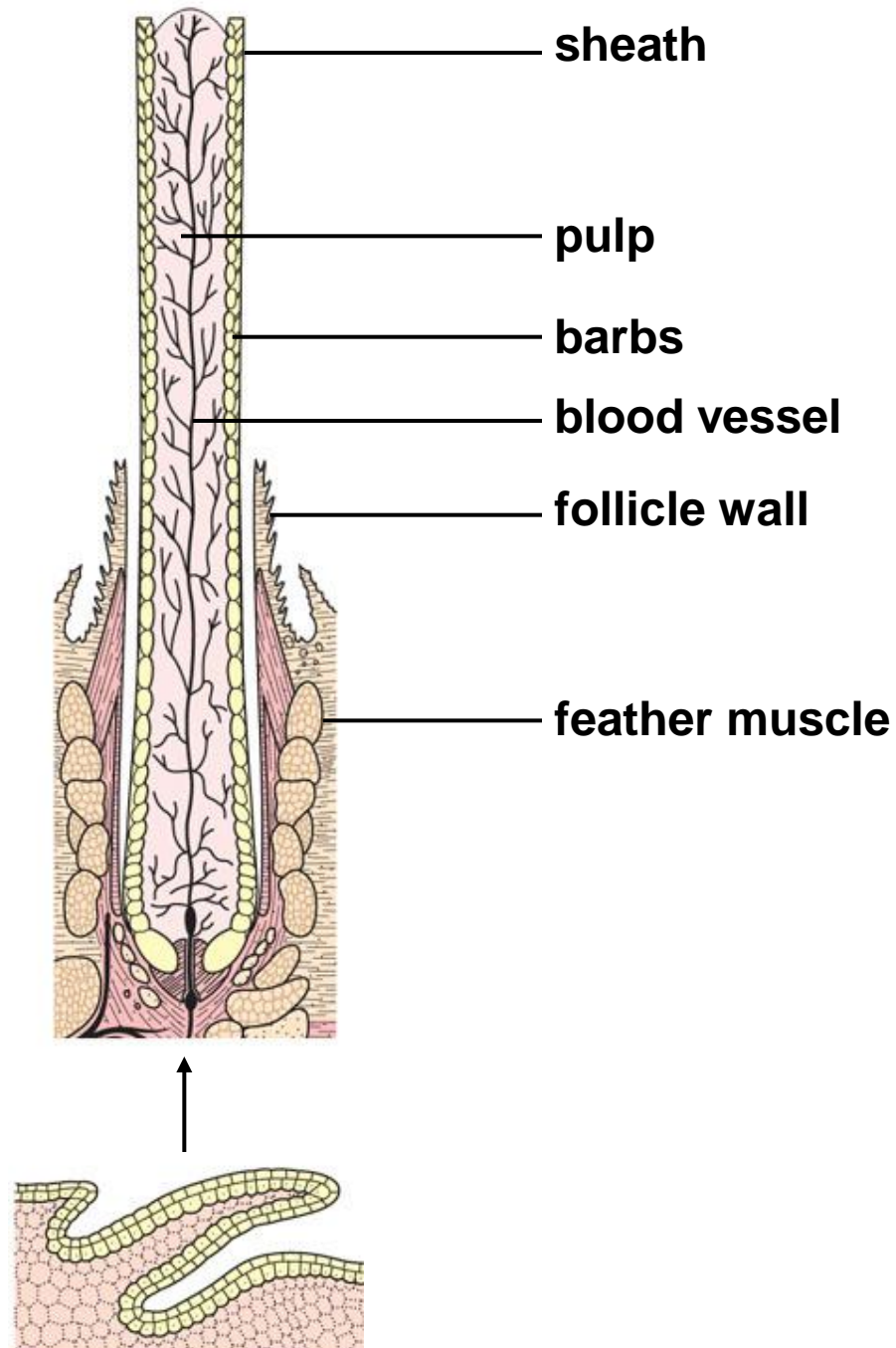
Birds

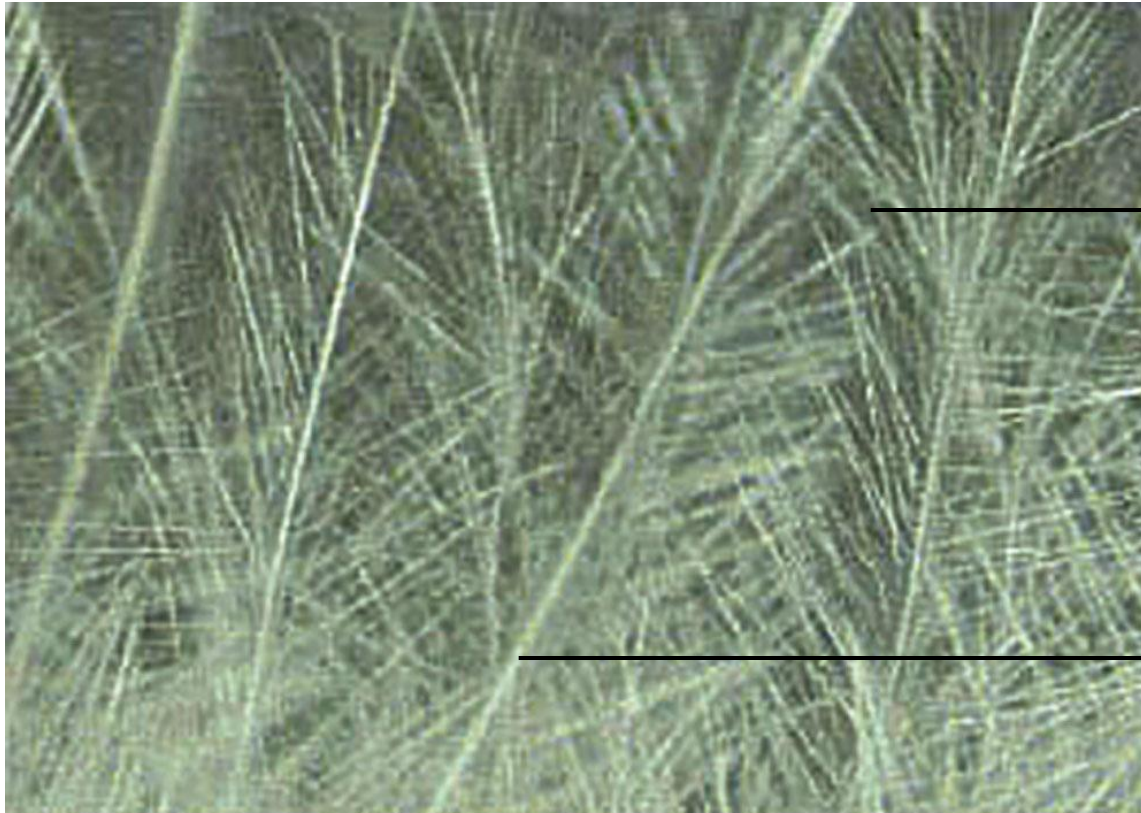
- Diverged from small theropod dinosaurs during the Mesozoic
- **Feathers are a unique trait**
 - Derived from reptilian scales
 - Serve in insulation and flight

Confuciusornis sanctus



© 2006 Thomson Higher Education





barbules

barb

© 2006 Brooks/Cole - Thomson

Bird Flight



© 2006 Brooks/Cole - Thomson

Adapted for Flight

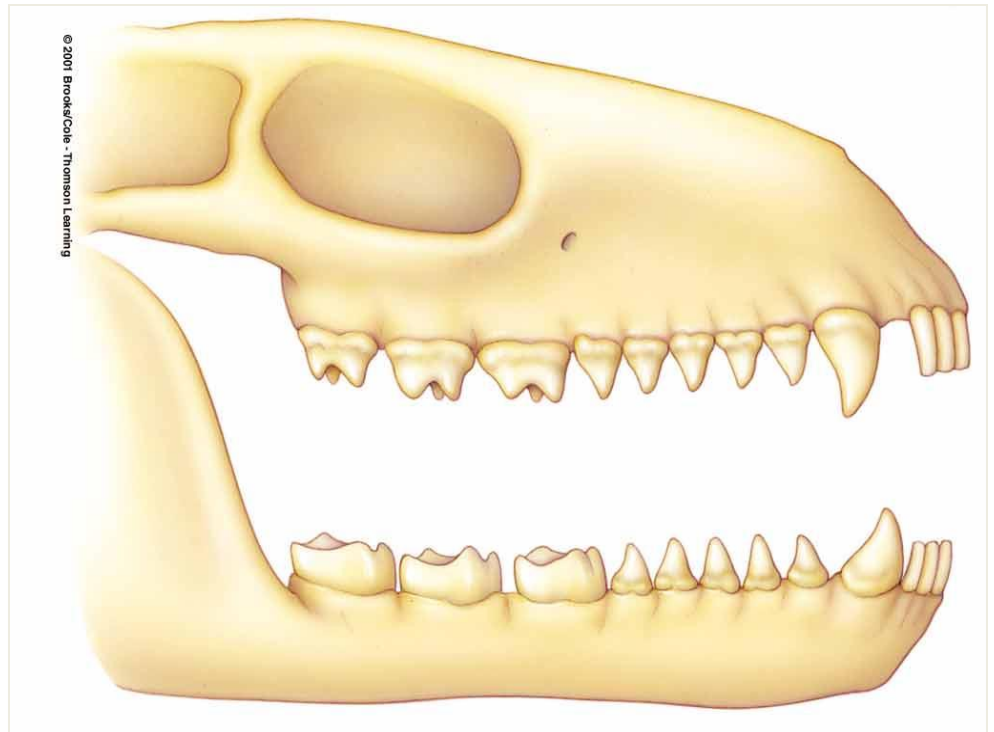
- Four-chambered heart
- **Highly efficient respiratory system**
- **Lightweight bones with air spaces**
- Powerful muscles attach to the keel



Fig. 26-22, p.447

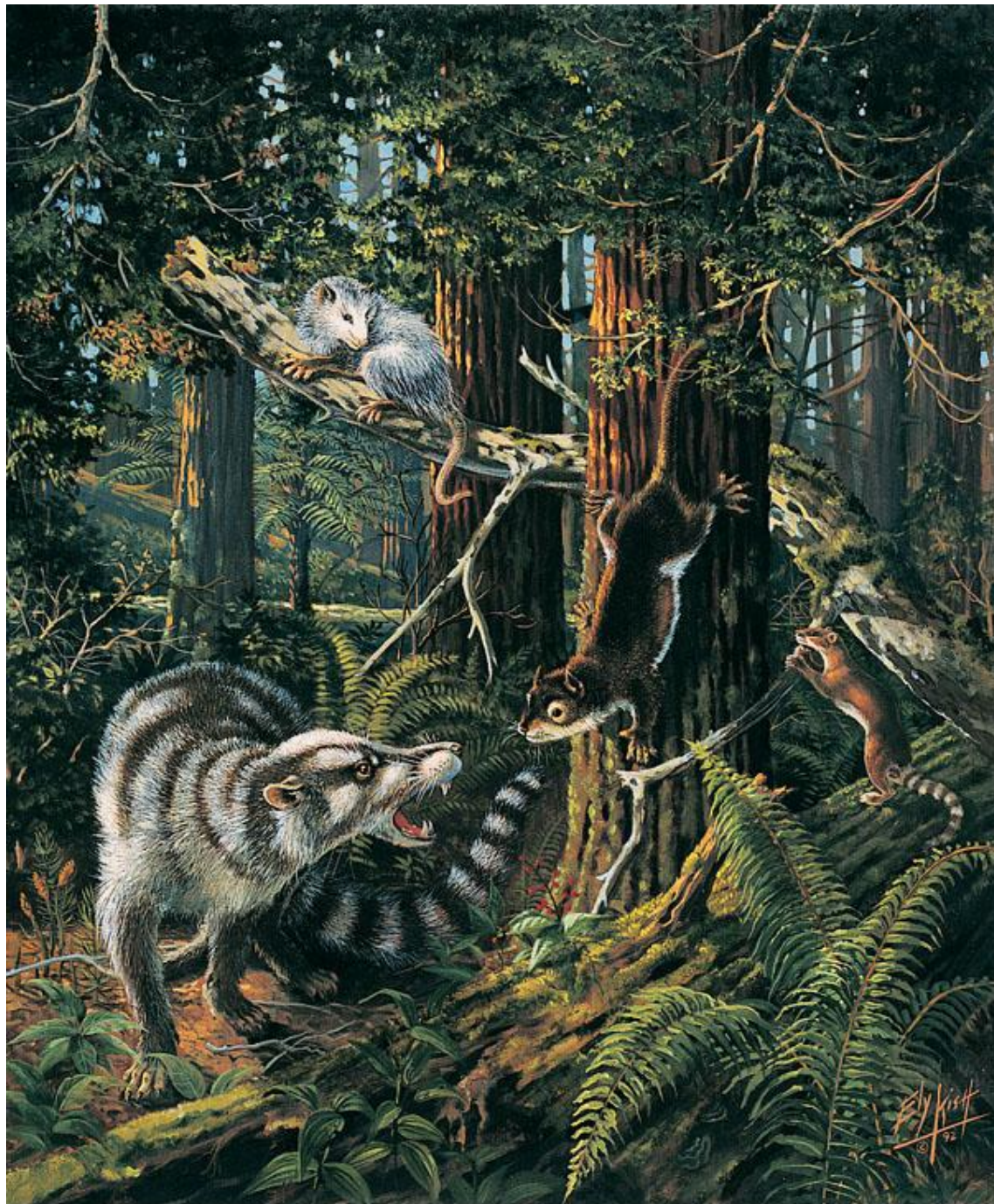
Mammals: Phylum Mammalia

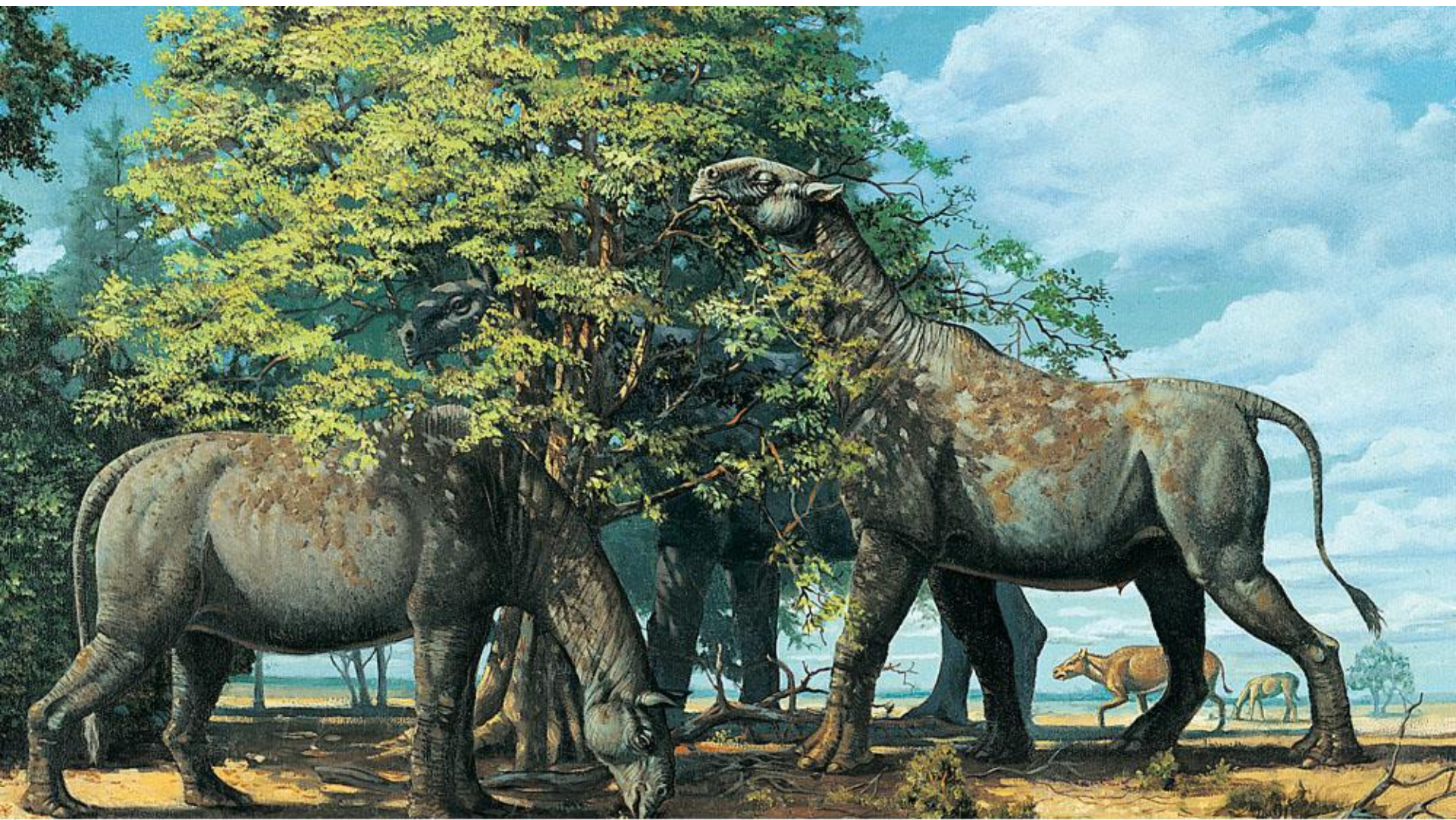
- Hair
- Mammary glands
- Distinctive teeth
- Highly developed brain
- Extended care for the young



Mammal Origins & Radiation

- During Triassic, synapsids gave rise to therapsids (ancestors of mammals)
- **By Jurassic, mouselike therians had evolved**
- Therians coexisted with dinosaurs through Cretaceous
- **Radiated after dinosaur extinction**





© 2006 Thomson Higher Education

Fig. 26-25a, p.448

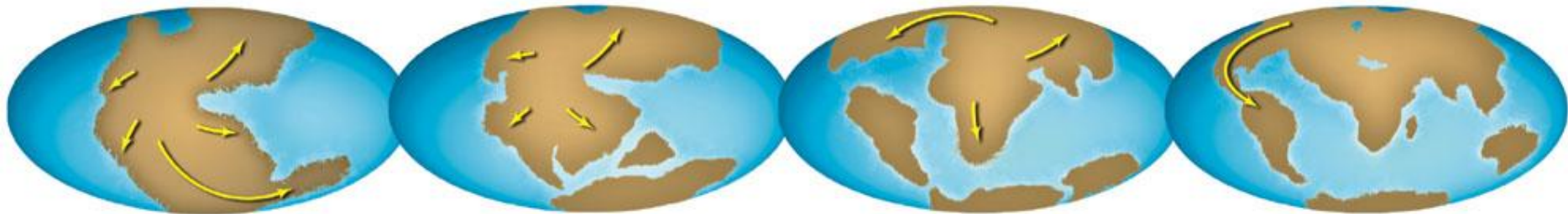


© 2006 Thomson Higher Education

Fig. 26-25b, p.448

Three Mammalian Lineages

- **Monotremes**
 - Egg-laying mammals
- **Marsupials**
 - Pouched mammals
- **Eutherians**
 - Placental mammals



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

b Between 130 and 85 million years ago, in the Cretaceous, placental mammals emerged and started to spread. Monotremes and marsupials of the southern supercontinent evolved in isolation from placental mammals.

c About 20 million years ago, in the Miocene, placental mammals expanded in range and diversity. On Antarctica, mammals vanished. 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.

Living Monotremes

- Three species
 - Duck-billed platypus
 - Two kinds of spiny anteater
- All lay eggs





Living Marsupials

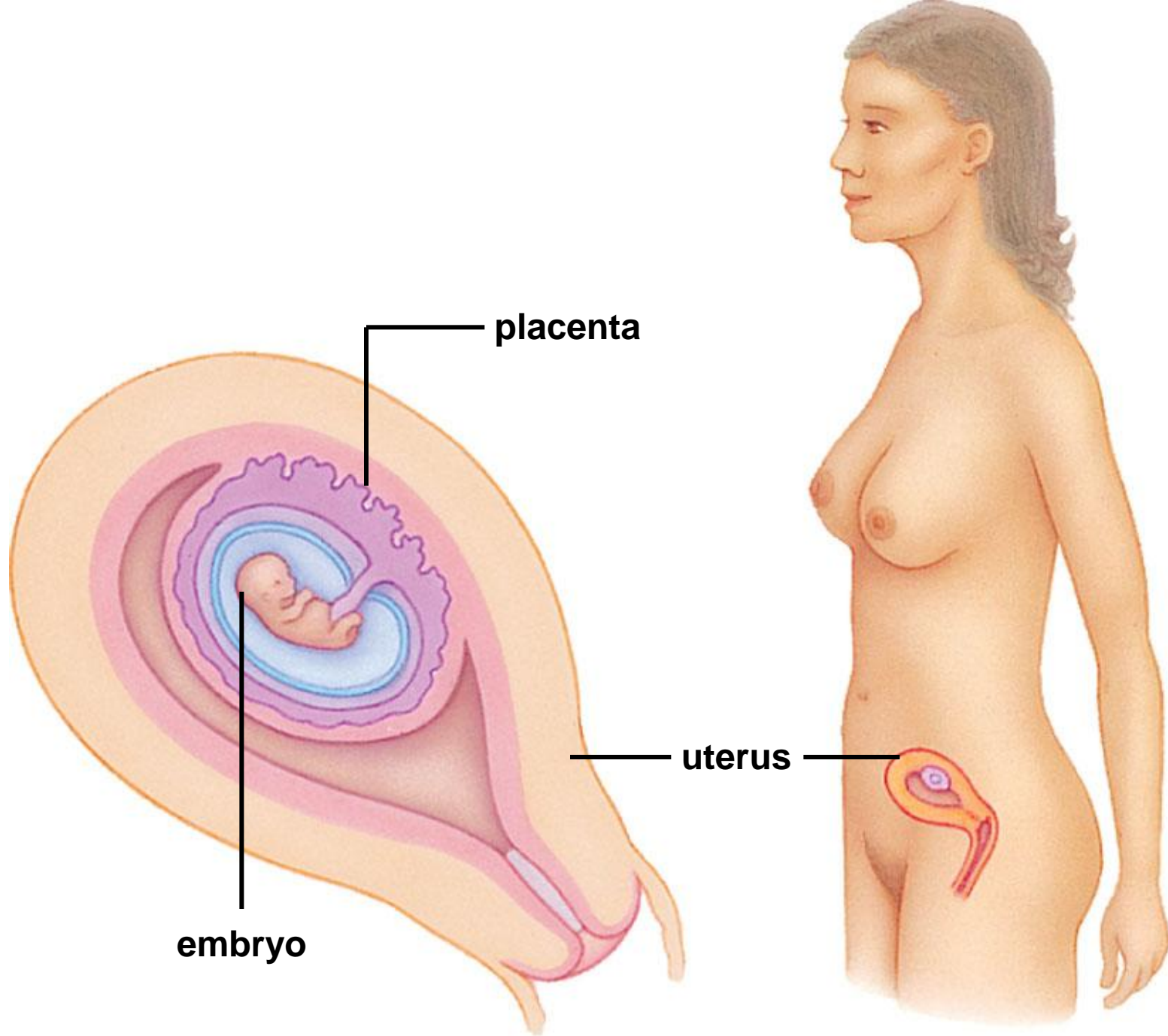
- Most of the 260 species are native to Australia and nearby islands
- Only the opossums are found in North America
- **Young are born in an undeveloped state and complete development in a permanent pouch on mother**

Living Placental Mammals

- **Most diverse mammalian group**
- Young develop in mother's uterus
- Placenta composed of maternal and fetal tissues; nourishes fetus, delivers oxygen, and removes wastes
- **Placental mammals develop more quickly than marsupials**

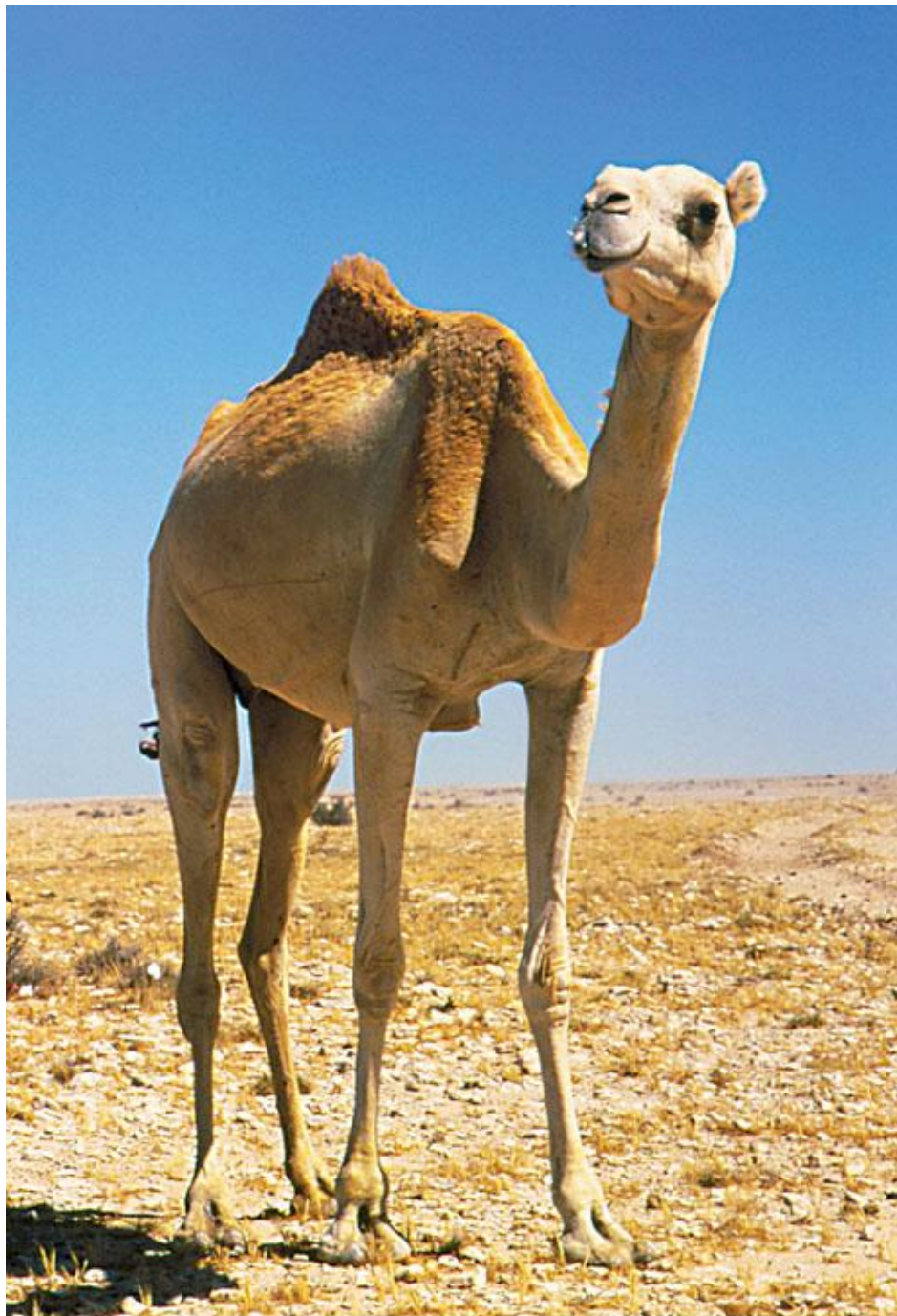
Table 26.1 Convergences Among Groups of Mammals

Life-Style	Home	Mammalian Family
Aquatic invertebrate eater	North America Central America Australia	Water shrew (Soricidae) Water mouse (Cricetidae) Platypus (Ornithorhynchidae)
Carnivore on land	North America Australia	Wolf (Canidae) Tasmanian wolf (Thylacinidae)
Anteater on land	South America Africa Australia	Giant anteater (Myrmecophagidae) Aardvark (Orycteropodidae) Spiny anteater (Tachyglossidae)
Ground-dwelling leaf, tuber eater	North America South America Eurasia	Pocket gopher (Geomyidae) Tuco-tuco (Ctenomyidae) Mole rat (Spalacidae)
Tree-dwelling leaf eater	South America Africa Madagascar Australia	Howler monkey (Cebidae) Colobus monkey (Cercopithecidae) Woolly lemur (Indriidae) Koala (Phascolarctidae)
Tree-dwelling nut, seed eater	Southeast Asia Africa Australia	Flying squirrel (Sciuridae) Flying squirrel (Anomaluridae) Flying squirrel (Phalangeridae)

















Earliest Primates

- Primates evolved more than 60 million years ago during the Paleocene
- First primates resembled tree shrews
 - Long snouts
 - Poor daytime vision

Hominoids

- **Apes, humans, and extinct species of their lineages**
- **In biochemistry and body form, humans are closer to apes than to monkeys**
- **Hominids**
 - Subgroup that includes humans and extinct humanlike species

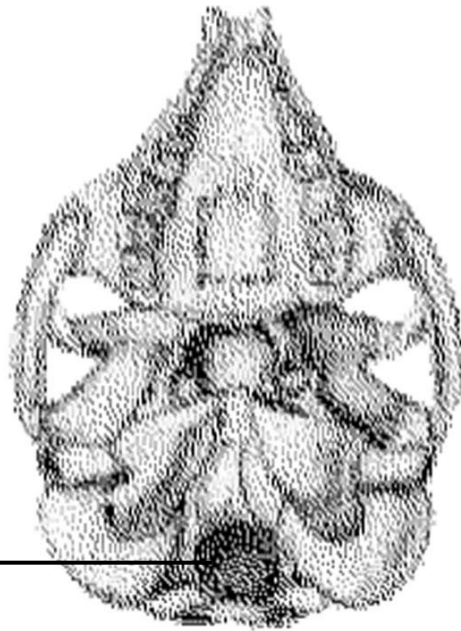
Trends in Lineage Leading to Humans

- Less reliance on smell, more on vision
- **Skeletal changes to allow bipedalism**
- **Modifications of hand allow fine movements**
- **Bow-shaped jaw and smaller teeth**
- Longer lifespan and period of dependency

Adaptations to an Arboreal Lifestyle

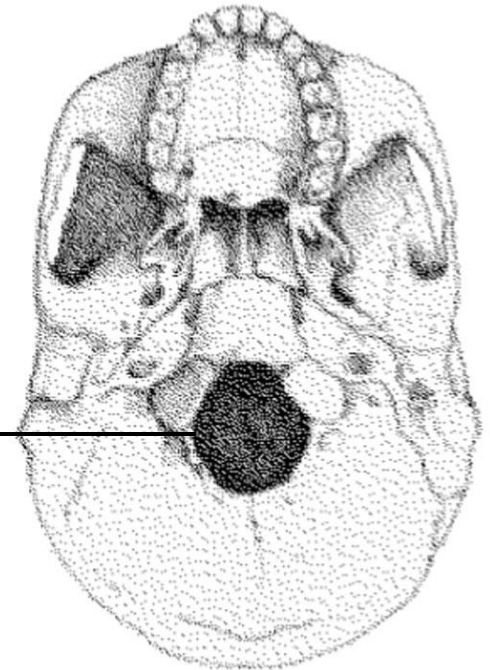
- **Better daytime vision**
- Shorter snout
- **Larger brain**
- **Forward-directed eyes**
- **Capacity for grasping motions**

a Hole at back of skull; the backbone is habitually parallel with ground or a plant stem



© 2006 Thomson Higher Education

b Hole close to center of base of skull; the backbone is habitually perpendicular to ground

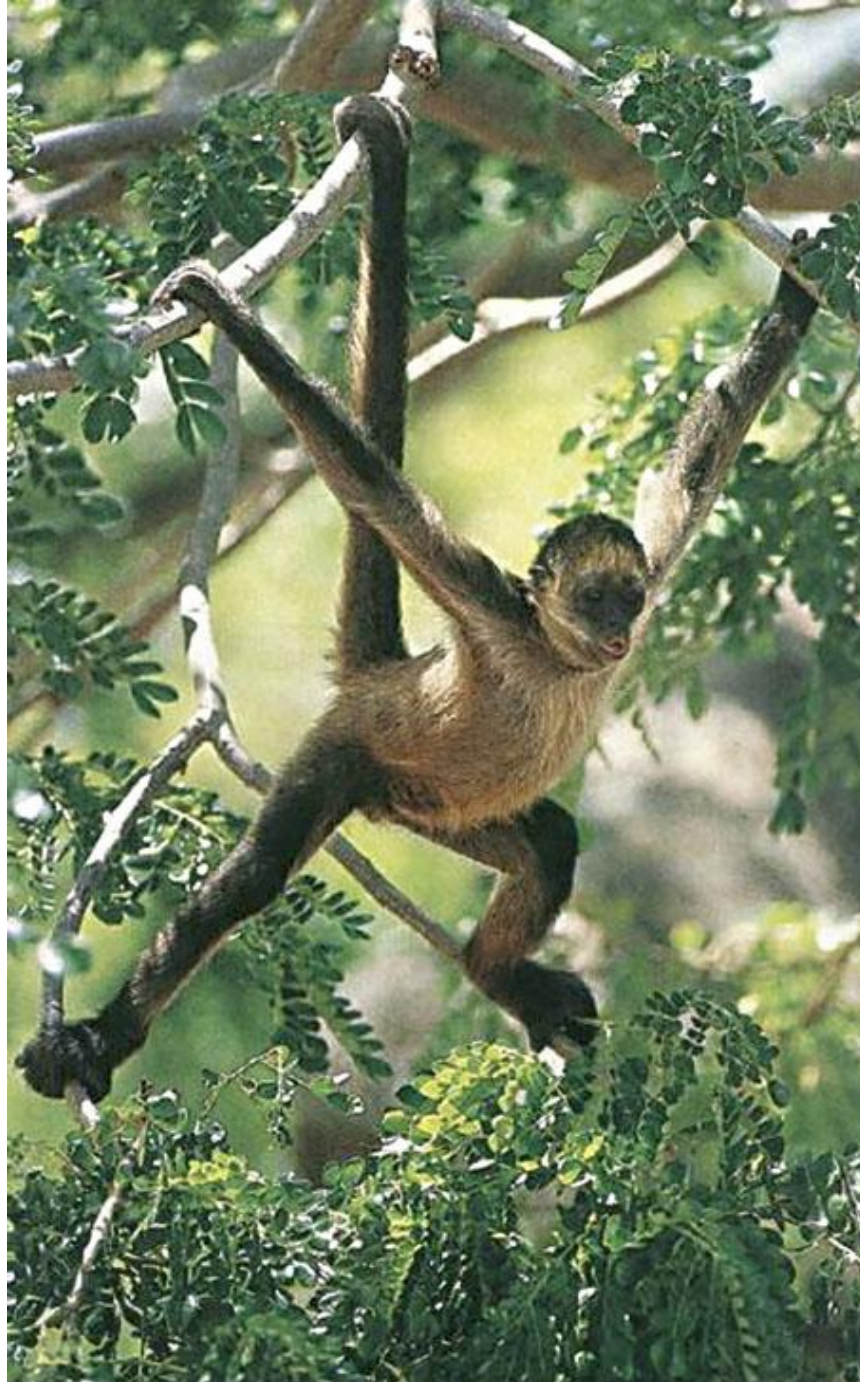


© 2006 Thomson Higher Education



© 2006 Brooks/Cole - Thomson

Fig. 26-30a, p.453







© 2006 Brooks/Cole - Thomson

Fig. 26-30d, p.453





The First Hominoids

- Appeared during Miocene
- **Arose in Central Africa**
- **Spread through Africa, Asia, Europe**
- **Climate was changing, becoming cooler and drier**



© 2006 Thomson Higher Education



© 2006 Thomson Higher Education

Fig. 26-31b-d, p.454

The First Hominids

- *Sahelanthropus tchadensis* arose 6-7 million years ago
- Bipedal australopiths evolved during Miocene into Pliocene

A. anamensis

A. afarensis

A. africanus

A. garhi

A. boisei

A. robustus

- Exact relationships are not known

Sahelanthropus
Tchadensis
7-6 million years



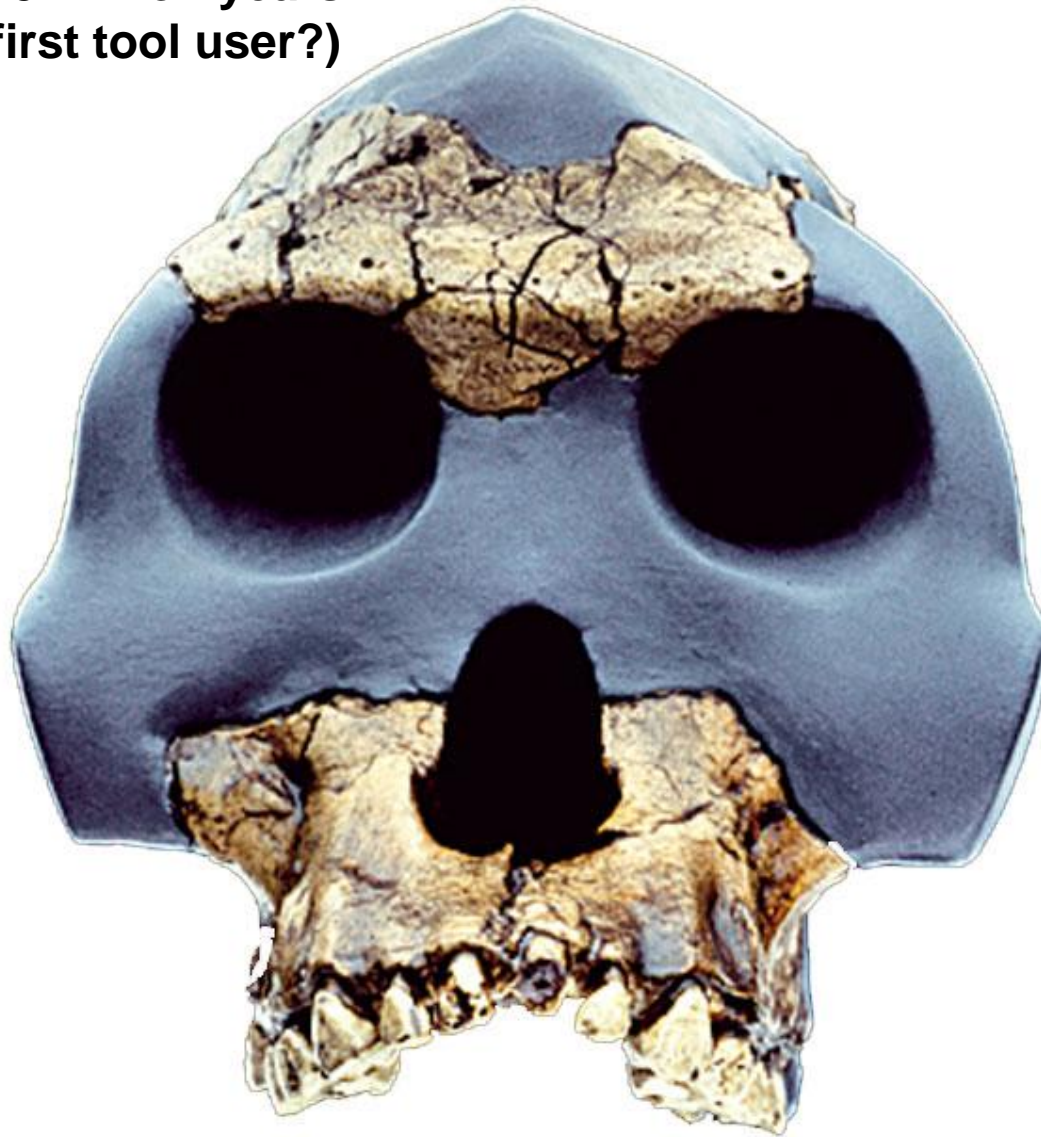
Australopithecus
Afarensis
3.6–2.9 million years



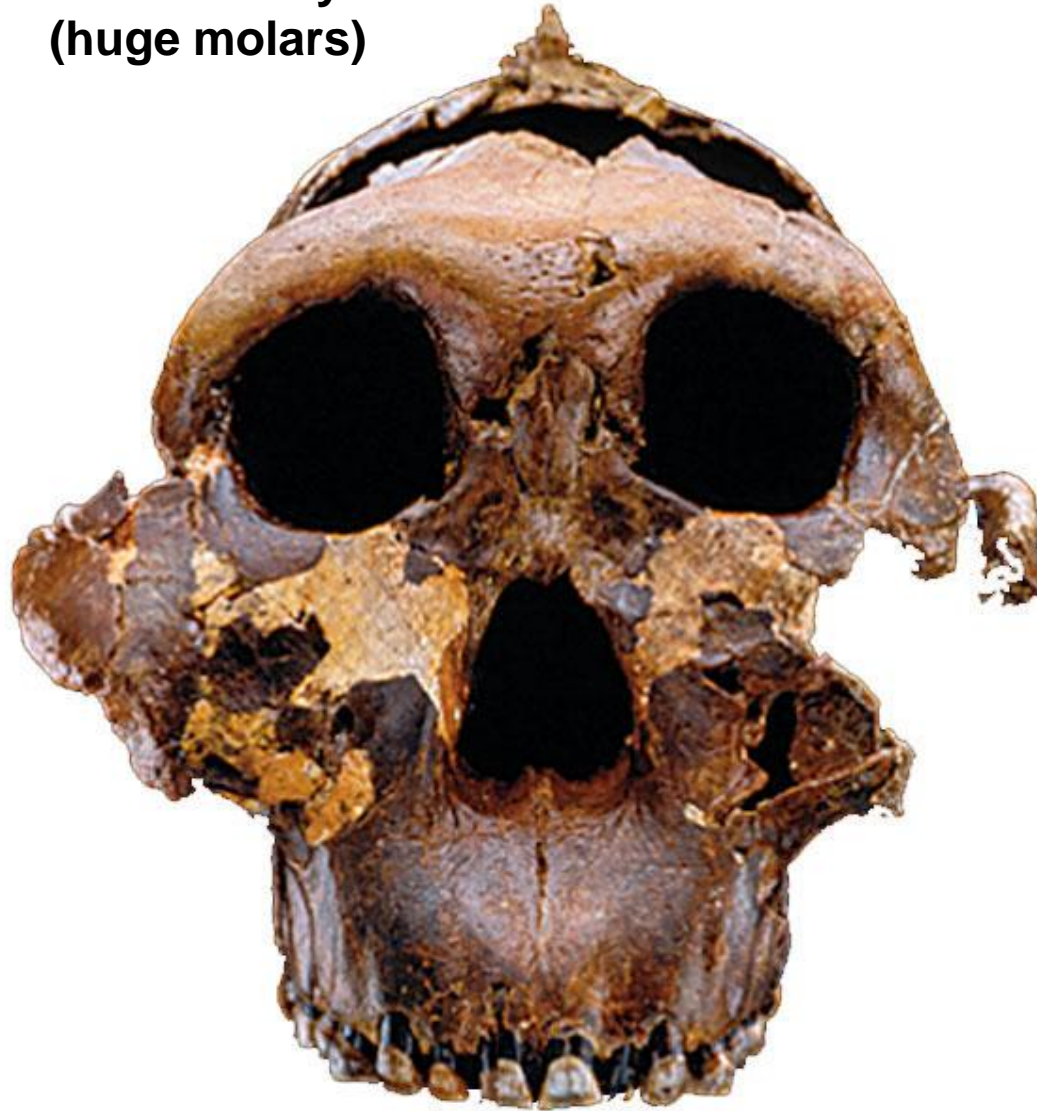
A. africanus
3.2–2.3 million years



Garhi
2.5 million years
(first tool user?)



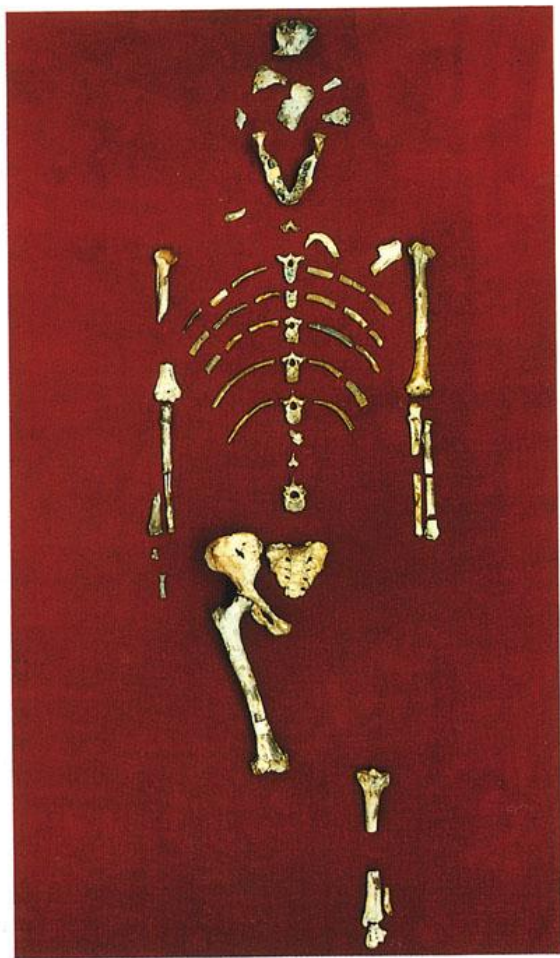
Paranthropus boisei
2.3–1.4 million years
(huge molars)



P. Robustus
1.9–1.5 million years



Fig. 26-33f, p.455



© 2006 Brooks/Cole - Thomson



© 2006 Brooks/Cole - Thomson



© 2006 Brooks/Cole - Thomson

Fig. 26-34a-c, p.455

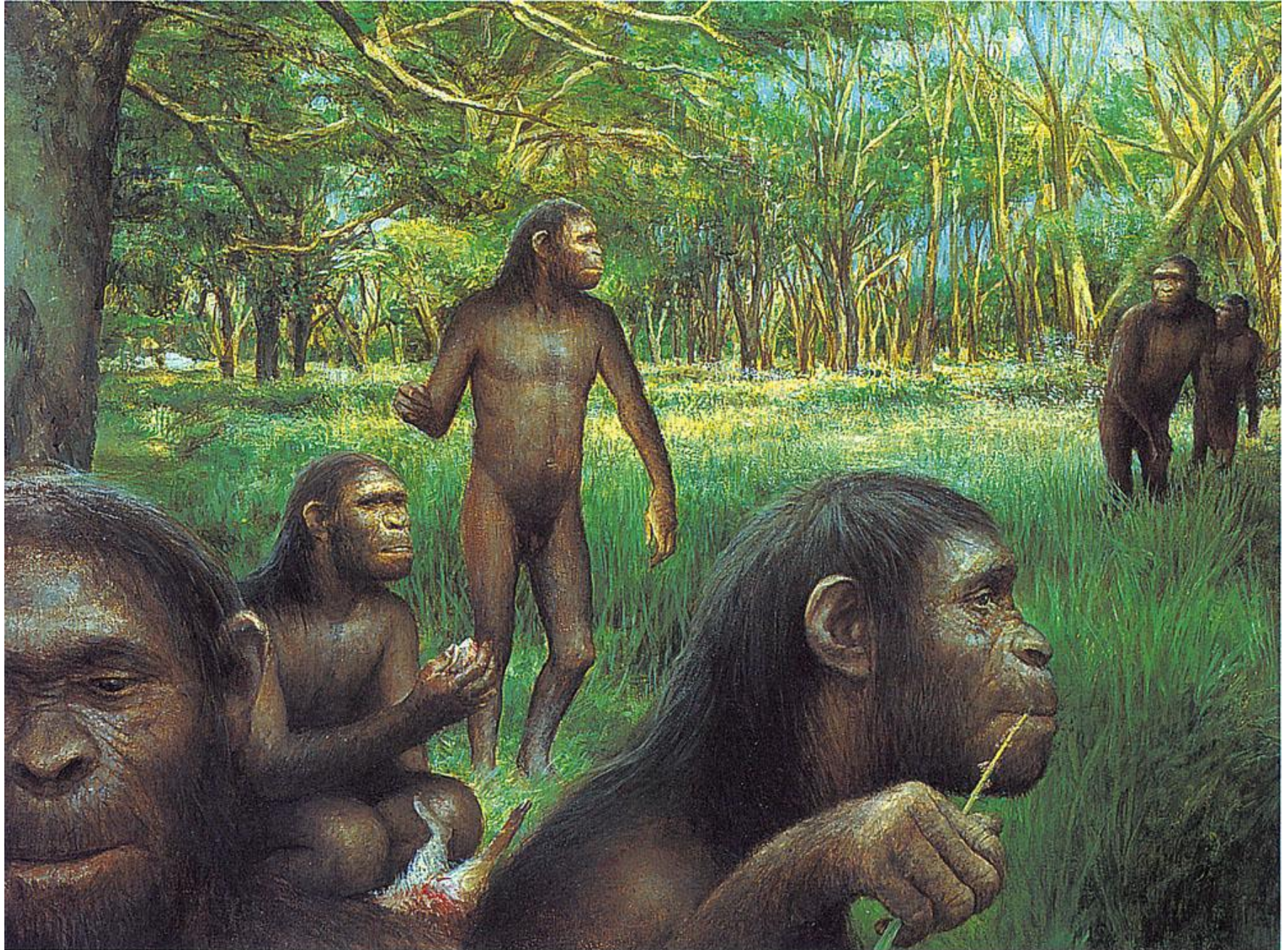
Homo Habilis

1.9-1.6 million years ago

- May have been the first member of genus
- Lived in woodlands of eastern and southern Africa



H. habilis

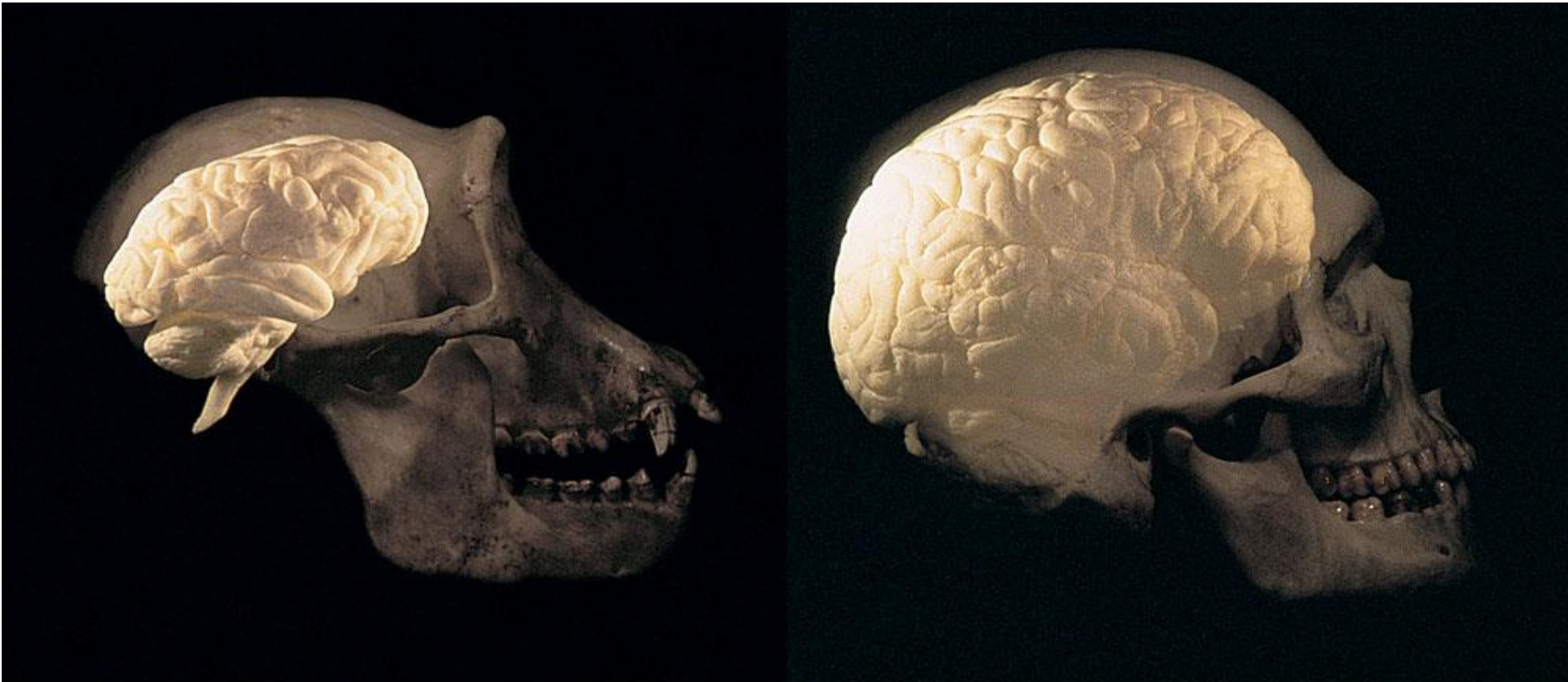




Homo rudolfensis
2.4-1.8
million years



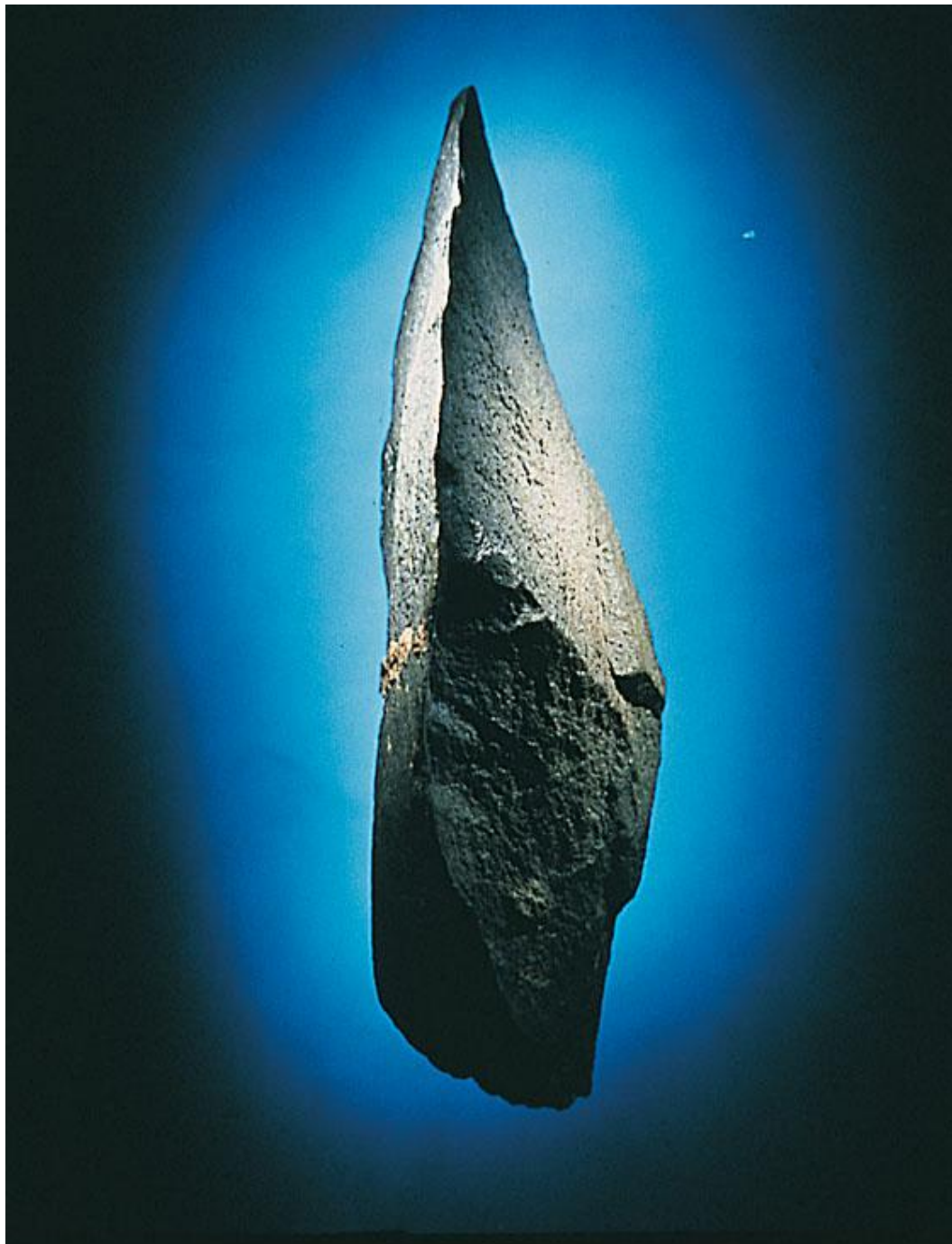
H. habilis
1.9-1.6
million years

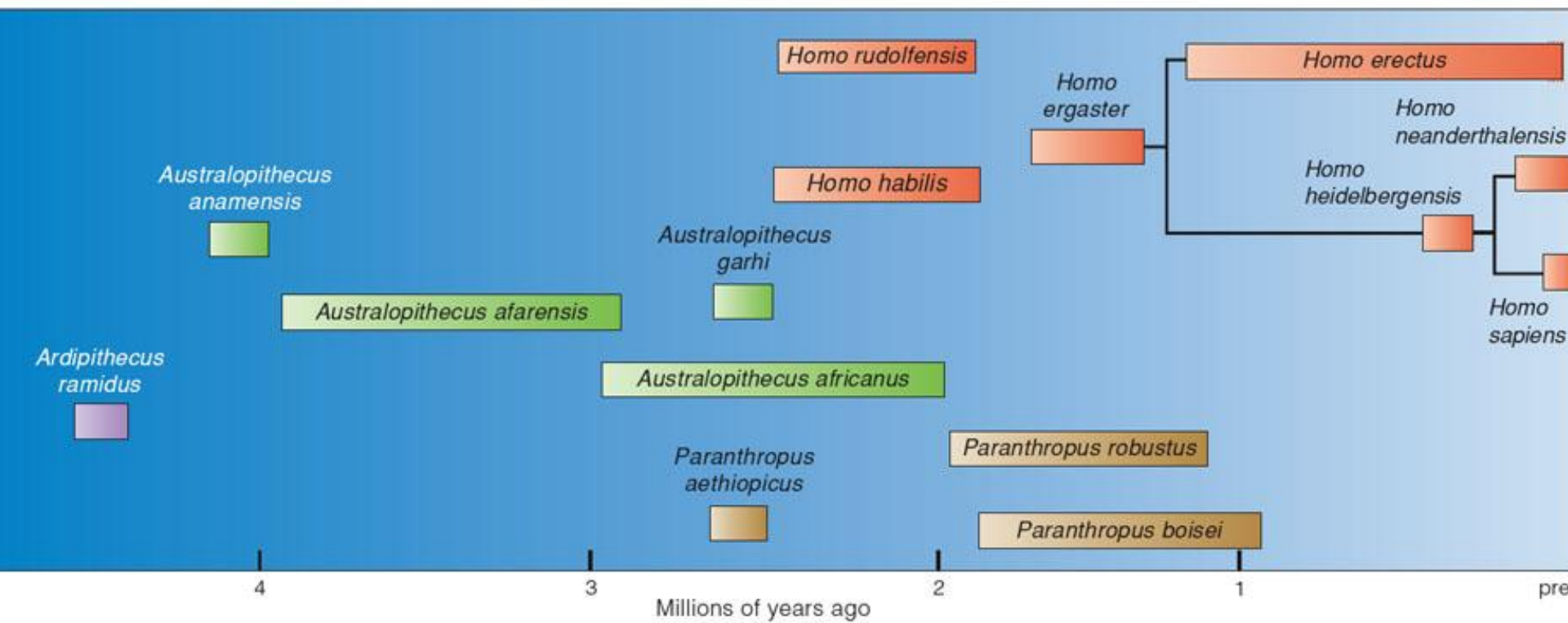


© 2006 Thomson Higher Education









Homo erectus

2 million-53,000? years ago

- **Evolved in Africa**
- **Migrated into Europe and Asia**
- Larger brain than *H. habilis*
- **Creative toolmaker**
- **Built fires and used furs for clothing**

Homo sapiens

- Modern man evolved by 100,000 years ago
- Compared to *Homo erectus*:
 - Smaller teeth and jaws
 - Chin
 - Smaller facial bones
 - Larger-volume brain case

Neanderthals

- Early humans that lived in Europe and Near East
- **Massively built, with large brains**
- **Disappeared when *H. sapiens* appeared**
- DNA evidence suggests that they did not contribute to modern European populations



© 2006 Thomson Higher Education

H. erectus
2 million-53,000? years



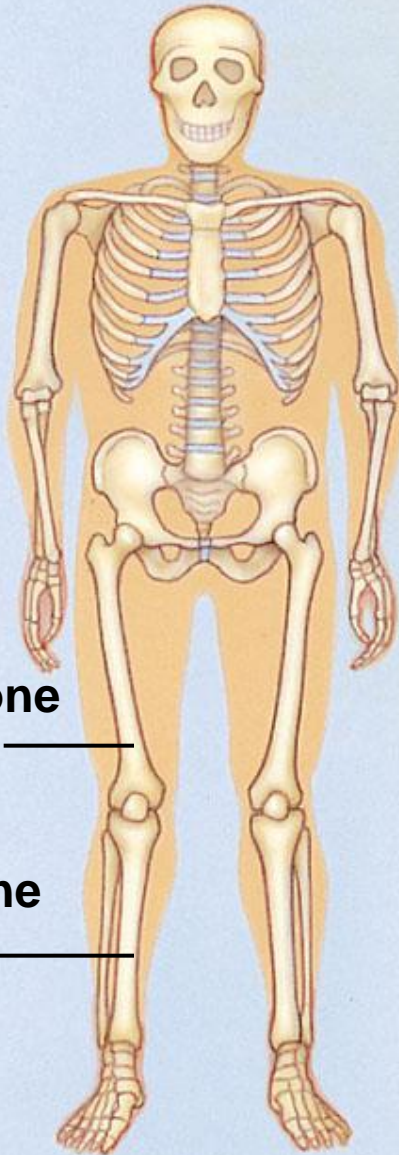
© 2006 Thomson Higher Education

H. neanderthalensis
200,000-30,000 years

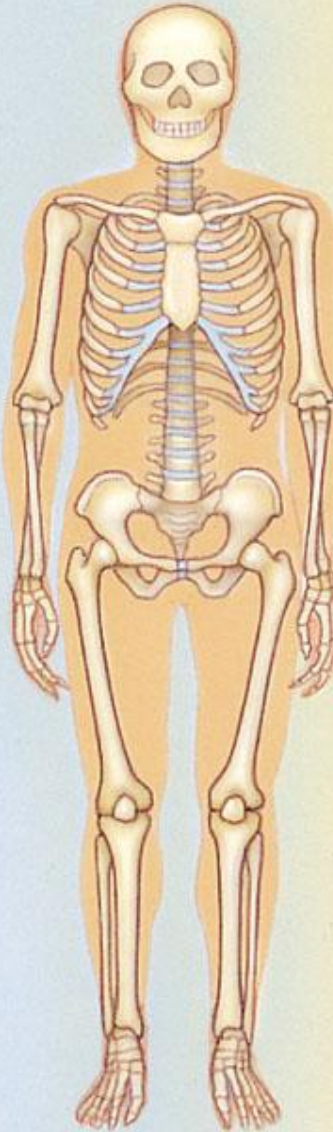
1.8 meters (6 feet)

thighbone
(femur)

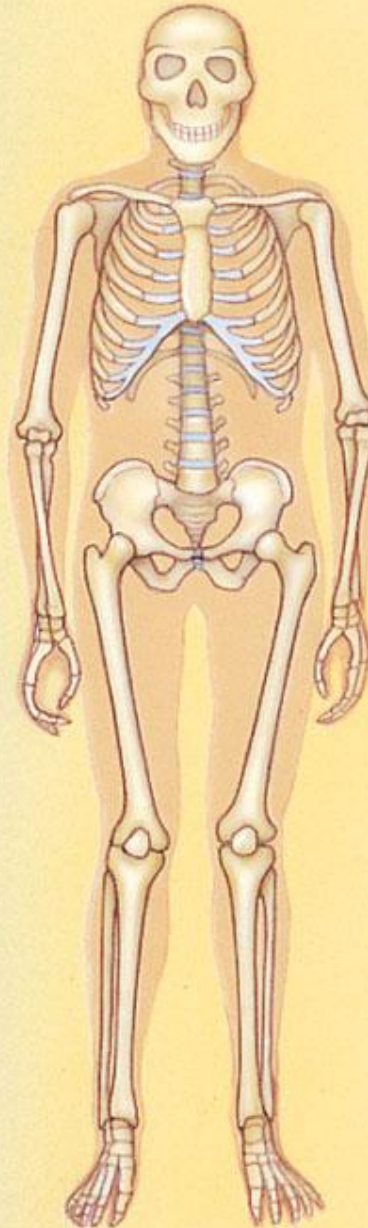
shinbone
(tibia)



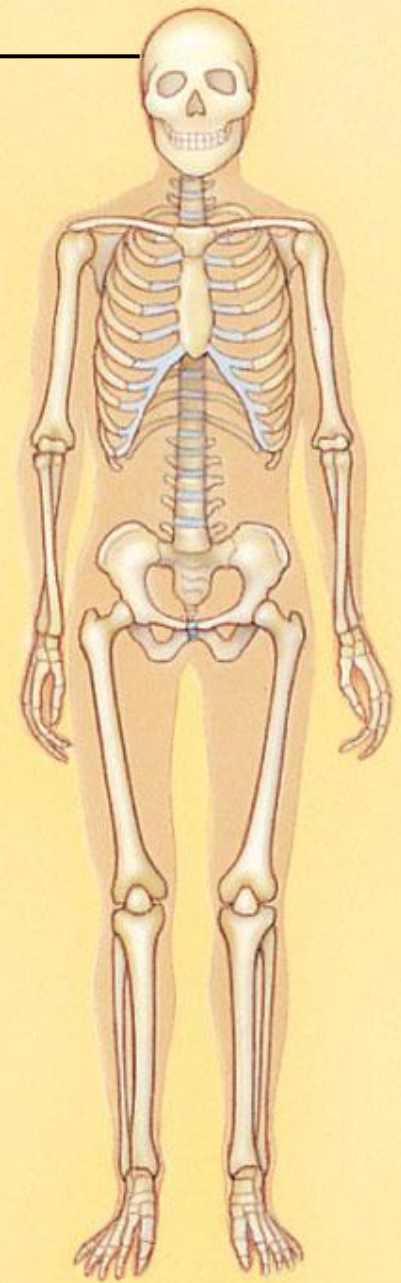
Neanderthal



Modern Inuit



Homo erectus



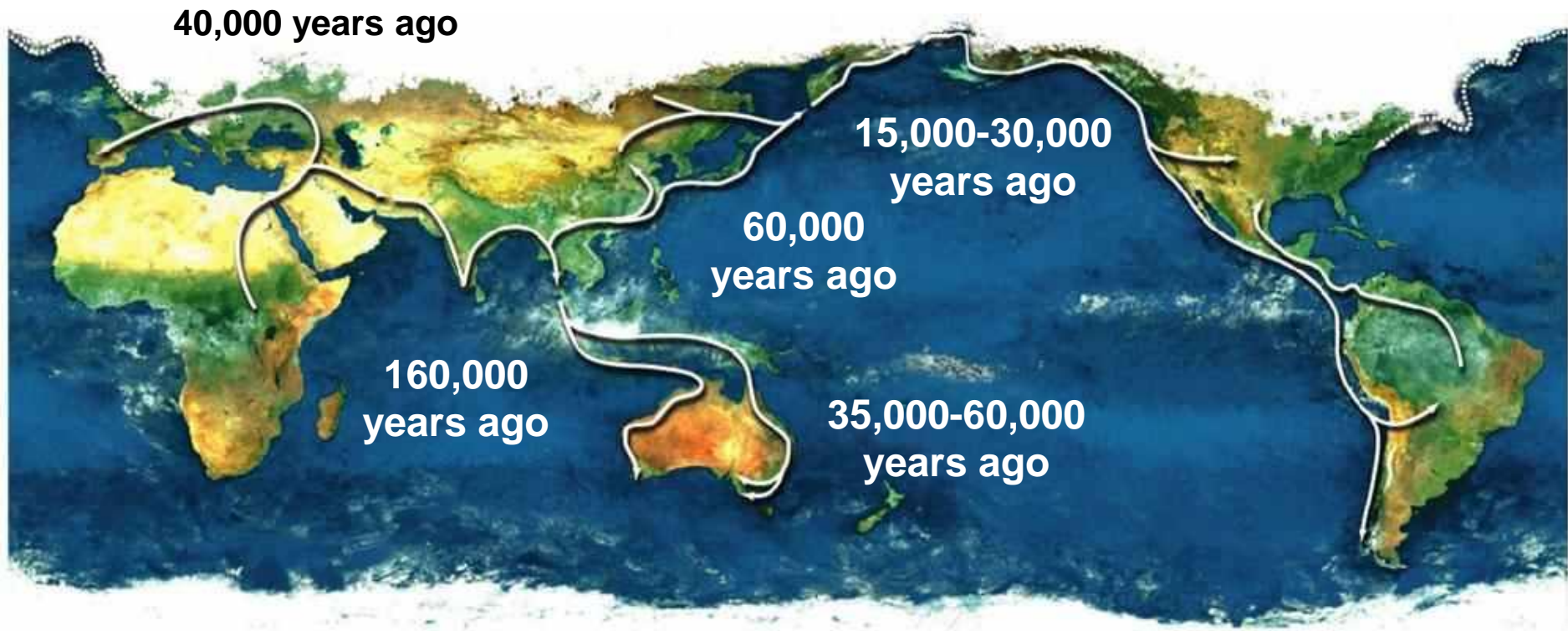
Modern Masai

Earliest Fossils Are African

- Africa appears to be the cradle of human evolution
- No human fossils older than 2 million years exist anywhere but Africa
- *Homo erectus* left Africa in waves from 2 million to 500,000 years ago



H. sapiens
Fossil from Ethiopia,
160,000 years old



© 2006 Brooks/Cole - Thomson

Fig. 26-41b, p.459

Genetic Distance Data

