

10. Two other groups of tetrapods: _____
11. Two groups with amniotic eggs: _____
12. Feed their young milk: _____

Exercise 2 (Modules 19.2–19.3)

These modules describe the major groups of fishes and fishlike vertebrates. Match each of the descriptions below with the correct group or groups.

- | | |
|--|--|
| _____ 1. Jawed fishes with a cartilage skeleton | |
| _____ 2. Two other groups of fishes with jaws | |
| _____ 3. Lungfishes are in this group. | |
| _____ 4. Chondrichthyans | |
| _____ 5. Two groups that lack hinged jaws | |
| _____ 6. Largest and most diverse group of fishes | |
| _____ 7. Bones in muscular fins may have enabled them to “walk.” | |
| _____ 8. Craniates but not vertebrates | |
| _____ 9. Trout, perch, and seahorse | |
| _____ 10. Possess a buoyant swim bladder | |
| _____ 11. One lineage led to tetrapods. | |
| _____ 12. Operculum helps pump water over gills. | |
| _____ 13. Notochord is their main skeletal support. | |
| _____ 14. Secrete slime for defense | |
| _____ 15. Fins supported by thin, flexible skeletal rods | |
| _____ 16. Parasites that scrape a hole in a fish to feed | |
| _____ 17. Two groups that lack paired pectoral and pelvic fins | |

- A. Hagfishes
- B. Lampreys
- C. Sharks and rays
- D. Ray-finned fishes
- E. Lobe-finned fishes

Exercise 3 (Module 19.4)

Adaptation to life on land — the evolution of the tetrapods — was a key event in vertebrate history. State whether each of the following is true or false (T or F) and then *correct* the false statements to make them true.

- _____ 1. Tetrapods appeared in the late Devonian period, about 360–365 million years ago.
- _____ 2. The first tetrapods probably lived in shallow salt water.
- _____ 3. The direct ancestors of tetrapods were ray-finned fishes.
- _____ 4. Gas exchange, water conservation, support, and movement are challenges of life on land.
- _____ 5. The fossil record gives us little information about the evolution of land vertebrates.
- _____ 6. *Eusthenopteron* was fishlike and *Ichthyostega* was adapted for life on land, but we do not know what kind of creature bridged the gap between them.
- _____ 7. *Panderichthyes* was rather fishlike, but had lungs as well as gills.
- _____ 8. *Tiktaalik* had a neck and limbs with fingers and toes, but fishy scales.
- _____ 9. *Acanthostega* came later, and had a neck and limbs with fingers and toes.
- _____ 10. *Acanthostega* and *Tiktaalik* show that the first tetrapods were fish with lungs.
- _____ 11. A neck, an upturned snout, and lungs were useful adaptations in stagnant pools.
- _____ 12. Modern amphibians are the only descendants of these early tetrapods.

Exercise 4 (Modules 19.5–19.8)

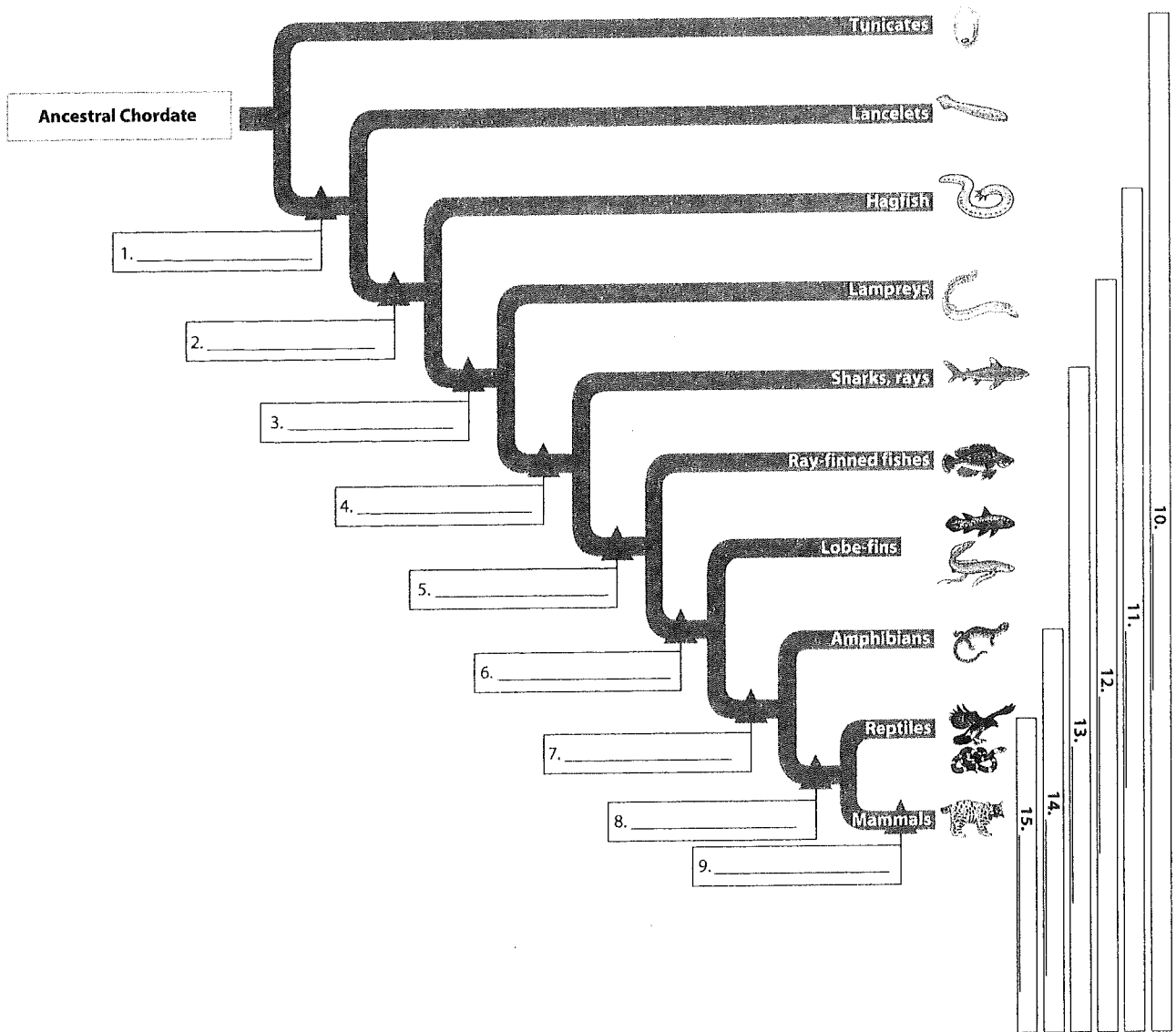
The tetrapods—amphibians, reptiles (including birds), and mammals—are the dominant large animals on land. Read up on these animals and then match each statement with a group or groups of tetrapods: Amphibians (A), Reptiles (R), Birds (B), or Mammals (M). Some questions have multiple answers.

- _____ 1. The first tetrapods
- _____ 2. Two groups of endothermic tetrapods
- _____ 3. First vertebrates with amniotic eggs
- _____ 4. Two other groups of amniotes
- _____ 5. Feathered reptiles
- _____ 6. Have hair
- _____ 7. Scales help them live on dry land.
- _____ 8. Mice, tigers, bats, and porpoises
- _____ 9. Frogs, toads, and salamanders
- _____ 10. Proliferated after the dinosaurs died out
- _____ 11. Widespread and diverse in the Carboniferous period
- _____ 12. Eutherians, marsupials, and monotremes
- _____ 13. Feed their young milk
- _____ 14. Two groups descended from early reptiles
- _____ 15. Populations are dramatically declining around the world.
- _____ 16. The largest animal ever is in this group.
- _____ 17. Two groups that are ectothermic
- _____ 18. Go through an aquatic tadpole larva stage
- _____ 19. The young of most in this group develop inside their mothers.
- _____ 20. *Archaeopteryx* is an extinct form.
- _____ 21. The largest land animals ever were in this group.
- _____ 22. Most live on land, but have aquatic eggs and larvae
- _____ 23. Have light, honeycombed bones
- _____ 24. Gave rise to reptiles and mammals
- _____ 25. Most nourish their young via a placenta.
- _____ 26. Adaptations include losing their teeth and their long tails.
- _____ 27. Lizards and snakes
- _____ 28. Evolved from a type of dinosaur
- _____ 29. Turtles, crocs, and birds
- _____ 30. Humans

Exercise 5 (Modules 19.1–19.8)

Review the chordates by labeling this phylogenetic tree. First, identify the major steps in chordate evolution by labeling the derived characters on each clade along the left side of the tree (1–9). (Write out terms; don't just use letters to label.) Choose from: **legs, head, lobed fins, milk, lungs or derivatives, vertebral column, brain, jaws, amniotic egg**

Next identify the broad groupings of chordates by labeling the "bars" down the right side of the tree (10–15). (Again, write out the words.) Choose from: **tetrapods, chordates, amniotes, craniates, vertebrates, jawed vertebrates**



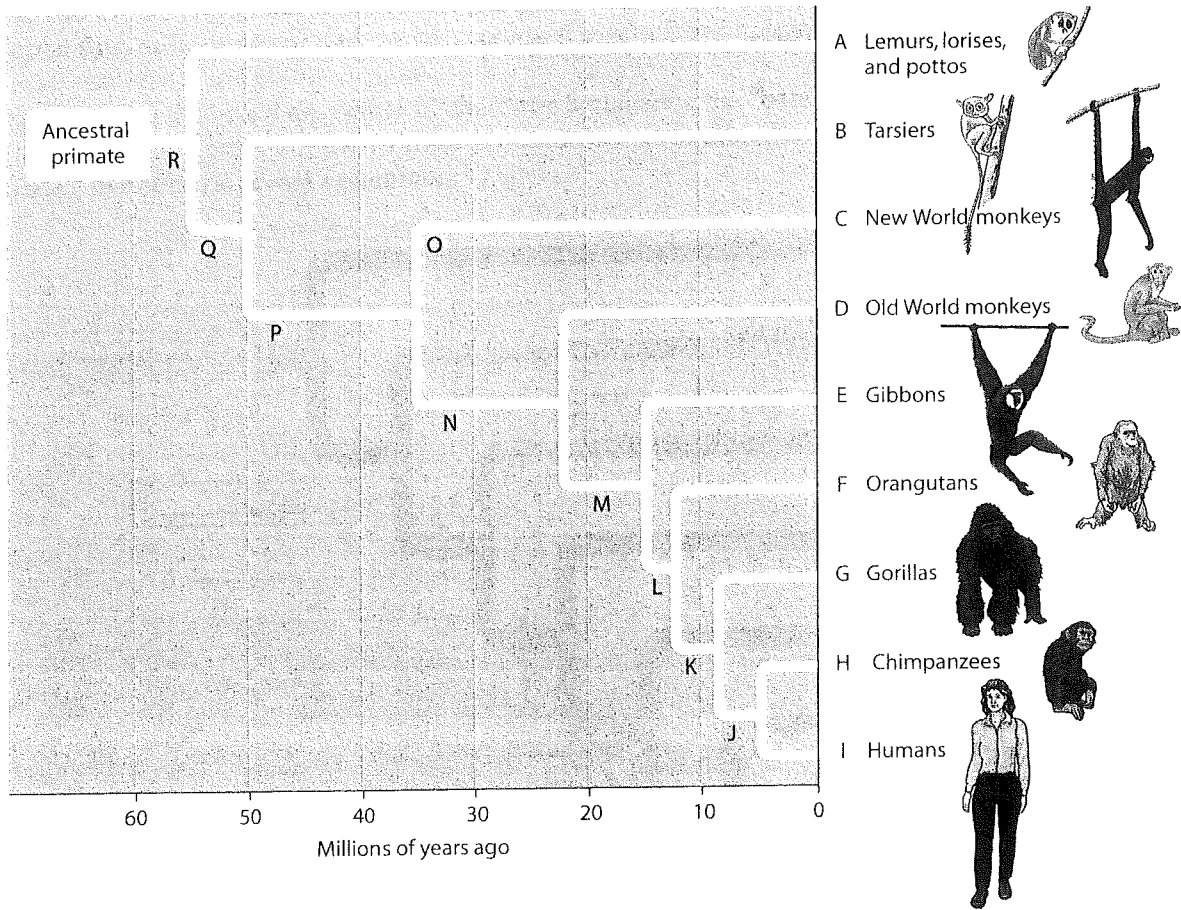
Exercise 6 (Module 19.9)

You are a primate. Review the characteristics of primates, and then explain which of these characteristics enables you to do each of the following.

1. Find a quarter among a pocketful of coins
2. Catch a ball that is thrown to you
3. Pick up a postage stamp from your desktop
4. Do a handspring
5. Thread a needle
6. Shoot a basketball

Exercise 7 (Modules 19.9–19.10)

Match each of the statements below with the major modern groups of primates (A–I) shown on the phylogenetic tree. (Some questions will require more than one answer.)



- _____ 1. These groups make up the hominoids.
- _____ 2. These are all anthropoids.
- _____ 3. Apes
- _____ 4. The largest ape
- _____ 5. New World monkeys
- _____ 6. Old World monkeys
- _____ 7. Two groups of prosimians
- _____ 8. Tarsiers
- _____ 9. Lorises, potoos, and lemurs
- _____ 10. Chimps
- _____ 11. The sifaka, from Madagascar

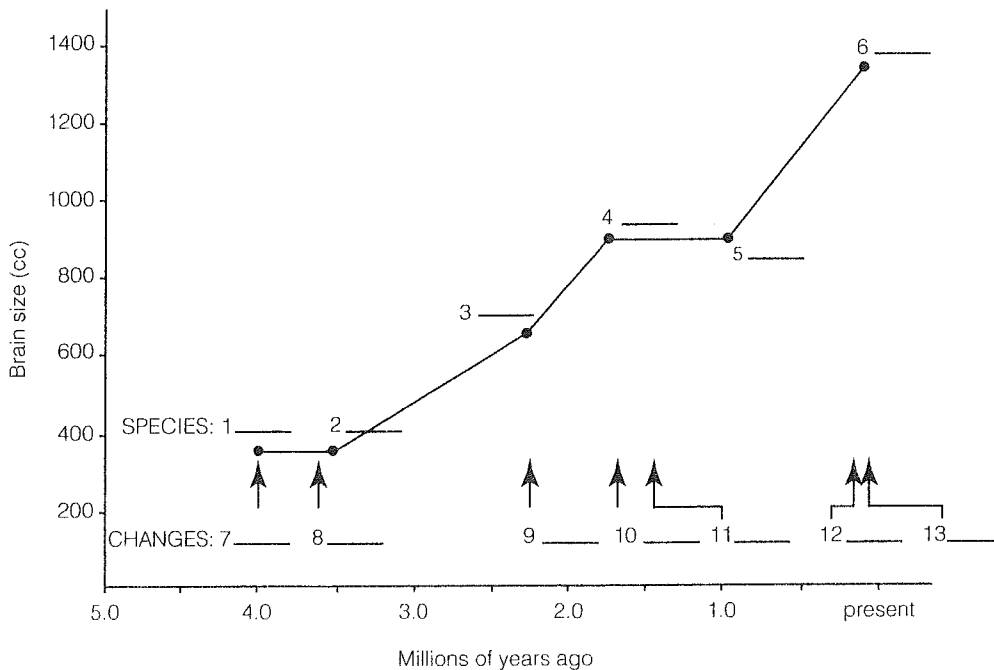
- _____ 12. The golden lion tamarin
- _____ 13. Baboons
- _____ 14. Gibbons
- _____ 15. Orangutan
- _____ 16. Gorillas
- _____ 17. Spider monkey
- _____ 18. Rhesus macaque
- _____ 19. Lack tails and have relatively large brains, long arms, and short legs
- _____ 20. South American monkeys
- _____ 21. African and Asian monkeys
- _____ 22. Ape group that is most distantly related to other apes
- _____ 23. Earliest lineage of primates
- _____ 24. All the groups with a fully opposable thumb
- _____ 25. Monkeys with flat faces, widely spaced nostrils, and prehensile tails
- _____ 26. Monkeys with downward-pointing nostrils, lacking prehensile tails
- _____ 27. Closest living relatives of humans

Now match the statements below with important steps in primate evolution (J–R). (One answer each.)

- _____ 28. Common ancestor of humans and chimps.
- _____ 29. The earliest anthropoid
- _____ 30. The ancestral primate
- _____ 31. This primate seems to have rafted to South America.
- _____ 32. Cro-Magnon cave-painters
- _____ 33. Ancestor of all primates except lemurs, potoos, and lorises
- _____ 34. In 2004, fossils of this ancestor of all apes, named *Pierolapithecus catalaunicus*, were found in Spain.

Exercise 8 (Modules 19.11–19.16)

Humans and chimps are thought to have diverged from a common ancestor 5–7 million years ago. There are a dozen or more species of fossil hominids that have been identified—the human branch of the primate tree has itself branched and rebranched several times—but only our own species, *Homo sapiens*, remains. One of the most dramatic trends seen in hominid evolution is a drastic increase in the size of the brain. This graph traces change in brain size seen in various species of hominids over time. Label the graph, starting with the name of each hominid species (1–6). Then identify when other important physical and cultural changes are thought to have occurred (7–13) during the course of hominid evolution.



Species

- A. *Homo erectus*
- B. *Australopithecus anamensis*
- C. *Homo habilis*
- D. *Homo sapiens*
- E. *Australopithecus afarensis*
- F. *Homo ergaster*

Changes

- G. Earliest known stone tools
- H. Human *FOXP2* speech gene
- I. First hominids to leave Africa
- J. African footprints
- K. Modern humans leave Africa
- L. More sophisticated stone tools
- M. Bipedalism

Exercise 9 (Modules 19.11–19.18)

Over the last few decades, paleoanthropologists have made great strides in fleshing out the story of human evolution, shattering some of our old ideas. The quotes below reflect various lingering misconceptions and fallacies about human evolution. Counter each of these false statements with a more up-to-date correction.

1. "Scientists have very little evidence of our origins. They are still looking for the 'missing link.'"
2. "Human beings are descended from chimps."
3. "The key change that set us apart from other primates was the development of a larger brain. Walking upright came later."
4. "All hominid fossils show a single line of descent, progressing from the ancestors of *Australopithecus*, through *Homo erectus*, to modern humans."
5. "Modern humans are descended from the Neanderthals."
6. "Hominids first appeared in Africa, then spread around the globe. Modern *Homo sapiens* evolved in Europe."
7. "Humans are just one species out of many on Earth. Our actions can't have much effect on the planet."
8. "Skin color is a useful characteristic for classifying humans into different races."
9. "Human speech is something we can *learn* simply because we are so intelligent. It can't be a product of our evolution because there is nothing *genetic* about it."

Test Your Knowledge

Multiple Choice

1. Jaws probably evolved from
 - a. fin structures.
 - b. ribs.
 - c. gill structures.
 - d. teeth.
 - e. skull bones.
2. Which of the following is *not* thought to be in the lineage that led to human beings?
 - a. an amphibian
 - b. a dinosaur
 - c. a jawless vertebrate
 - d. a colonial protist
 - e. a lobefin
3. The first vertebrates to live on land were
 - a. dinosaurs.
 - b. reptiles.
 - c. amphibians.
 - d. cartilaginous fishes.
 - e. mammals.
4. There are three major groups of mammals, categorized on the basis of
 - a. their diet.
 - b. habitat.
 - c. method of locomotion.
 - d. teeth and digestive system.
 - e. method of reproduction.
5. Which of the following probably appeared earliest in the story of hominid evolution?
 - a. bipedal posture
 - b. speech
 - c. increase in brain size
 - d. increase in stature
 - e. symbolic thought
6. The lemurs of Madagascar are examples of
 - a. Old World monkeys.
 - b. anthropoids.
 - c. prosimians.
 - d. New World monkeys.
 - e. apes.
7. Which of the following is regarded as evidence of a major change that may have led to human speech?
 - a. Fossils that show that bipedal locomotion freed the hands for use of sign language
 - b. Discovery of a gene that shapes the brain for use of language

- c. Evidence that the tongue of *Homo sapiens* differed from that of *Homo erectus*
 - d. DNA studies of Neanderthals and other fossil humans
 - e. Changes in the nasal passages and voice box of early *Homo sapiens*
8. Biochemical evidence indicates that _____ are more closely related to humans than to other apes.
- a. the gorilla and the orangutan
 - b. the chimpanzee and the baboon
 - c. the orangutan and the chimpanzee
 - d. the gorilla and the chimpanzee
 - e. the orangutan and the gibbon
9. Fossil evidence suggests that humans evolved in _____
- a. Europe.
 - b. South America.
 - c. Asia.
 - d. the Middle East.
 - e. Africa.
10. Which of the following probably coexisted for a time with *Homo sapiens*?
- a. *Australopithecus robustus*
 - b. *Homo erectus*
 - c. *Australopithecus afarensis*
 - d. *Homo habilis*
 - e. *Australopithecus africanus*
11. Which of the following appear to be the best explanations so far for differences in human skin color?
- a. Darker skin shields the skin from UV; lighter skin allows synthesis of vitamin D.
 - b. Darker skin cools the body; lighter skin allows synthesis of folate.
 - c. Darker skin warms the body; lighter skin prevents breakdown of folate.
 - d. Darker skin prevents breakdown of folate; lighter skin allows synthesis of vitamin D.
 - e. Darker skin warms the body; lighter skin cools the body.
12. Which of the following correctly pairs a hominid with a "first" in hominid evolution?
- a. *Homo sapiens*—out of Africa
 - b. *Homo erectus*—bipedal stance
 - c. Neanderthal—cave paintings
 - d. *Australopithecus*—large brain
 - e. *Homo habilis*—stone tools
13. As *Homo sapiens* spread around the world, they probably reached which of the following last?

- a. North America
- b. South America
- c. Asia
- d. Europe
- e. Australia

Essay

1. Describe the characteristics of lobe-finned fishes that make them the most likely aquatic ancestors of land vertebrates (tetrapods). Scientists expected the transitional forms to be fishes with lungs that gradually developed legs as they dragged themselves from pool to pool. What kinds of fossils did they find?
2. Describe adaptations of birds for flight.
3. The spadefoot toad of the southwestern United States is an unusual amphibian; it is capable of surviving in the desert. Few amphibians can tolerate dry desert conditions, but many reptiles—horned toads, rattlesnakes, and desert tortoises—thrive in hot, arid regions. In what ways are reptiles better adapted to life in the desert than amphibians?
4. List the specialized characteristics of primates.
5. Which primate is the closest living relative of humans? What is the evidence for this close relationship?
6. Describe the characteristics that separate each of the paired groups:
 - a. anthropoids—prosimians
 - b. Old World monkeys—New World monkeys
 - c. monkeys—apes
 - d. other apes—humans
7. Describe genetic evidence that points to when and where *Homo sapiens* originated. Do fossils support these data?

Apply the Concepts

Multiple Choice

1. Which of the following are all vertebrates but not amniotes?
 - a. frog, trout, lancelet, lungfish
 - b. lamprey, lizard, lobefin, shark
 - c. shark, lamprey, salamander, trout
 - d. sparrow, lizard, raccoon, turtle
 - e. trout, frog, turtle, lungfish

2. There are relatively few species of cartilaginous fishes, compared with the bony fishes. Cartilaginous fishes are mostly limited to a lifestyle of swimming fast in open water. Ray-finned fishes have adapted to many different lifestyles—clinging to seaweed, hiding in crevices, even burrowing in the bottom. This could probably be attributed to the fact that ray-finned fishes
 - a. have more rigid skeletons.
 - b. are smaller than cartilaginous fishes.
 - c. have operculums and swim bladders.
 - d. have lateral line systems and paired fins.
 - e. are endothermic.
3. Which of the following is *least* closely related to all the others?
 - a. shark
 - b. human
 - c. tuna
 - d. salamander
 - e. garter snake
4. Imagine that you are a paleontologist (a scientist who studies fossils). In recent digs, you have unearthed bones of all of the following. Which could you have found in the oldest sediments?
 - a. amphibians
 - b. crocodiles
 - c. dinosaurs
 - d. birds
 - e. marsupials
5. Which of the following is a shared derived character of reptiles (including birds) and mammals?
 - a. legs
 - b. amniotic egg
 - c. jaws
 - d. lungs
 - e. all of the above
6. Which of the following is *least* closely related to the others?
 - a. human
 - b. baboon
 - c. gorilla
 - d. squirrel monkey
 - e. lemur
7. At the zoo, Tom saw a species of primate he had never even heard of before. He said, "It was called a white-faced saki. It had long, dark, spiky fur, a long fluffy tail, forward-facing brown eyes, a white forehead, and yellow cheeks." Based on this information, the white-faced saki could *not* be
 - a. an ape.
 - b. a prosimian.
 - c. a New World monkey.
 - d. an Old World monkey.
 - e. an anthropoid.
8. Emma saw an old Tarzan movie on television. The movie supposedly took place in Africa, but Emma easily spotted that it was not really filmed there. Which of the following could have tipped her off?
 - a. Chimps like Tarzan's sidekick Cheetah do not live in Africa.
 - b. The monkeys in the jungle had prehensile tails.
 - c. There were no prosimians shown in the forest.
 - d. Tarzan wrestled with a gorilla.
 - e. Only Old World monkeys were shown.
9. Which of the following categories includes all of the others?
 - a. apes
 - b. Old World monkeys
 - c. anthropoids
 - d. hominids
 - e. New World monkeys
10. Most known species of hominids
 - a. were the ancestors of modern humans.
 - b. evolved during the last million years or so.
 - c. had large brains.
 - d. lived primarily in trees.
 - e. were not our ancestors.
11. Which of the following is a hominoid, but not a hominid?
 - a. Neanderthal
 - b. lemur
 - c. *Australopithecus africanus*
 - d. gorilla
 - e. squirrel monkey
12. The bonobo, an ape closely related to the chimpanzee, displays behaviors very similar to those of humans, and some anthropologists have suggested that the bonobo is the living primate most closely related to humans. Which of the following would be the easiest way to try to substantiate this idea?
 - a. Look for fossils of bonobos, chimps, and humans.
 - b. Study the DNA of bonobos and chimps.
 - c. Determine which of the species are anthropoids.
 - d. Compare the DNA of bonobos and humans.
 - e. Compare the DNA of bonobos, chimps, and humans.