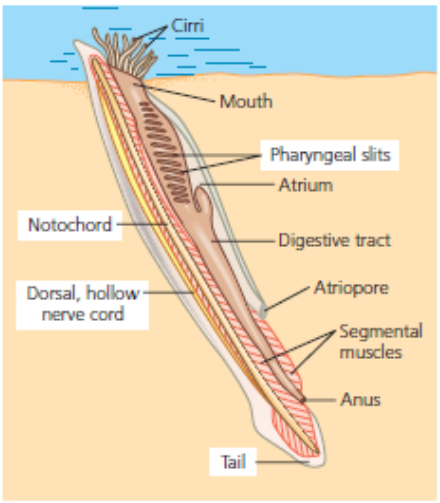
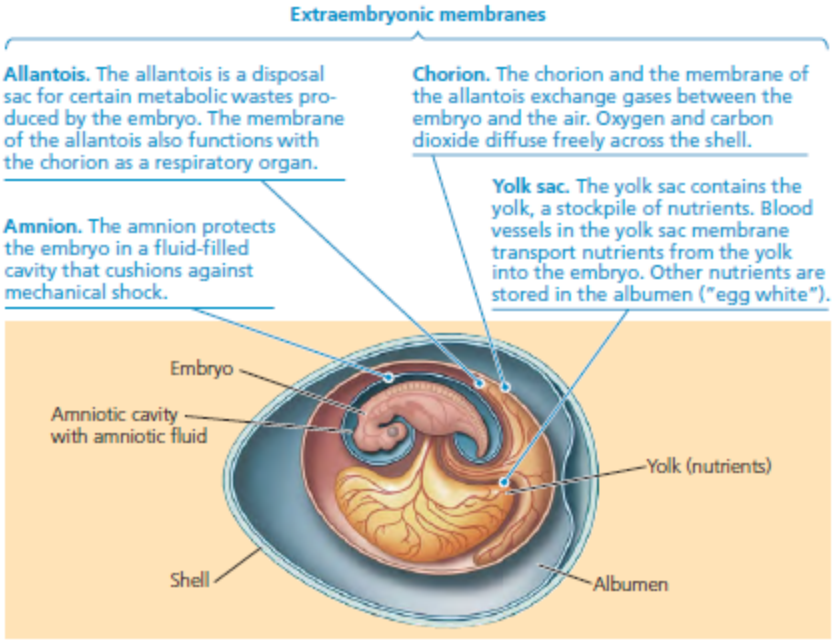
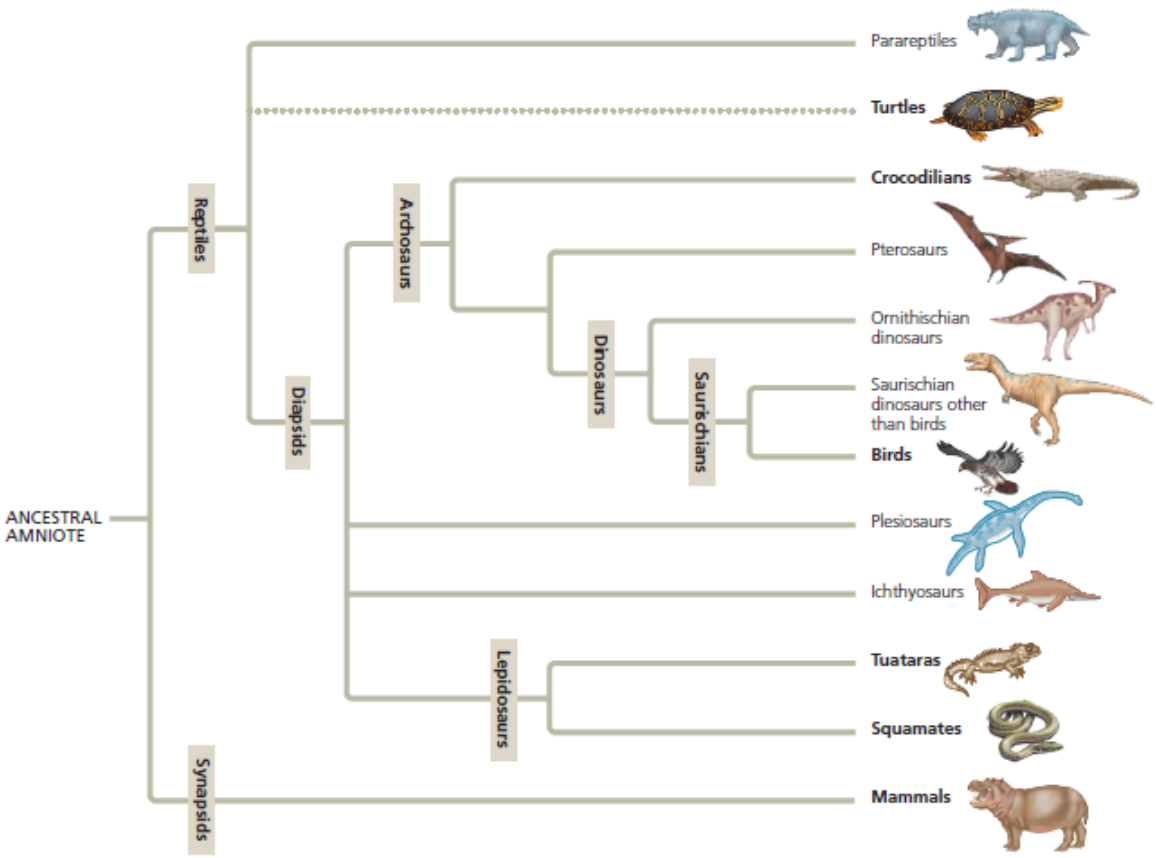
Cheat Sheet



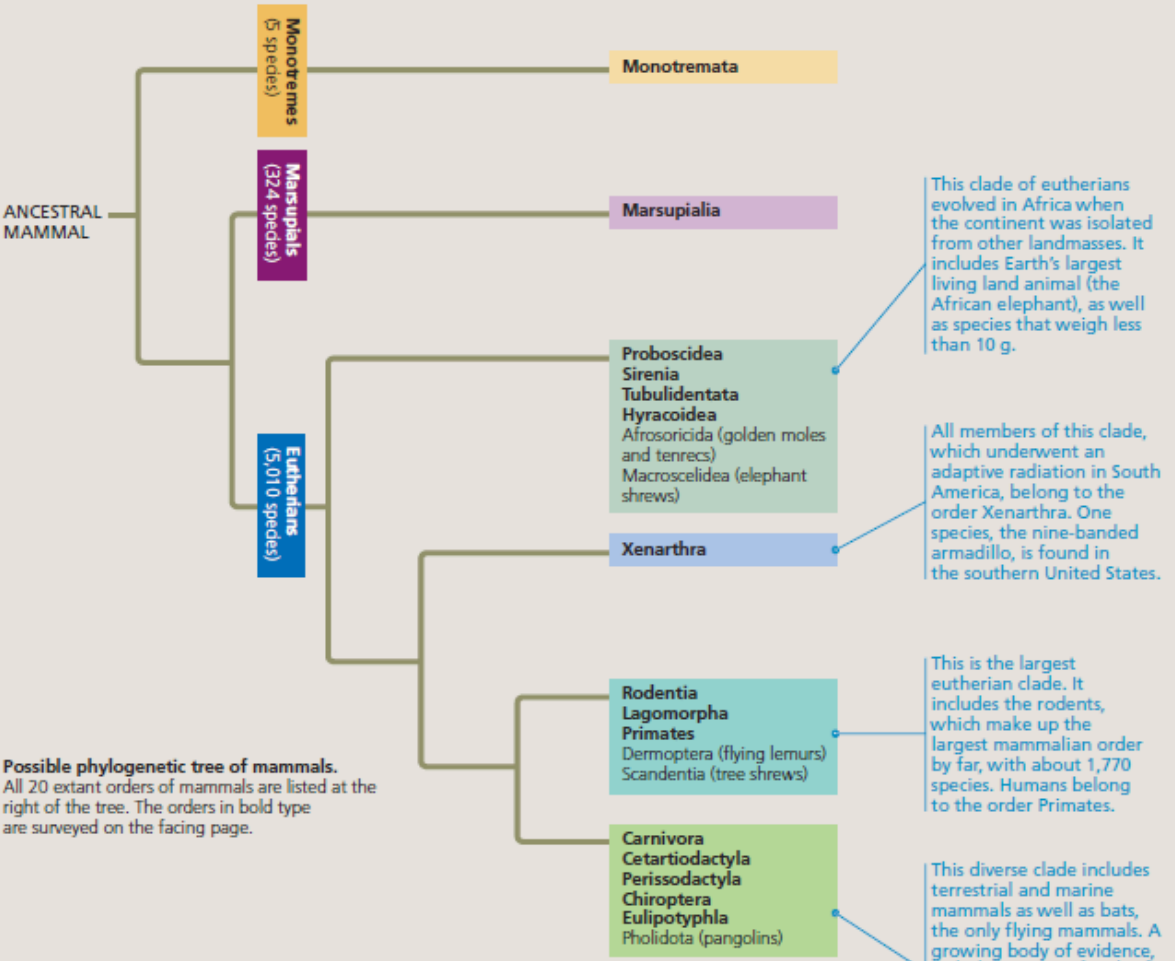
◀ **Figure 34.4 The lancelet *Branchiostoma*, a cephalochordate.** This small invertebrate displays all four main chordate characters. Water enters the mouth and passes through the pharyngeal slits into the atrium, a chamber that vents to the outside via the atriopore; large particles are blocked from entering the mouth by tentacle-like cirri. The serially arranged segmental muscles produce the lancelet's wavelike swimming movements.




ANCESTRAL AMNIOTE
Reptiles
Synapsids
Diapsids
Archosaurs
Lepidosaurs
Dinosaurs
Saurischians
Parareptiles
Turtles
Crocodilians
Pterosaurs
Ornithischian dinosaurs
Saurischian dinosaurs other than birds
Birds
Plesiosaurs
Ichthyosaurs
Tuataras
Squamates
Mammals

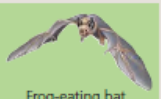
Phylogenetic Relationships of Mammals

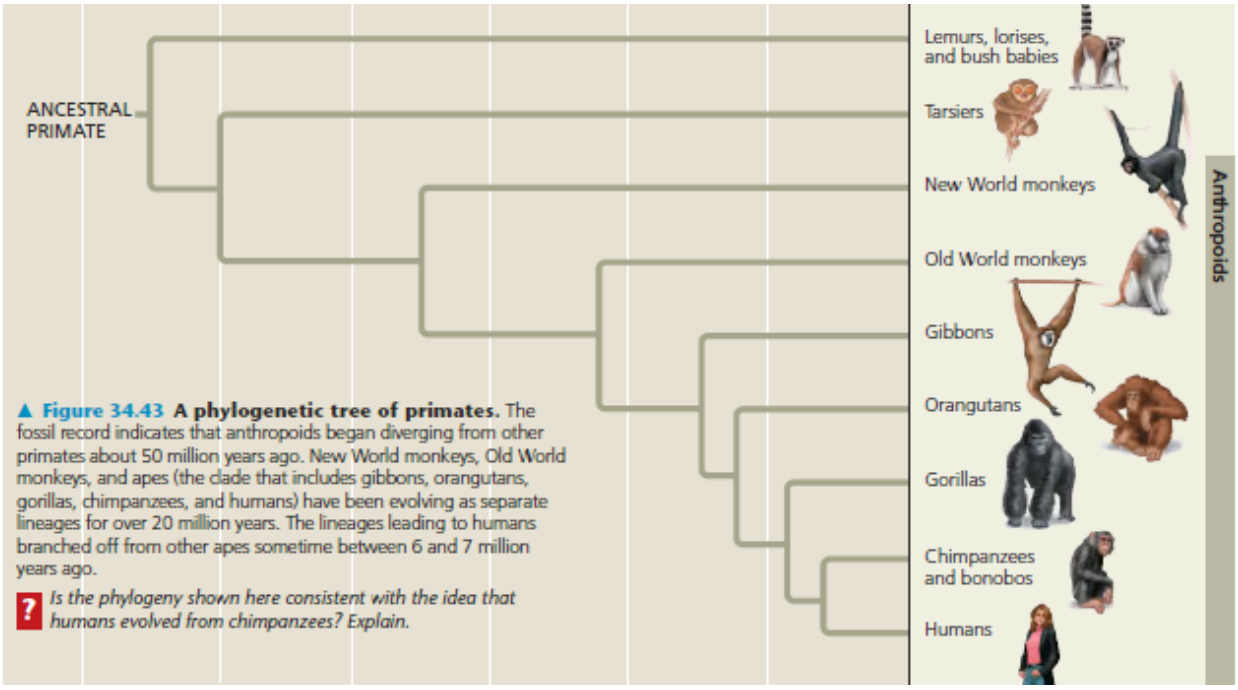
Evidence from numerous fossils and molecular analyses indicates that monotremes diverged from other mammals about 180 million years ago and that marsupials diverged from eutherians (placental mammals) about 140 million years ago. Molecular systematics has helped to clarify the evolutionary relationships between the eutherian orders, though there is still no broad consensus on a phylogenetic tree. One current hypothesis, represented by the tree shown below, clusters the eutherian orders into four main clades.



Possible phylogenetic tree of mammals.
All 20 extant orders of mammals are listed at the right of the tree. The orders in bold type are surveyed on the facing page.

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; herbivorous
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	Completes embryonic development in pouch on mother's body
Tubulidentata Aardvarks  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, chimpanzees, gorillas, 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 insectivores": some moles, some shrews  Star-nosed mole	Eat mainly insects and other small invertebrates



▲ **Figure 34.43 A phylogenetic tree of primates.** The fossil record indicates that anthropoids began diverging from other primates about 50 million years ago. New World monkeys, Old World monkeys, and apes (the clade that includes gibbons, orangutans, gorillas, chimpanzees, and humans) have been evolving as separate lineages for over 20 million years. The lineages leading to humans branched off from other apes sometime between 6 and 7 million years ago.

? *Is the phylogeny shown here consistent with the idea that humans evolved from chimpanzees? Explain.*

Chapter 34 Questions

1. **What are vertebrates?**
2. **What are chordates?**
3. **Which two groups of invertebrates are classified within the chordates?**
4. **What are the four key characteristics of chordates?**
5. **What are lancelets (life cycle, feeding, gas exchange)?**
6. **How do lancelets swim?**
7. **What are somites?**
8. **Describe the anatomy of a lancelet.**
9. **What are tunicates?**
10. **What distinguishes vertebrates from chordates?**
11. **What is the neural crest?**
12. **What are the hagfish and lamprey class?**
13. **What is special about hagfishes and lampreys?**
14. **What are cyclostomes?**
15. **What are hagfishes?**
16. **What are lampreys?**
17. **What is *Petromyzon marinus*?**
18. **What is the first chordate to have a head?**
19. **What are conodonts?**
20. **What characterized vertebrates of the Ordovician, Silurian, and Devonian periods?**
21. **What are gnathostomes?**
22. **When were cyclostomes common?**
23. **What is the lateral line system?**
24. **What are fin rays?**
25. **What are placoderms?**
26. **What are acanthodians?**
27. **What are chondrichthyans?**
28. **How do sharks swim?**
29. **Describe shark digestion.**
30. **Describe the sensory features of sharks.**
31. **Describe shark reproduction.**
32. **Describe the ray lifestyle.**
33. **What are osteichthyans?**
34. **How do fishes breathe?**
35. **How do fishes maintain buoyancy?**
36. **Describe the skin of fishes.**
37. **Describe fish reproduction.**
38. **What are ray-finned fishes (Actinopterygii)?**
39. **What is *Gadus morhua*?**
40. **What are lobe-fins (Sarcopterygii)?**

41. What are tetrapods?
42. What is *Tiktaalik*?
43. What are amphibians?
44. What are salamanders (urodeles)?
45. What are frogs (anurans)?
46. What are caecilians (apodans)?
47. Describe the life cycle of an amphibian?
48. Where do amphibians live?
49. Describe amphibian reproduction.
50. What is *Batrachochytrium dendrobatidis* (*Bd*)?
51. What are amniotes?
52. Describe the first amniotes.
53. What are reptiles?
54. What is the difference between ectothermic and endothermic?
55. What are diapsids?
56. What are lepidosaurs?
57. What are archosaurs?
58. Describe the amniote phylogeny.
59. What are pterosaurs?
60. What are dinosaurs?
61. What are tuataras?
62. What are squamates?
63. What are turtles?
64. What are crocodilians?
65. What are birds?
66. Where and why did feathers evolve?
67. What was the earliest bird?
68. What is Neornithes?
69. What are ratites?
70. What are mammals?
71. What are synapsids?
72. What are monotremes?
73. What are marsupials?
74. What are Eutherians?
75. What are primates?
76. Describe mammalian phylogeny.
77. What is brachiating?
78. What are the three main groups of living primates?
79. What are apes?
80. Describe the primate phylogeny.
81. What are humans?
82. What is paleoanthropology?
83. What are hominins?

84. What is the oldest hominin?
85. What is the foramen magnum?
86. What are australopiths?
87. Why did bipedalism evolve?
88. What are the earliest *Homo* fossils?
89. What are *H. ergaster* and *H. erectus*?
90. What are Neanderthals?
91. Where did humans originate from?

Chapter 34 Answers

1. Animals with vertebrae (bones that make up the vertebral column (backbone))
2. Bilaterian animals, belong to Deuterostomia
3. Cephalochordata (lancelets) and urochordata (tunicates)
4. notochord - skeletal structure (all chordate embryos), longitudinal, flexible rod located between digestive tube and nerve cord. Composed of large, fluid-filled cells encased with stiff, fibrous tissue, provides skeletal support (in humans, forms part of disks between vertebrae)

   Dorsal, hollow nerve cord - develops from plate of ectoderm that rolls into neural tube (other phyla have solid nerve cords that are often ventrally located), develops into brain/spinal cord

   Pharyngeal slits/clefts - Grooves (clefts) that separate series of arches that form along outer surface of pharynx (region posterior to mouth), become slits that open into pharynx (allow water entering mouth to exit body without passing through digestive tract)

   Post-anal tail with skeletal elements and muscles
5. most basal group of living chordates, have bladelike shape, develop characteristic chordate traits as larvae (feed on plankton in water column, trap particles in their pharynx). Reach 5 cm, adult swims to seafloor and wriggles backward in sand, only anterior exposed, cilia draw in seawater (passes through slits, where filtered by mucus), gas exchange occurs across external body surface
6. Feebly, coordinated contraction of muscles arranged like rows of chevrons (>>>) along sides of notochord flexes chord (produce undulations)
7. Blocks of mesoderm from which muscle segments in lancelets develop (found along side of notochord in all chordate embryos)
8. See picture
9. Chordate characteristics apparent in brief larval stage (swims to substrate guided by light/gravity sensitive cells then undergoes metamorphosis where chordate characters disappear). Tail/notochord resorbed, nervous system degenerates, organs rotate 90º. Adult draws water through incurrent siphon (water passes through slits into chamber called atrium and exits excurrent siphon, anus opens to siphon), have four less *Hox* genes than all other chordates
10. Vertebrates have two or more *Hox* genes and other important gene families, have vertebrae that enclose or flank notochord (lancelets and tunicates only have one *Hox*)
11. collection of cells that appears along the edges of the closing neural tube of an embryo (disperse throughout embryo, give rise to teeth, bones/cartilage in the skull, neurons, sensory capsules, etc.)
12. Myxini and Petromyzontida

13. Only lineages of living vertebrates without jaws, do not have backbone but have cartilage vertebrae
14. Clade of living jawless vertebrates (hagfishes/lampreys)
15. Jawless vertebrates, reduced vertebrae, cartilage skull, use segmental muscles pushing against notochord to swim (retain in adulthood), have small brain, eyes, ears, and nasal opening that connects to pharynx, mouths contain teeth made of keratin. All are marine (30 species), most are scavengers
16. 38 species, inhabit marine/freshwater, some are parasites (clamp mouth onto flank of host then ingest blood/tissues). Live in streams as larvae (suspension feeders that resemble lancelets, usually buried in sediment). Non-parasitic species feed only as larvae (mature, reproduce, and die within a few days). Parasitic migrate to sea/lakes as they mature. skeleton of cartilage (no collagen). Notochord persists as main skeleton, have sheath around it (extensions enclose nerve cord)
17. Sea lamprey, invaded Great Lakes
18. *Myllokunmingia*, lacked vertebrae
19. Some of earliest vertebrates (slender, soft-bodied, lacked jaws, skeleton of cartilage). Large eyes, mineralized dental tissues that form hooks
20. Paired fins, inner ear (two semicircular canals, provide sense of balance), lacked jaw, had muscular pharynx, armored with mineralized bone, became extinct after Dev
21. Jawed vertebrates, jaw = hinged structures that grip and slice (evolved by modification of skeletal rods that supported anterior pharyngeal slits, have additional duplication of *Hox* genes, forebrain is enlarged (enhanced smell/vision)
22. Paleozoic era
23. Organs that form row along each side of the body, sensitive to vibrations of water (in marine gnathostomes), precursors present in head shields of jawless vertebrates
24. Fins hardened by bone structures, evolved in early gnathostomes, provide thrust/steering control
25. Among earliest gnathostomes, armored vertebrates, 10 cm to 10 m
26. jawed vertebrates, among earliest, radiated during Silurian/Devonian, became extinct after placoderms
27. sharks, rays, relatives, have skeleton composed of cartilage often impregnated with calcium. abt 1000 species living, largest group consists of sharks, rays, skates. Other group includes ratfishes (chimaeras).
28. Streamlined body, trunk and tail fin movements propel them, dorsal fins function as stabilizers, paired pectoral (fore) and pelvic (hind) fins important for maneuvering, gains buoyancy by storing oil in its liver, sinks if it stops swimming because it is more dense than water. Continual swimming ensures water flows through shark gills, when resting use jaw muscles/pharynx to to pump water
29. Largest are suspension feeders, eat plankton. Most are carnivores, several rows of teeth that move to front of mouth as old teeth are lost, digestive tract is proportionately shorter than other vertebrates, have spiral valve (corkscrew-shaped ridge that increases surface area and prolongs food journey through tract)

30. Have sharp vision, no color, have nostrils that open into dead-end cups (smell but don't breath). Have regions in skin of head that can detect electric fields generated by muscle contractions. Have no eardrums, body transmits sound to hearing organs
31. Eggs fertilized internally, male has pair of claspers on pelvic fins, transfer sperm to female reproductive tract. Oviparous = lay eggs that hatch outside mother's body (these sharks release fertilized eggs after coating them). Ovoviviparous = retain fertilized eggs in oviduct (embryos develop on egg yolk, are born after hatching). Viviparous = Young develop within uterus (get nourishment by yolk sac placenta or eating other eggs). Reproductive tract empties with excretory system and digestive tract into cloaca (common chamber that has single opening to outside)
32. Bottom dwellers, feed by using jaws to crush molluscs/crustaceans
33. Have ossified (bony) endoskeleton with hard matrix of calcium phosphate), includes tetrapods and bony fishes.
34. Draw water over four/five pairs of gills located in chambers covered by a protective bony flap called the operculum (water is drawn into mouth, through pharynx and out between gills by muscles surrounding gill chambers.
35. Fill air sac (swim bladder) by shuttling gas between blood and swim bladder. Swim bladder arose from lungs
36. Skin covered by flattened bony scales (different from sharks), glands secrete slimy mucus over skin (reduces drag), have lateral line system (looks like row of tiny pits)
37. Most are oviparous, but others have lot of variation
38. Nearly all familiar aquatic osteichthyans, 27,000 species, named for bony rays that support fins, originated during Silurian, serve as major human food source
39. Cod in northwest Atlantic
40. Originated during Silurian, have rod-shaped bones surrounded by muscle in pectoral and pelvic fins, lived in brackish waters in Devonian (some were massive predators). Only 3 lineages survive (coelacanths (Actinistia, 1 species), lungfishes (Dipnoi, 6 species, 3 genera, have gills and lungs, can estivate, or wait in stasis, found in freshwater), organisms that gave rise to tetrapods)
41. Four limbed animals, head separated from body by neck (started with one vertebrae (only up/down) then became two vertebrae (left-right/up-down)). Bones of pelvic girdle (where hind legs are attached) are fused to backbone, adults don't have gills (except for axolotl/etc.)
42. Ancient lobe-fin with fish and tetrapod characters
43. 6150 species in three clades (salamanders (Urodela), frogs (Anura), and caecilians (Apoda))
44. Some are aquatic, other live on land as adults. Most terrestrial walk with side-side bending, paedomorphosis common among aquatic salamanders
45. Better suited to locomotion on land, toads are frogs with leather skin/other land adaptations. Frog catches prey with tongue attached to front of mouth, skin glands secrete mucus that protects it from predators
46. Legless, nearly blind, resemble earthworms, inhabit tropical areas

47. Start with larval stage (tadpole), usually aquatic herbivore with gills, lateral line system, and long,finned tail. Metamorphosis creates external eardrums, legs, lungs, and carnivorous digestive system. Gills disappear, lateral line usually disappear. In salamanders and caecilians, larvae and adults often are both carnivorous.
48. Found in damp habitats because moist skin required for gas exchange. Also, eggs lack shell and dehydrate quickly in dry air.
49. Fertilization is external, male spills sperm over eggs as female sheds them, some frogs lay many eggs (have high egg mortality) others lay few and care for eggs. Amphibians have complex social behaviours.
50. Fungal pathogen that causes skin infections
51. Group of tetrapods (extant members = reptiles/mammals). Have amniotic egg (four specialized membranes (extraembryonic membranes, develop from tissue layers that grow out from embryo), see picture), slows dehydration of embryo. Use rib cage to ventilate lungs (more efficient than throat-based ventilation in amphibians)
52. Lived in warm, moist areas, spread to new environments, resembled lizards with sharp teeth
53. Tuataras, lizards, snakes, turtles, crocodiles, birds. Have scales of keratin (protect from desiccation and abrasion). Lay shelled eggs on land, fertilization occurs internally before secretion of eggshell), do not use metabolism to control body temp.
54. Absorb external heat as main source of body heat, require 10% of food of similar-size mammal (most reptiles)

    Capable of maintaining body temperature through metabolic activity (birds)
55. Earliest reptiles, pair of holes on each side of skull behind eye sockets, muscles pass through them to control jaw movement
56. Tuataras, lizards, snakes, ancient marine reptiles, descended from diapsids.
57. turtles, crocodilians, pterosaurs, and dinosaurs
58. see picture
59. Originated late Triassic, first flapping flight, wings of collagen-strengthened membrane stretched between trunk/hind leg and long digit on foreleg.
60. Ornithischians were herbivores with cool defenses. Saurischians included long necked giants and theropods (bipedal carnivores such as *T. rex* and ancestors of birds), some may be endotherms
61. Lizard-like reptiles, thrived in Cretaceous, now only found on islands near New Zealand. Can live to 100 yrs old.
62. Snakes and lizards (7,900 species). Snakes descended from lizards with legs. Snakes are carnivorous
63. 307 species. Do not have holes in skull behind eye sockets. Other reptiles have two behind each. Lost holes. have box-like shell (upper and lower shields fused to the vertebrae, clavicles (collarbones) and ribs). Most have hard shell. Acquired full shell in stages. Earliest turtles could not retract, now side-necked turtles fold neck horizontally, vertical necked turtles fold neck vertically.

64. ALligators and crocodiles, reaches to late Triassic, confined to warm regions (23 known species).
65. 10000 species. Lack urinary bladder, females have one ovary, gonads very small, increase in size during breeding season. Living are toothless, feathers are made of ß-keratin. Wings flapped by pectoral (breast) muscles anchored to a keel on sternum (breastbone). Endothermic, feathers and sometimes layer of fat provide insulation, tubes leading to/from elastic air sacs in lungs improve airflow / oxygen uptake. Four chambered heart. Have color vision, excellent eyesight. Brain larger than amphibians and other reptiles. Fertilization internal. Copulation = contact between cloacas
66. Originally originated in theropods before flight, used for insulation, camouflauge, etc.
67. *Archaeopteryx*.
68. Clade including the 28 orders of living birds
69. Order of flightless birds (sternal keel is absent, pectoral muscles are small), not penguins
70. 5,300 known species. Have mammary glands (produce milk). Have hair and fat layer under skin. Have kidneys. Endothermic, a larger brain, four-chambered heart, parental care, variety of teeth.
71. Group of amniotes to which mammals belong. Early non mammalian ones lacked hair, had sprawling gait, laid eggs. Have single temporal fenestra (hole behind eye socket), jaw muscles pass through it and anchor on temple. Quadrate and articular that made up jaw joint incorporated into middle ear, articular forms malleus, incus = quadrate. Evolved into large herbivores/carnivores, were dominant tetrapods during Permian, diversity fell during Triassic, became increasingly mammalian
72. Found only in Australia/New Guinea, represented by platypus and four species of echidnas. Lay eggs, have hair, produce milk, lack nipples, milk secreted by glands on belly of mother.
73. Opossums, kangaroos, koalas, have higher metabolic rates, nipples provide milk, give birth to live young, embryo develops in uterus, lining of uterus/extraembryonic membranes form placenta (nutrients diffuse into embryo from mother's blood). Marsupial born early, completes development while nursing, held in maternal pouch (marsupium, faces front in most, back in bilbies/digging marsupials). Existed worldwide in Mesozoic, found only in Australia/North A/South A.
74. Placental mammals, placenta more complex than marsupials, have longer pregnancy, young complete development within uterus, joined to mother by placenta.
75. lemurs, tarsiers, monkeys, apes. Most have hands/feet adapted for grasping, flat nails (not narrow claws). Skin ridges on fingers, large brain, short jaws, forward-looking, close together eyes, well-developed parental care. Earliest were tree-dwellers. All except humans have big toe separated from others, all have relatively movable thumb, monkeys and apes have opposable thumb (can touch ventral surface of the tip of all four fingers with ventral surface of thumb on same hand).
76. See picture
77. Swinging from branch to branch.
78. Lemurs-lorises-bushbabies, tarsiers, and anthropoids (monkeys and apes)

Resemble early primates

more closely related to anthropoids than first

New world and old world monkeys originated in Africa or Asia. New world colonized South America. New world are arboreal, old world are ground-dwelling and arboreal. Most are diurnal

79. Genera *Hylobates* (gibbons), *Pongo* (orangutans), *Gorilla* (gorilla), *Pan* (chimps/bonobos), *Homo* (humans), diverged from old world monkeys. Relatively long arms, short legs, no tail. All spend time in trees (gibbons/orangutans primarily arboreal). Larger brain relative to body size
80. see picture
81. Stand upright, bipedal, larger brain, capable of language, reduced jawbones/ muscles, shorter digestive tract. Differ from chimps in expression of 19 regulatory genes.
82. Study of human origins
83. 20 extinct species more closely related to humans than chimps
84. Sahelanthropus tchadensis with reduced canines, flat faces, more bipedal than others
85. Hole at base of skull through which spinal cord passes (less far back in bipedal animals)
86. Hominins from 4 mya to 2 mya when hominin diversity increased dramatically. “robust” australopiths had sturdy skulls with powerful jaws and large teeth. “gracile” australopiths had lighter feeding equipment.
87. As Africa had more open land, bipedalism was favored for moving (four legs expended more energy because adapted for arboreal)
88. *Homo habilis*, short jaw, larger brain volume, stone tools
89. Large brained, slender-legged hominins, had short, straight fingers (did not climb trees). Reduced sexual dimorphism, originally thought to be *H. erectus*

First hominid to migrate out of Africa

90. *Homo neanderthalensis*, thick boned hominid with prominent brow, larger brain than humans, interbred with humans
91. Africa.