

# Origins of Bones

- \* Mineralization originated with mouthparts
- \* The entire skeleton was mineralized much later
- \* Gnathostomes are vertebrates that have jaws
- \* Jaws evolved from skeletal supports of the pharyngeal slits
- \* Also have enhanced sensory systems, mineralized endoskeleton, and paired appendages

Fig. 34.14

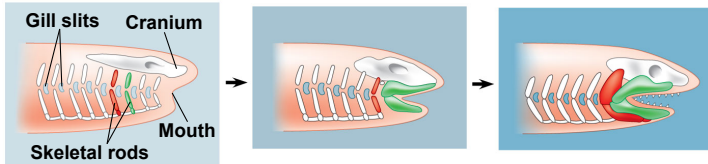
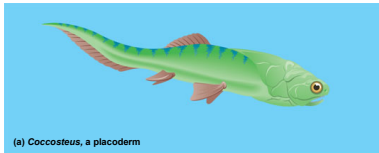


Fig. 34.13

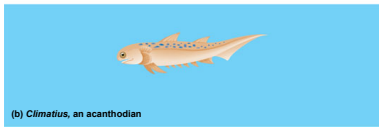
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# Gnathostome Evolution

- \* Placoderms - extinct lineage of armored vertebrates
- \* Acanthodians - radiated during the Devonian period (closely related to osteichthyans)



(a) *Coccoosteus*, a placoderm

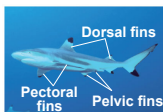
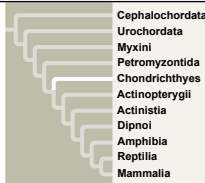


(b) *Climatius*, an acanthodian

2

# Class Chondrichthyan

- \* Skeleton composed primarily of cartilage
- \* Cartilaginous skeleton evolved secondarily from an ancestral mineralized skeleton
- \* Reproductive tract excretory system and digestive tract empty into a common cloaca
- \* Includes: sharks, rays, and ratfish



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



(b) Southern stingray (*Dasyatis americana*)

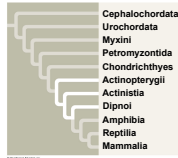


(c) Spotted ratfish (*Hydrolagus collieri*)

Fig. 34.15

3

# Ostiechthyes



- \* Nearly all have a bony skeleton
- \* We informally call them fish
- \* Control their buoyancy with an air sac known as a swim bladder
- \* Breathe by drawing water over gills
- \* Located in chambers covered by a protective bony flap called the operculum

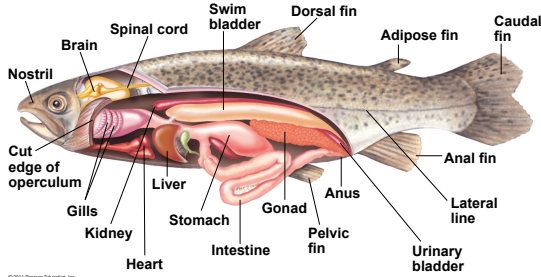
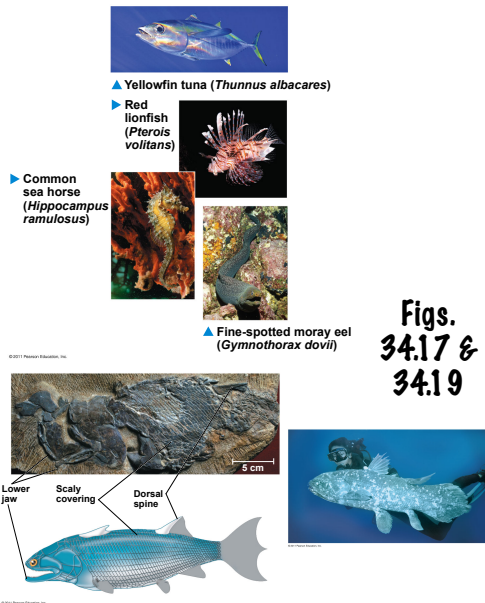


Fig. 34.16

4

# Ostiechthyes

- \* Class Actinopterygii
  - \* Ray-finned fish - fins supported by long flexible rays modified for maneuvering, defense, and other functions
- \* Class Sarcopterygii - have muscular, pectoral fins (ex. Coelacanth, lungfish, tetrapods)

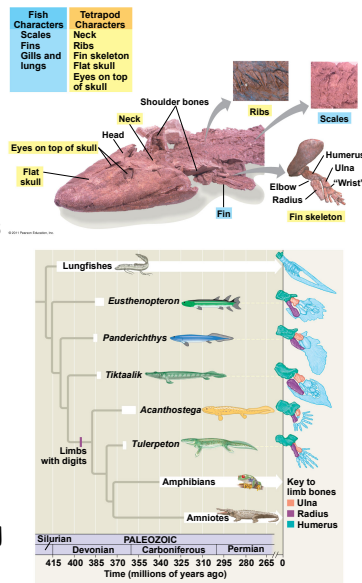


Figs. 34.17 & 34.19

5

# Tetrapods

- \* Gnathostomes that have limbs and feet
- \* One of the most significant events in vertebrate history was when the fin of lobe-fins evolved into the limbs and feet of tetrapods
- \* Fins became more limb-like
- \* Have four limbs and feet with digits
- \* Have ears for detecting airborne sounds

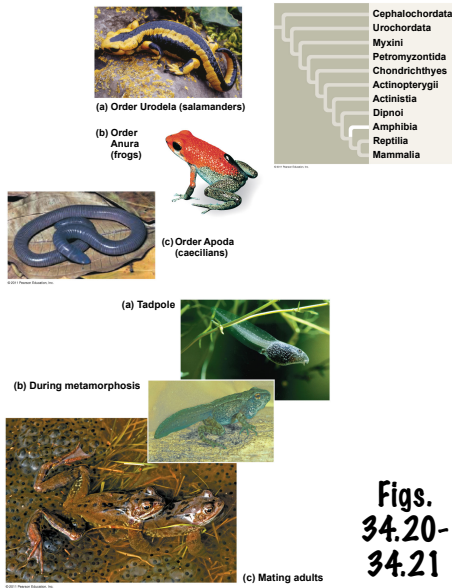


Figs. 34.20 & 34.21

6

# Class Amphibia

- \* 4,800 species
- \* Most have moist skin that complements the lungs in gas exchange
- \* Name means "two lives" - undergo metamorphosis from aquatic larva to terrestrial adult
- \* Order Urodela (salamanders) - have tails
- \* Order Anura (frogs, toads) - lack tails
- \* Order Apoda (caecilians) - legless and resemble worms



Figs. 34.20-34.21

7

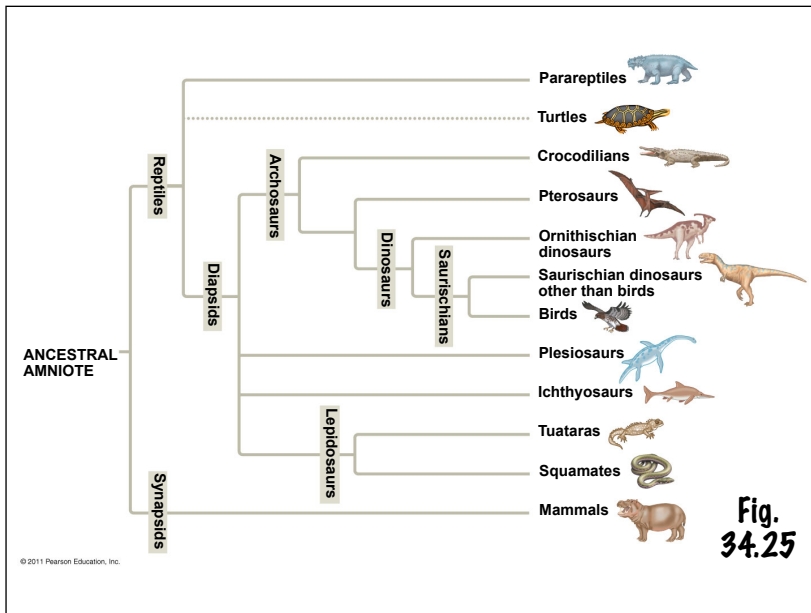


Fig. 34.25

8

# Amniotes

- \* Tetrapods that have a terrestrially adapted egg
- \* Living members are reptiles, birds, and some mammals
- \* Named for the major derived character (amniotic egg)
- \* Amniotic egg contains specialized membranes that protect the embryo
- \* Also have relatively impermeable skin and the ability to use the rib cage to ventilate the lungs
- \* Appeared in the Carboniferous period

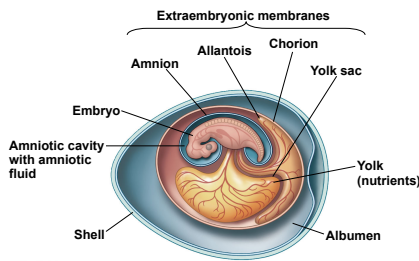
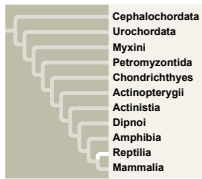


Fig. 34.26

9

# Reptiles



- \* Includes tuatara, lizards, snakes, turtles, crocodilians, birds, and dinosaurs
- \* Have scales that create a waterproof barrier
- \* Lay shelled eggs on land
- \* Most are ectothermic - absorb external heat as main source of body heat (Birds are endothermic - keep body warm through metabolism)
- \* Date back to about 300 million years ago
- \* First major group were parareptiles (large, stocky herbivores)
- \* As parareptiles dwindled, diapsids were diversifying (lepidosaurs and archosaurs)
- \* One surviving lineage of lepidosaurs is the two species lizard-like reptiles called tuatara
- \* The other lineage are lizards and snakes



Fig. 34.28

# Reptiles

- \* Snakes - legless lepidosaurs
- \* Turtles - have boxlike shells with upper and lower shields that fuse the the vertebrae, clavicles, and ribs
- \* Crocodylians - belong to the archosaur lineage that dates back to the Triassic
- \* Birds - archosaurs (almost every reptilian feature has undergone modification in adaptation to flight)

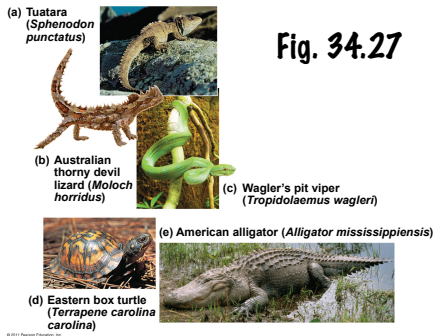
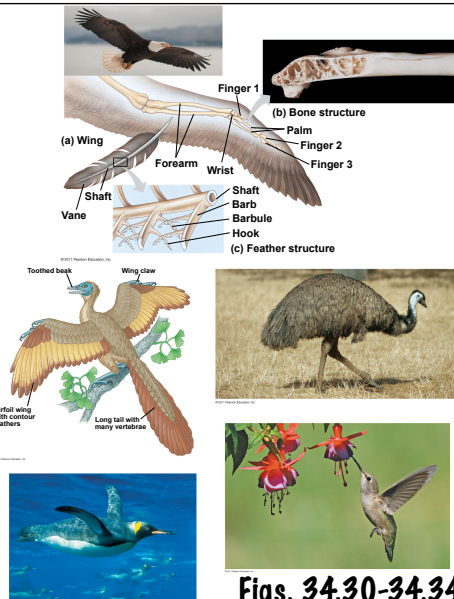


Fig. 34.27

# Birds

- \* Most obvious adaptations are wings and feathers
- \* Probably descended from theropods (group of small, carnivorous dinosaurs)
  - \* 150 millions years ago - Archaeopteryx (oldest known bird)
- \* Order Struthioniforms (flightless birds)
- \* Demands of flight have caused a general body form to evolve
- \* Foot structure also shows variation



Figs. 34.30-34.34



# Mammals

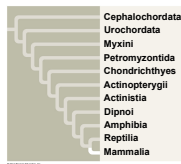
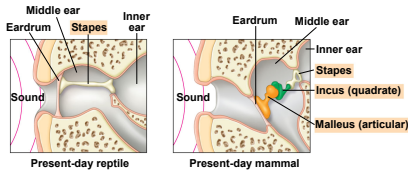


Fig. 34.32

- \* Amniotes that have hair and produce milk
- \* Generally have larger brains than other vertebrates of equivalent size
- \* Evolved from synapsids in the late Triassic



(a) Articular and quadrate bones in the jaw



(b) Articular and quadrate bones in the middle ear

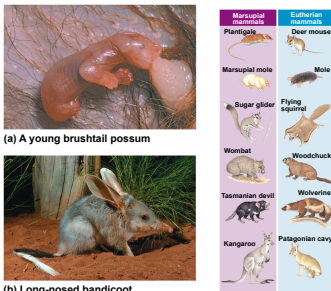
- \* Jaw was remodeled (two bones that were part of the jaw joint were incorporated into the middle ear)
- \* Living lineages originated in the Jurassic but did not undergo significant adaptive radiation until after the Cretaceous

# Mammals

- \* Monotremes - small group of egg-laying mammals (echidnas and platypus)
- \* Marsupials - opossums, kangaroos, and koalas
- \* Born very early in its development
- \* In some the marsupium opens in the rear



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Figs. 34.38-34.40

# Mammals

Fig. 34.41

- \* Eutherians - placental mammals
- \* Have a longer period of pregnancy (compared to marsupials)
- \* Young eutherians complete their embryonic development within a uterus joined to the mother by a placenta

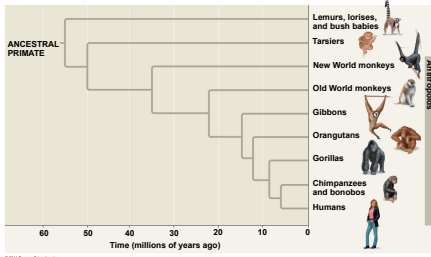
Orders and Examples	Main Characteristics	Orders and Examples	Main Characteristics
<b>Monotremata</b> Platypuses, echidnas Echidna	Lay eggs; no nipples; young suck milk from fur of mother	<b>Marsupialia</b> Kangaroos, opossums, koalas Koala	Completes embryonic development in pouch on mother's body
<b>Proboscidea</b> Elephants African elephant	Long, muscular trunk; thick, loose skin; upper incisors elongated as tusks	<b>Tubulidentata</b> Aardvarks Aardvark	Teeth consisting of many thin tubes cemented together; eats ants and termites
<b>Sirenia</b> Manatees, dugongs Manatee	Aquatic; finlike forelimbs and no hind limbs; herbivorous	<b>Hyracoidea</b> Hyraxes Rock hyrax	Short legs; stumpy tail; herbivorous; complex, multi-chambered stomach
<b>Xenarthra</b> Sloths, anteaters, armadillos Tamandua	Reduced teeth or no teeth; herbivorous (sloths) or carnivorous (anteaters, armadillos)	<b>Rodentia</b> Squirrels, beavers, rats, porcupines, mice Red squirrel	Chisel-like, continuously growing incisors worn down by gnawing; herbivorous
<b>Lagomorpha</b> Rabbits, hares, pikas Jackrabbit	Chisel-like incisors; hind legs longer than forelegs and adapted for running and jumping; herbivorous	<b>Primates</b> Lemurs, monkeys, chimpanzees, gorillas, humans Golden lion tamarin	Opposable thumbs; forward-facing eyes; well-developed cerebral cortex; omnivorous
<b>Carnivora</b> Dogs, wolves, bears, cats, weasels, otters, seals, walrus Coyote	Sharp, pointed canine teeth and molars for shearing; carnivorous	<b>Perissodactyla</b> Horses, zebras, tapirs, rhinoceroses Indian rhinoceros	Hooves with an odd number of toes on each foot; herbivorous
<b>Cetartiodactyla</b> Sheep, pigs, cattle, deer, giraffes Bighorn sheep	Hooves with an even number of toes on each foot; herbivorous	<b>Chiroptera</b> Bats Frog-eating bat	Adapted for flight; broad skinfold that extends from elongated fingers to body and legs; carnivorous or herbivorous
<b>Cetaceans</b> Whales, dolphins, porpoises Pacific white-sided porpoise	Aquatic; streamlined body; paddle-like forelimbs and no hind limbs; thick layer of insulating blubber; carnivorous	<b>Eulipotyphla</b> "Core insectivores": some moles, some shrews Star-nosed mole	Eat mainly insects and other small invertebrates

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# Mammals

Fig. 34.43-34.44

- \* Primates - include lemurs, tarsiers, monkeys, and apes
- \* Hands and feet adapted for grasping
- \* Large brain and short jaw
- \* Forward-looking eyes close together on the face providing depth perception
- \* Well-developed parental care and complex social behavior
- \* Opposable thumbs
- \* Oldest known anthropoid fossils are from about 45 million years ago

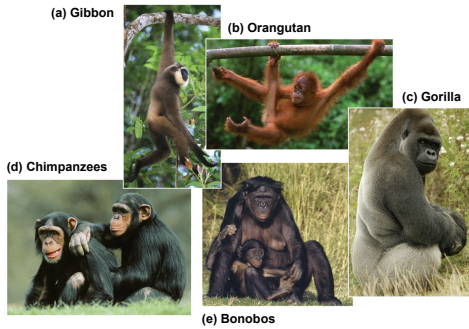


16

# Evolution of Primates

Figs. 34.39-34.40

- \* New and Old World monkeys underwent separate adaptive radiations during millions of years of separation
- \* The other group of anthropoids are hominoids (consist of primates called apes)
- \* Hominoids diverged from Old World monkeys about 20-25 million years ago



17

# Derived Characters of Hominins

- \* Bipedal hominoids with a large brain
- \* Language capabilities
- \* Symbolic thought
- \* Manufacture and use of complex tools
- \* Shortened jaw
- \* Humans and chimpanzee genomes are more than 99% identical

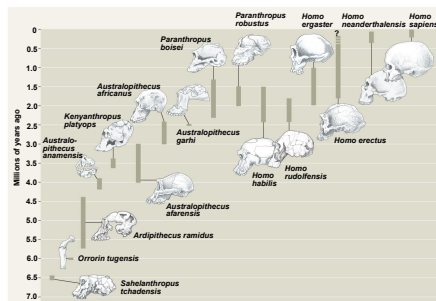


Fig. 34.46

18

# Hominids

- \* Study of human origins is paleoanthropology
- \* 20 species of distinct hominins have been discovered
- \* Originated in Africa 6-7 million years ago
- \* Australopiths lived between 4 and 2 million years ago
- \* Early hominids had a small brain
- \* Two common misconceptions:
  - \* Often thought of as chimpanzees
  - \* Thinking of human evolution as a ladder leading to Homo sapiens
- \* Began to walk on two legs for long distances about 1.9 million years ago
- \* Began to use tools (cut marks on animal bones) about 2.5 million years ago



(a) The Laetoli footprints



(b) Artist's reconstruction of *A. afarensis*



Figs. 34.47 & 34.48

# Hominids

- \* *Homo habilis* - 2.4 to 1.6 million years ago
  - \* Stone tools have been found with them
- \* *Homo ergaster* - 1.9 to 1.6 million years ago
  - \* First fully bipedal, large brained hominid
- \* *Homo erectus* - about 1.8 million years ago
  - \* First hominid to leave Africa
- \* *Homo neanderthalensis* - 200,000 to 30,000 years ago
  - \* Lived in Europe and the Near East
  - \* Large, thick browed
  - \* Became extinct a few thousand years after *Homo sapiens* arrived in Europe
- \* *Homo sapiens* - 160,000 years ago
  - \* Oldest fossils outside of Africa about 50,000 years ago



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Figs. 34.49 & 34.50