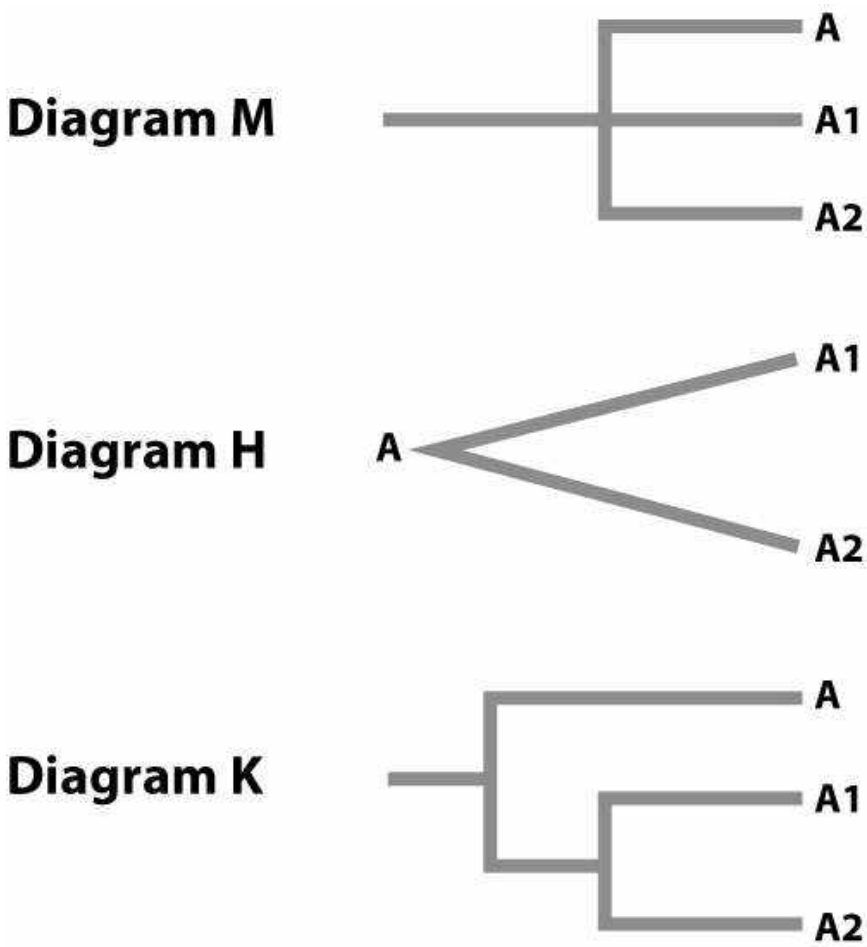
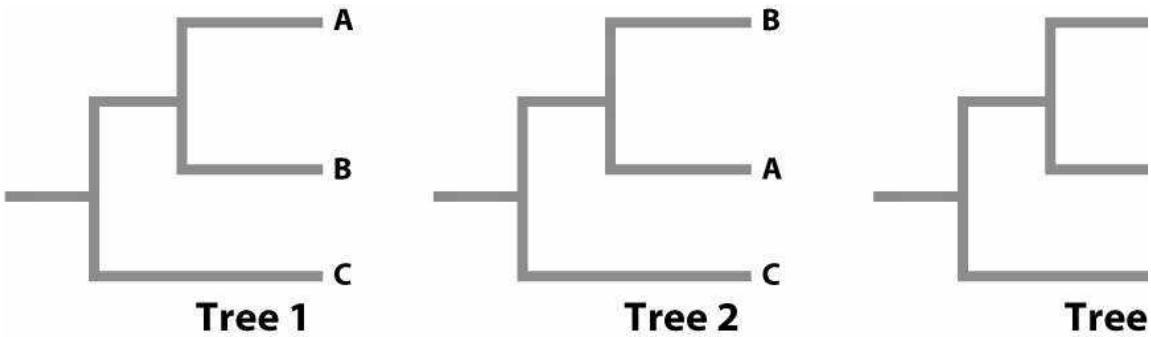
1. A population of rodents, called population A, lived together in harmony on a large landmass until one group of the population dispersed to a nearby island. Two million years later, the island population is split into two smaller, equal-sized populations when a river formed across the middle of the island. Now two new species have evolved on the island, A1 and A2. They have replaced the population from which they were derived. Which represents the phylogeny of the populations discussed in this scenario?



A) diagram M
B) diagram H
C) diagram K

2. In a phylogenetic tree, a node or branching point represents:
   A) the common ancestor from which the descendent species diverged.
   B) the species in the fossil record from which the descendent species diverged.
   C) one of the descendent species in the phylogeny.
   D) the ancestral species from which all species in the phylogeny arose.
   E) None of the answer options is correct.

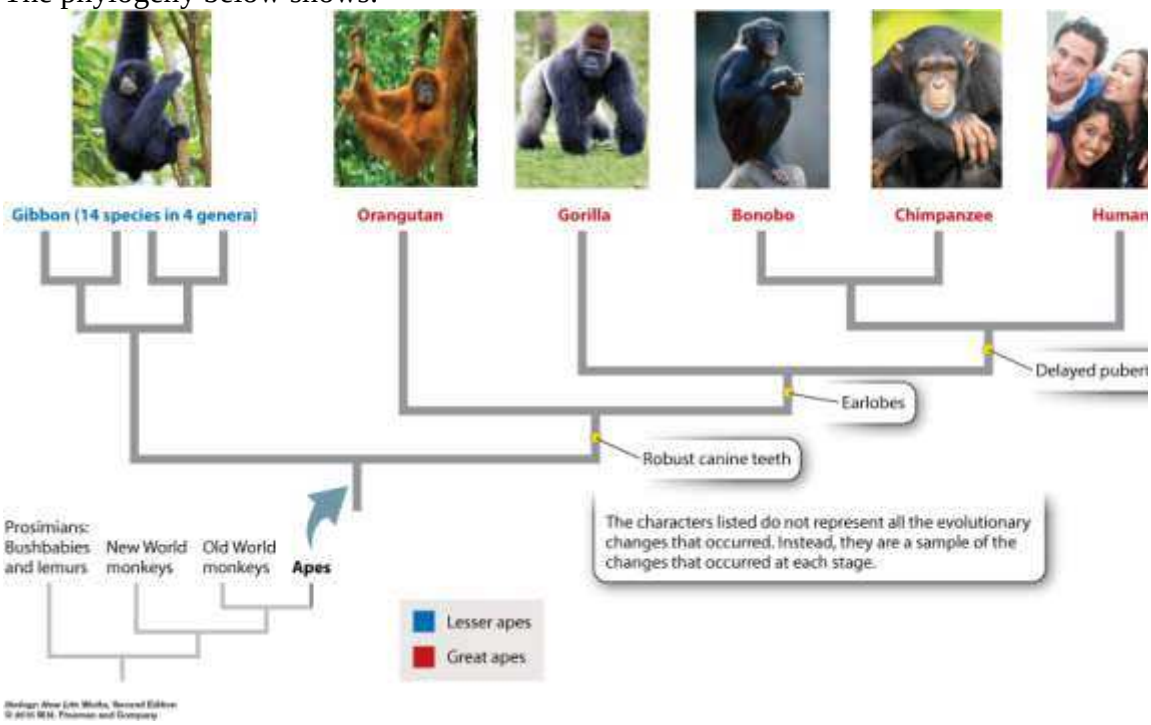
3. The diagram below depicts three phylogenetic trees. Which of the three show the same sister group relationships among groups A, B, and C?



A) Trees 1 and 2 are equivalent.
B) Trees 2 and 3 are equivalent.
C) Trees 1 and 3 are equivalent.
D) All three trees are equivalent.
E) All three trees are different: no two are equivalent.

4. A taxon that does NOT include the last common ancestor of all its members is a _____ group.
A) monophyletic
B) paraphyletic
C) polyphyletic

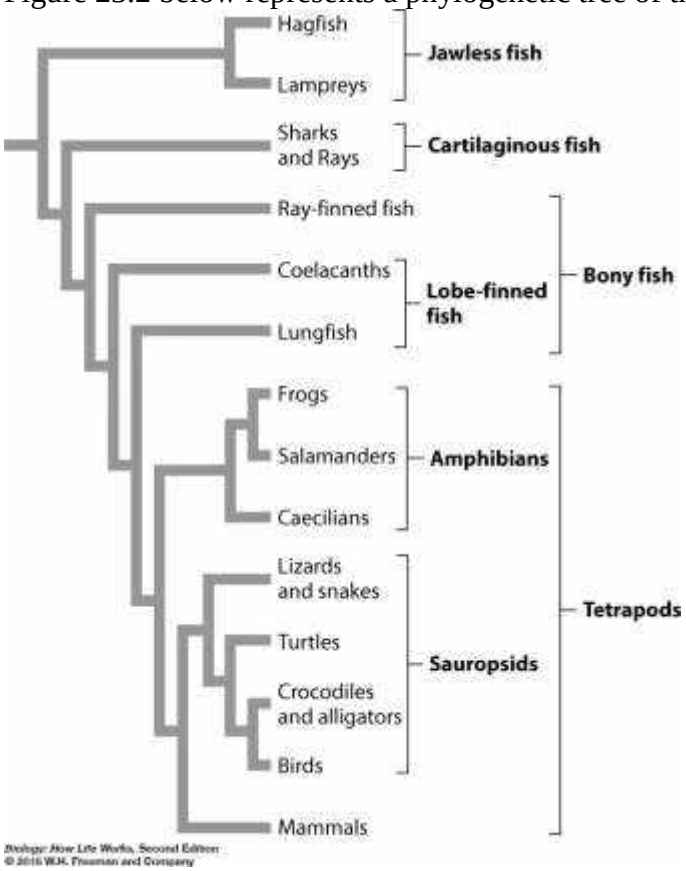
5. The phylogeny below shows:



(left to right) Zoonar/K. Jorgensen/age fotostock; S Sailer/A Sailer/age fotostock; J & C Sohns/age fotostock; Michael Dick/ Animals Animals–Earth Scenes; FLPA/Jurgen & Christi/age fotostock; Yellow Dog Productions/Getty Images.

A) orangutans and gorillas are more closely related than humans and gorillas.
B) humans and gorillas are more closely related than orangutans and gorillas.
C) the gorilla is the most recent common ancestor to bonobos, chimps, and humans.
D) the orangutan is the most recent common ancestor of all great apes.
E) all great apes walk with an upright gait.

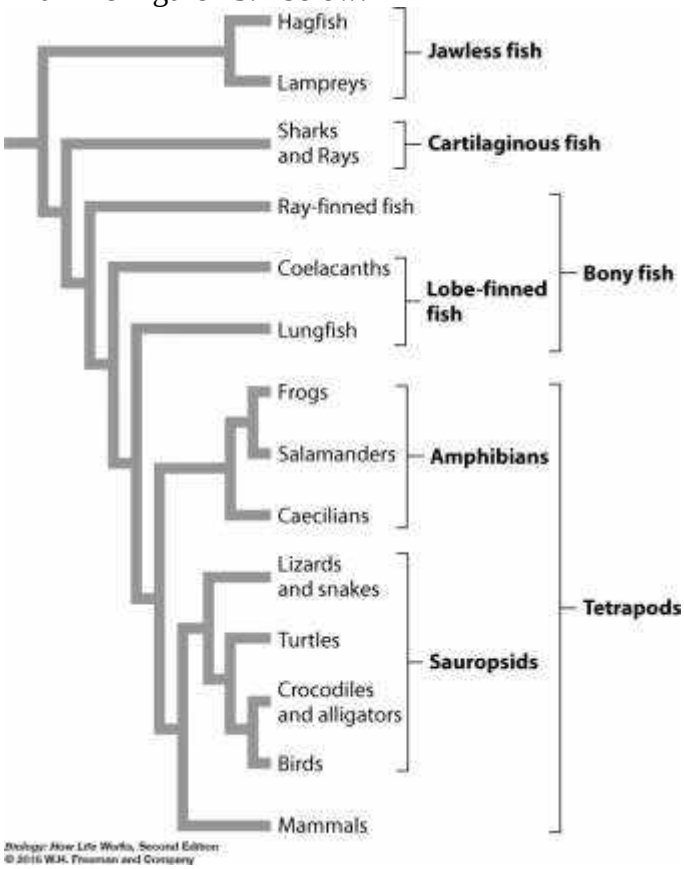
6. Figure 23.2 below represents a phylogenetic tree of the vertebrate animals.



According to this tree, what is the sister group to the tetrapods?

A) sauropsids
B) mammals
C) lungfish
D) amphibians
E) coelacanths

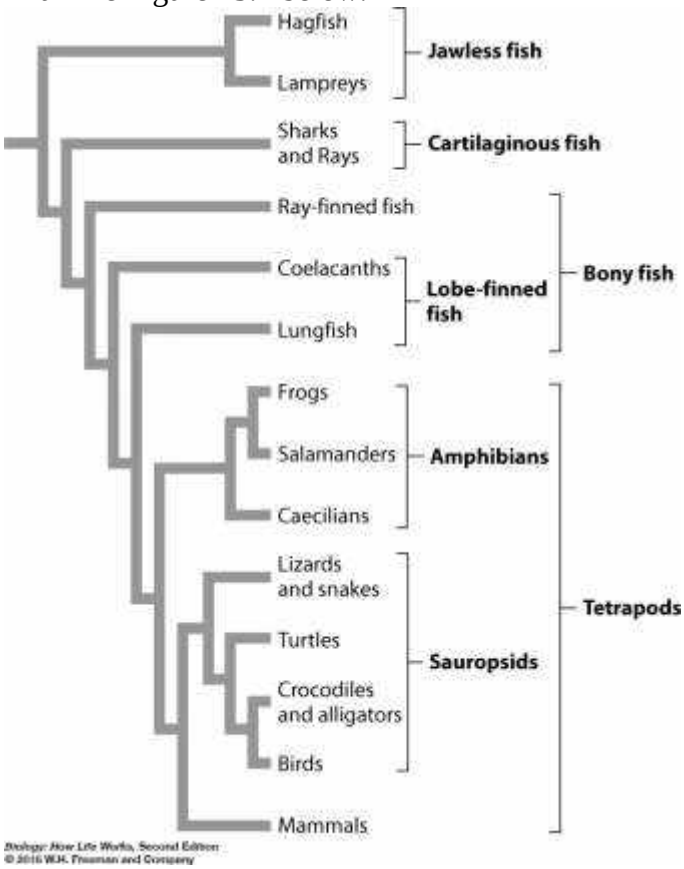
7. Examine Figure 23.2 below.



What is the sister group to mammals?

A) sauropsids
B) tetrapods
C) birds
D) crocodiles and alligators
E) birds plus crocodiles and alligators

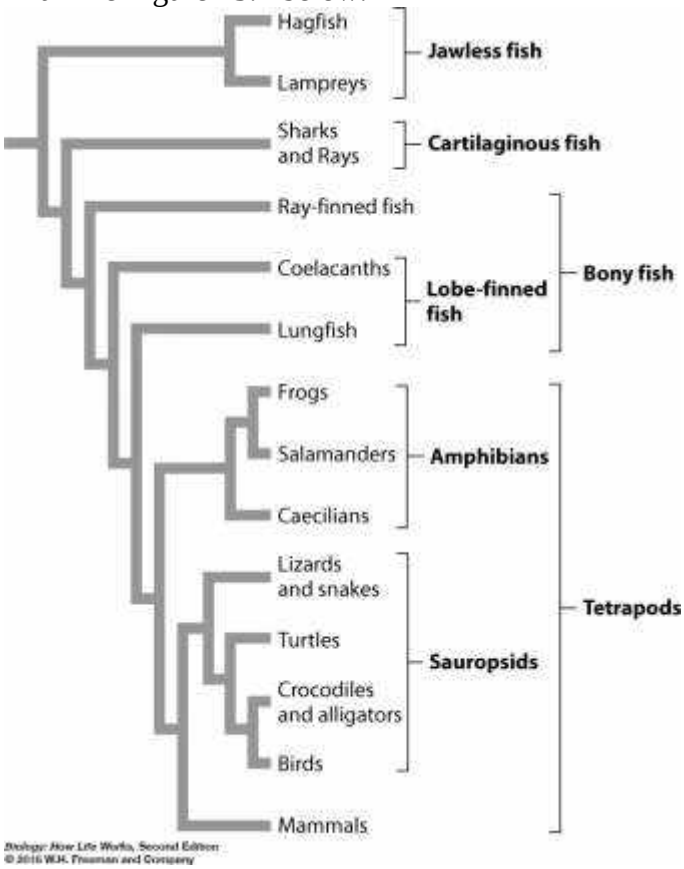
8. Examine Figure 23.2 below.



According to the figure, the closest relatives of turtles are:

A) lizards and snakes.
B) sauropsids.
C) tetrapods.
D) crocodiles, alligators, and birds.
E) hagfish.

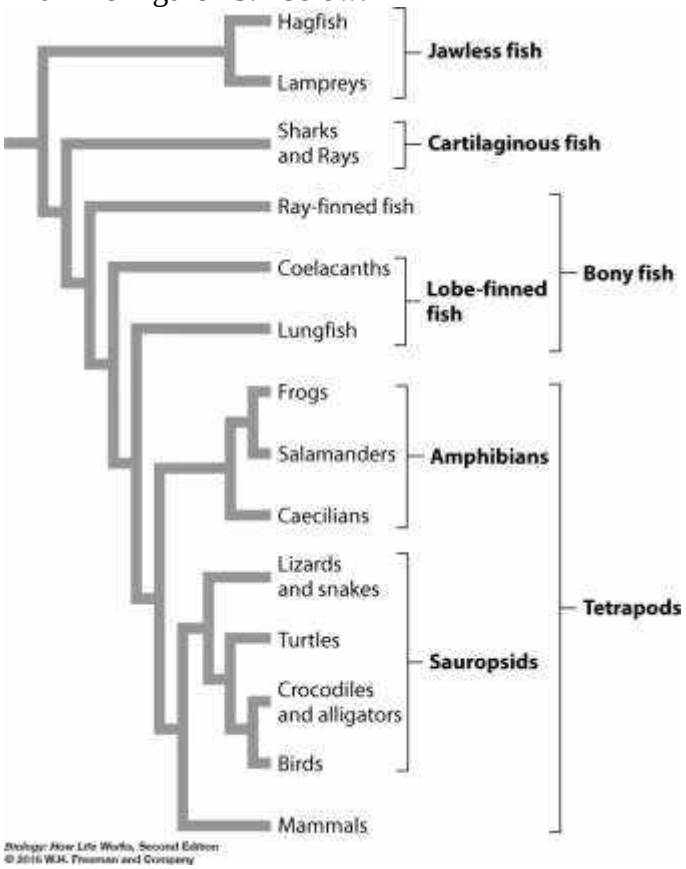
9. Examine Figure 23.2 below.



According to this figure, the amphibians are a _____ group.

A) monophyletic
B) paraphyletic
C) polyphyletic

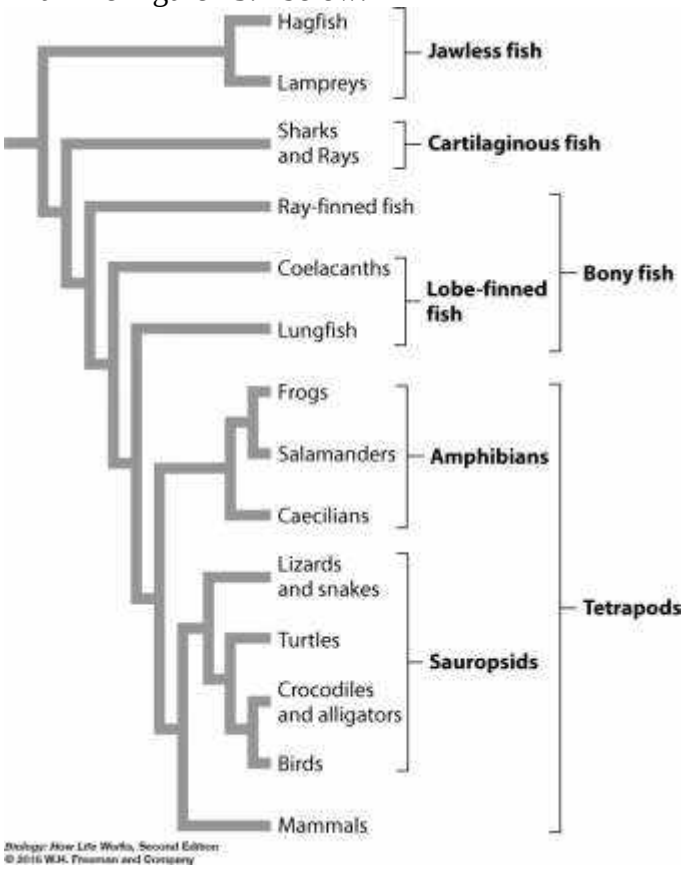
10. Examine Figure 23.2 below.



The group "fish" includes all vertebrates except the tetrapods. The taxon "fish" is therefore a _____ group.

A) monophyletic
B) paraphyletic
C) polyphyletic

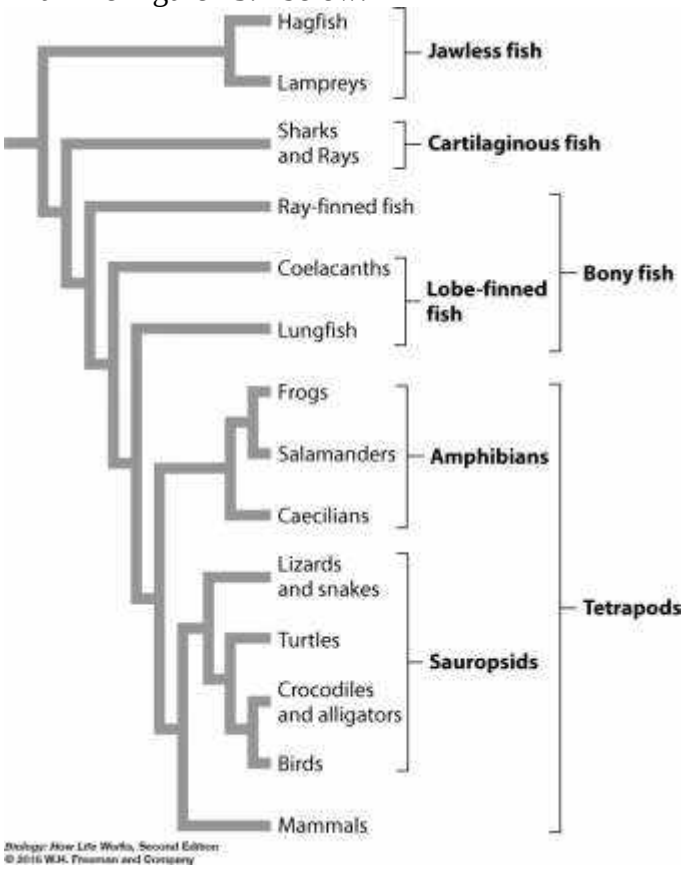
11. Examine Figure 23.2 below.



If we define the taxon Actinopterygii to include the ray-finned fish, coelacanths, lungfish, tetrapods, and their most recent common ancestor, it would be a _____ group.

A) monophyletic
B) paraphyletic
C) polyphyletic

12. Examine Figure 23.2 below.



If we defined a taxon to include only the coelacanths and lungfish but not their most recent common ancestor, it would be a _____ group.

A) monophyletic
B) paraphyletic
C) polyphyletic

13. Organisms in the same family will all be from the same genus.

A) True
B) False

14. Individual populations cannot be included as separate taxa in a phylogenetic tree.

A) True
B) False

15. Which of the following BEST describes the purpose of phylogenetics?
    A) Phylogenetics names species, genus, order, class, phylum, and kingdom.
    B) Phylogenetics looks for patterns of relatedness.
    C) Phylogenetics compares anatomical or molecular features.
    D) Phylogenetics looks for patterns of relatedness and compares anatomical or molecular features.

16. Which phylogenetic group includes all descendants of a common ancestor and only the descendants of that ancestor?
    A) monophyletic
    B) paraphyletic
    C) polyphyletic
    D) genus

17. Based on the diagram below, you predict that the earliest fossil gorilla (which may not resemble modern-day gorillas) would be _____ than the earliest fossil _____.

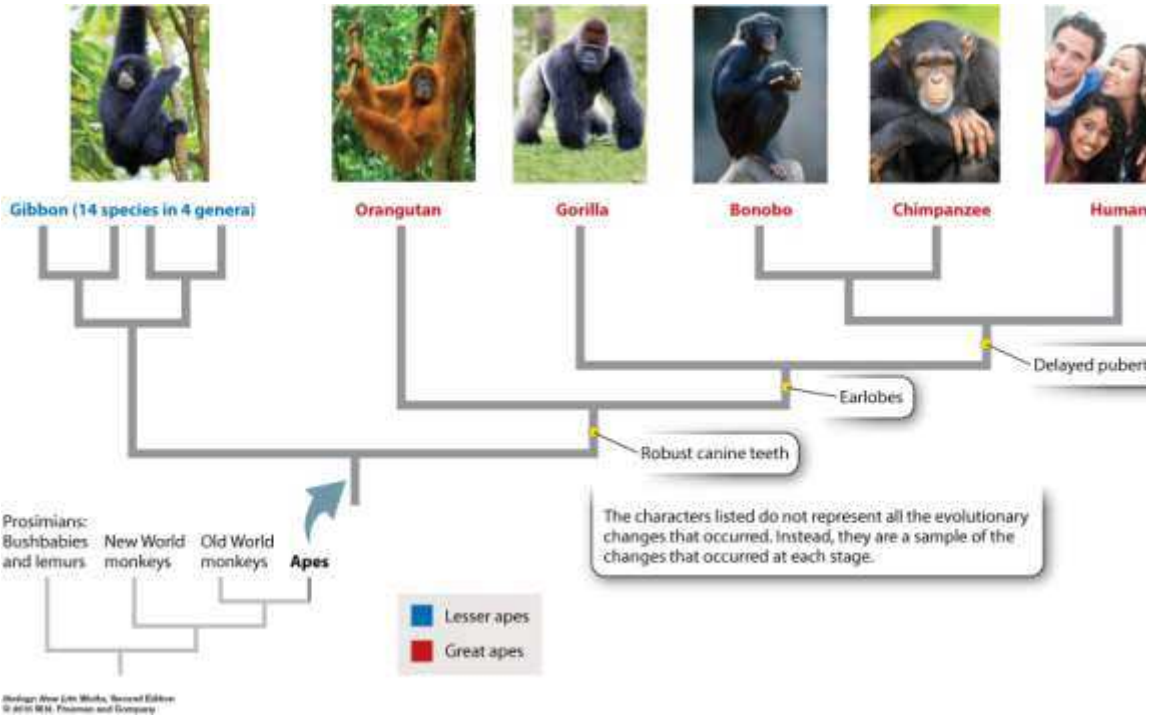


Photo sources: (left to right) Zoonar/K. Jorgensen/age fotostock; S Sailer/A Sailer/age fotostock; J & C Sohns/age fotostock; Michael Dick/ Animals Animals–Earth Scenes; FLPA/Jurgen & Christi/age fotostock; Yellow Dog Productions/Getty Images.

    A) older; bonobo
    B) younger; bonobo
    C) younger; chimp
    D) older; orangutan
    E) None of the answer options is correct.

18. Which of the following statements is always TRUE about sister taxa on a phylogenetic tree?
    A) Sister taxa are always the result of speciation events that result in two new genera.
    B) Sister taxa always share a most recent common ancestor that is not shared with any other taxon on the phylogeny.
    C) Sister taxa are always the result of the most recent divergence event represented on a phylogeny.
    D) Sister taxa are always defined by shared ancestral characteristics that have been modified in all other taxa in the phylogeny.

19. Traditional levels of taxonomy are nested in categories from least to most inclusive. This same relationship is also represented on a phylogenetic tree by moving from the terminal (most recent) nodes to the earliest nodes.
    A) True
    B) False

20. A phylogenetic tree is a:
    A) hypothesis about the evolutionary history of species.
    B) guess about the evolutionary history of species.
    C) factual representation of the evolutionary history of species.
    D) detailed timeline of a species' evolutionary history.
    E) None of the answer options is correct.

21. A taxon that includes a single common ancestor and some, but not all, of its descendants is a _____ group.
    A) monophyletic
    B) paraphyletic
    C) polyphyletic

22. The phylogeny below shows:

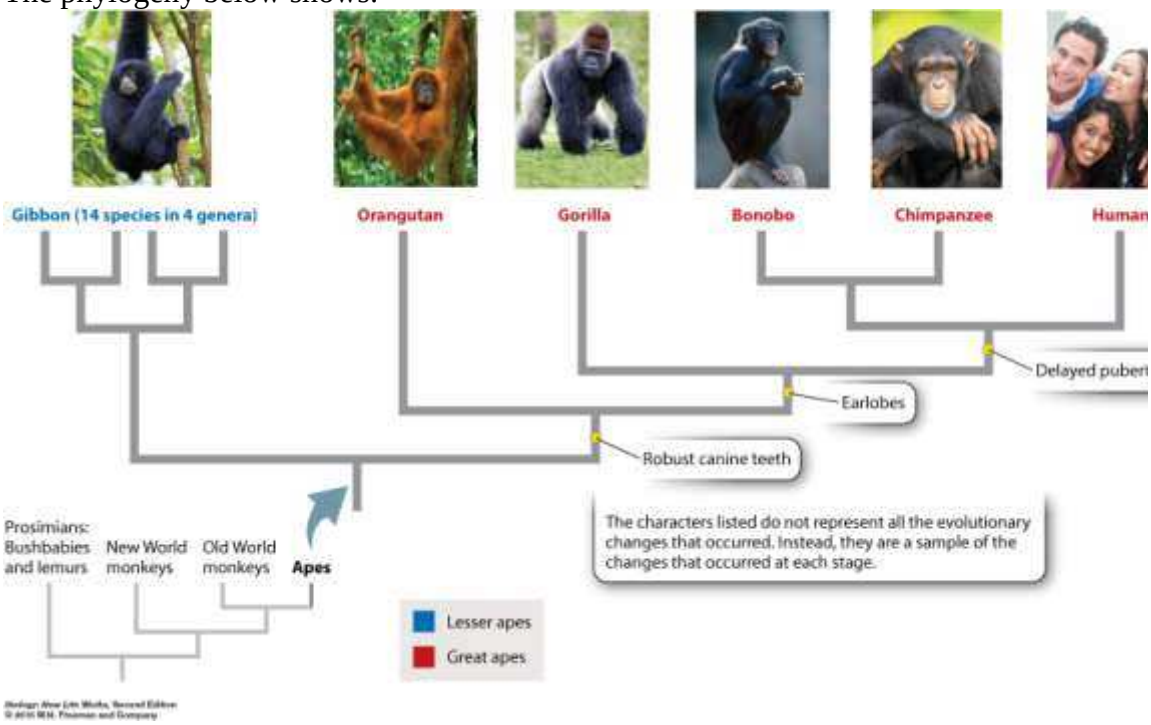


Photo sources: (left to right) Zoonar/K. Jorgensen/age fotostock; S Sailer/A Sailer/age fotostock; J & C Sohns/age fotostock; Michael Dick/ Animals Animals–Earth Scenes; FLPA/Jurgen & Christi/age fotostock; Yellow Dog Productions/Getty Images.

A) a hypothesis about the evolutionary relationships of the apes.
B) proof of the evolutionary relationships between humans and chimps.
C) chimps gave rise to humans.

23. The evolutionary history of a group of organisms is called a:
A) phylogeny.
B) taxonomy.
C) morphology.
D) fossil.

24. A taxon that includes a single common ancestor and all its descendants is a _____ group.
A) monophyletic
B) paraphyletic
C) polyphyletic

25. Which of the following statements is TRUE regarding a phylogenetic tree?
    A) Phylogenetic trees could be considered physical representations of hypotheses those that seek to establish the evolutionary relationships between different organisms.
    B) Given the sheer number of prokaryotic and eukaryotic species on Earth, it is impossible to create a phylogenetic tree encompassing all of these organisms.
    C) Phylogenetic trees are constructed based solely on the morphological characteristics of species; sequence similarities among different organisms are only evaluated by taxonomists.
    D) Within a phylogenetic tree, the order of groups located at the tree tips—not the nodes within a tree—determines sister group relationships.
    E) Phylogenetic trees only depict the evolutionary relationships between different classes; relationships among different species within the same genus are not illustrated in such trees.

26. Imagine that you are chatting with one of your friends. He states that reptiles are obviously a monophyletic group, as this group contains all of the organisms (outside of fish) that possess scales. This statement is:
    A) true, as monophyletic groups are based solely on the morphological characteristics of their included species.
    B) true, as the reptile group includes all of the organisms derived from a common ancestor on the phylogenetic tree.
    C) false, as reptiles are a polyphyletic group, much like birds and bats.
    D) false, as reptiles are a paraphyletic group; this group does not include birds, even though birds share a common ancestor with reptiles.

27. Imagine that a taxonomist is provided with several flashcards on which the names of different species are written. She would likely organize these flashcards to construct a phylogenetic tree. To do this, would she pay attention to which species belong to which genus or class?
    A) yes
    B) no

28. Consider a generalized tree of life, with three large branches representing Archaea, Bacteria, and Eukarya. These three branches would represent different:
    A) domains.
    B) genera.
    C) species.
    D) kingdoms.
    E) phyla.

29. The nodes on a phylogenetic tree represent:
    A) common ancestors.
    B) descendant lineages.
    C) sister groups.
    D) present-day groups.
    E) homologies.

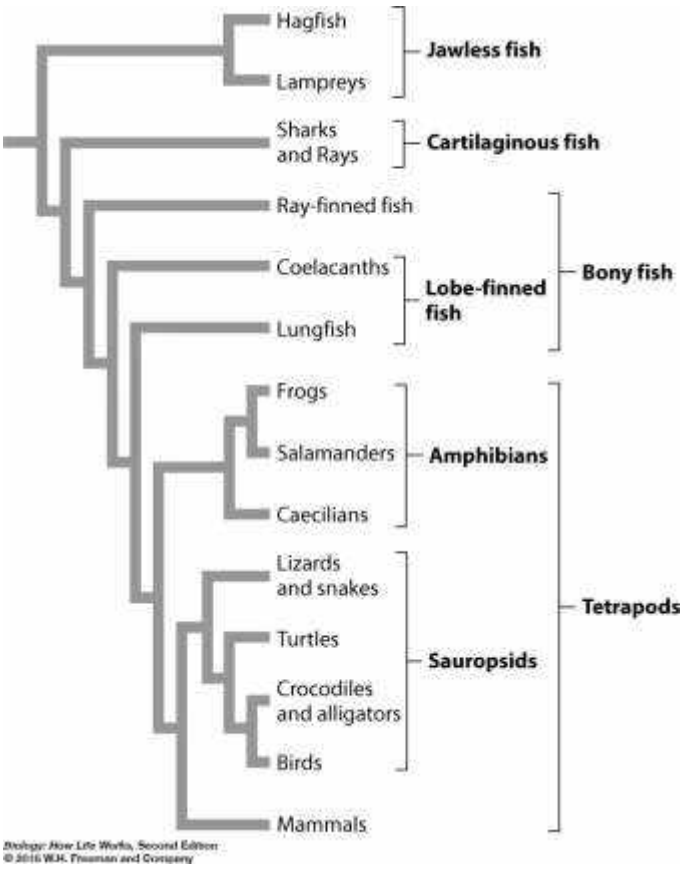
30. The tips of the branches on a phylogenetic tree represent:
    A) present-day groups or extinct taxa.
    B) common ancestors.
    C) analogies.
    D) sister groups.
    E) homologies.

31. Phylogenetic trees represent hypotheses about the evolutionary relationships among groups of organisms.
    A) True
    B) False

32. The order of groups along the tips of a phylogenetic tree indicates how closely those groups are related.
    A) True
    B) False

33. Two taxa that are more closely related to each other than to any other taxon are called _____ groups.
    A) sister
    B) paraphyletic
    C) homologous
    D) polyphyletic
    E) analogous

34. According to Figure 23.2 below, the most recent common ancestor of a bird and a turtle is also the most recent common ancestor of a bird and which other group?



A) snake
B) human
C) crocodile
D) frog
E) None of the answer options is correct.

35. Which of the following represents the MOST informative evolutionary history of a taxon?
A) monophyletic groups
B) paraphyletic groups
C) polyphyletic groups
D) derived groups
E) All of these choices are correct.

36. A grouping that includes an ancestor and some, but not all, of the descendants of that ancestor is described as:
    A) paraphyletic.
    B) polyphyletic.
    C) monophyletic.
    D) convergent.
    E) analogous.

37. Of the following taxonomic categories, which is the MOST inclusive?
    A) class
    B) genus
    C) species
    D) family
    E) order

38. The _____ level of the taxonomic hierarchy is more inclusive than a family, but less inclusive than a class.
    A) order
    B) phylum
    C) kingdom
    D) genus
    E) species

39. If two organisms are in the same class, then which of the following must also be TRUE?
    A) They are in the same phylum.
    B) They are in the same family.
    C) They are in the same genus.
    D) They are in the same order.
    E) None of the answer options is correct.

40. What types of data can be used to construct phylogenies such as the one below?

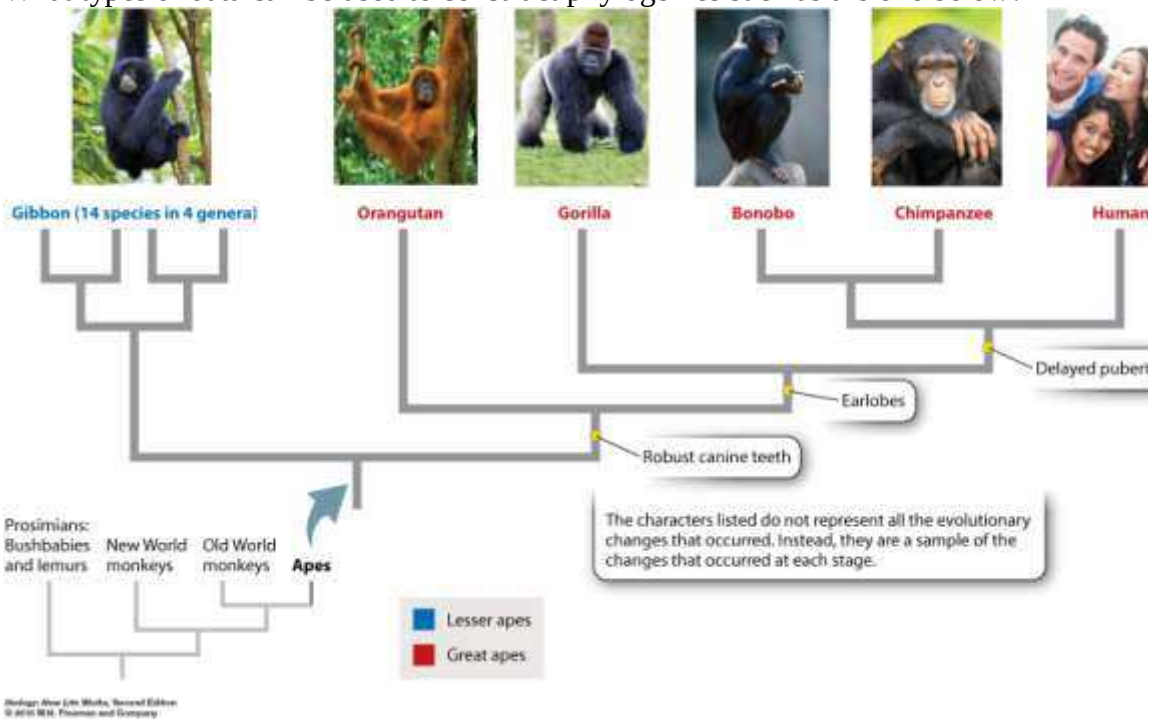


Photo sources: (left to right) Zoonar/K. Jorgensen/age fotostock; S Sailer/A Sailer/age fotostock; J & C Sohns/age fotostock; Michael Dick/ Animals Animals–Earth Scenes; FLPA/Jurgen & Christi/age fotostock; Yellow Dog Productions/Getty Images.

A) molecular data
B) fossil evidence
C) anatomical, physiological, and developmental studies of extant species
D) molecular data, fossil evidence, and anatomical, physiological, and developmental studies of extant species
E) None of the answer options is correct.

41. You discover a new species of ape that is more closely related to gorillas than to any other species of ape, but walks upright. How would you change the phylogeny below?

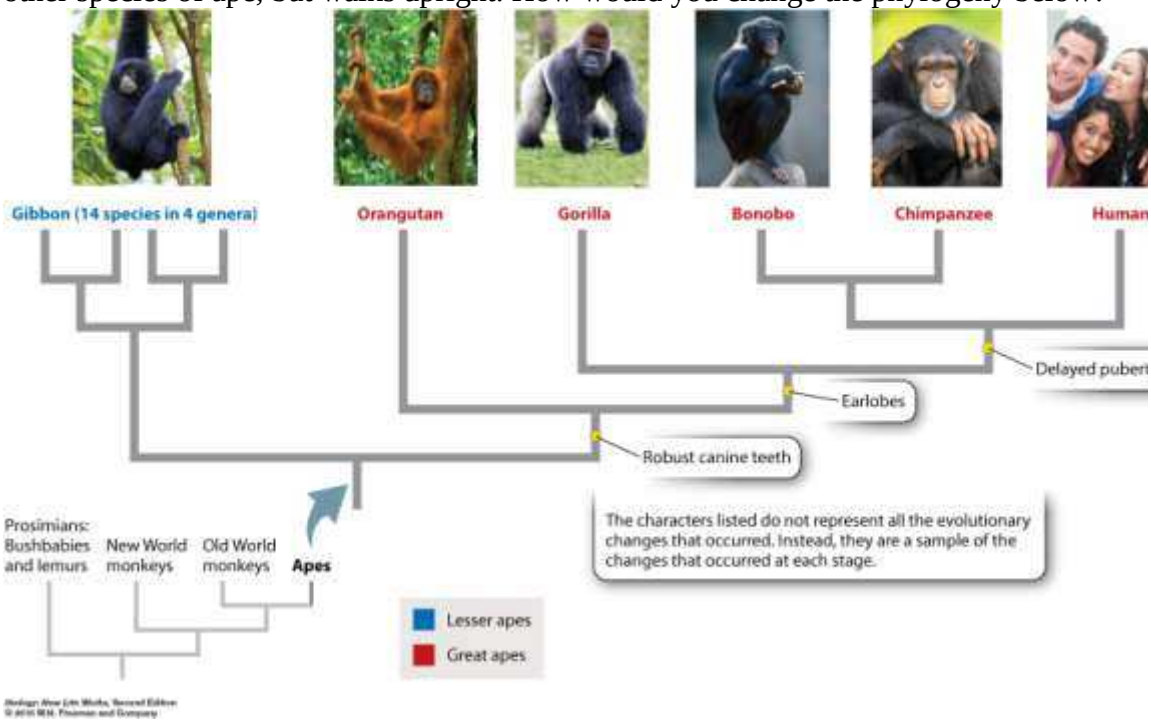


Photo sources: (left to right) Zoonar/K. Jorgensen/age fotostock; S Sailer/A Sailer/age fotostock; J & C Sohns/age fotostock; Michael Dick/ Animals Animals–Earth Scenes; FLPA/Jurgen & Christi/age fotostock; Yellow Dog Productions/Getty Images.

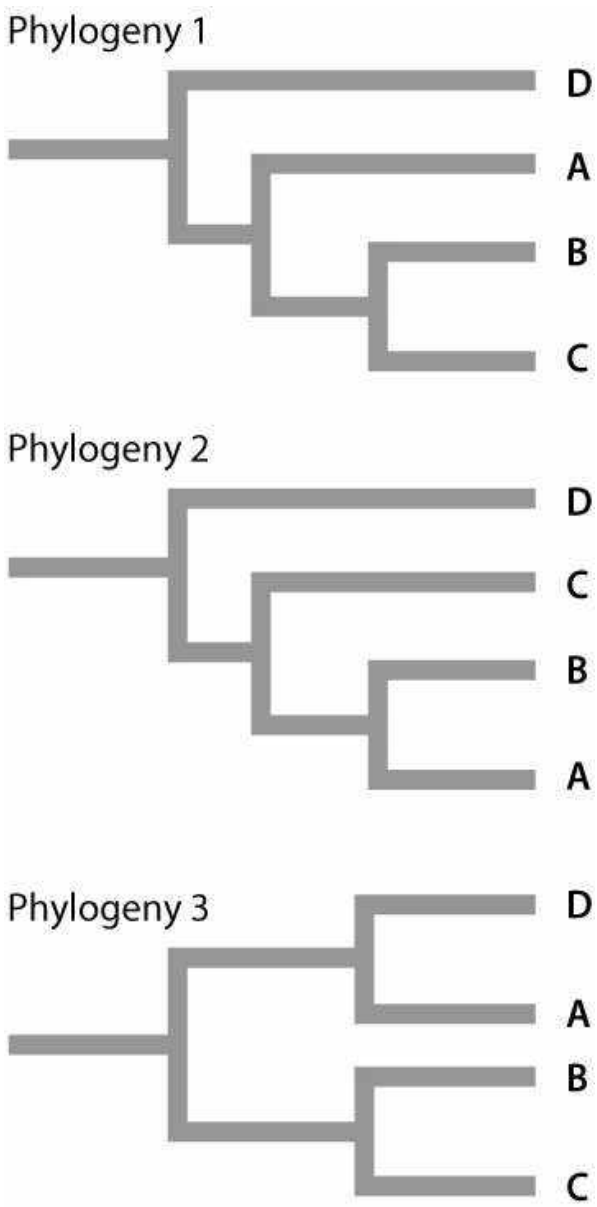
A) I would not change the phylogeny at all because only molecular data are considered when studying evolutionary relationships.
B) I would not change the phylogeny at all until a fossil of the new species is found because fossil evidence is a required component of the data set.
C) I would group gorillas with humans based on the synapomorphy (shared trait) of upright stance.
D) I would branch the gorilla lineage and add the new species sister to gorillas.

42. While taking a hike in the forest, you find some fossils in layers of sedimentary rocks whose age, you later find out, is said to cover a span of 100–400 million years. You decide to send the fossils out for analysis to a company that dates rocks by radioactive decay, and, some weeks later, receive a report informing you that a volcanic ash bed associated with one of the fossils has a 1:1 ratio of ^{235}U: ^{207}Pb. Do these data support or refute the assumed age of the rocks in which the fossil was found? (Note: The half-life of ^{235}U is about 704 million years.)
A) Yes, because the rock layers are less than 704 million years old.
B) Yes, because the ratio of ^{235}U to ^{207}Pb represents one half-life and that would be approximately 350 million years old.
C) No, because the ratio of ^{235}U to ^{207}Pb represents one half-life and that would be about 700 million years old.
D) No, because the rock layers are less than 704 million years old.

43. You are given a fossil and told that approximately 3% of the ^{14}C originally in the sample is still there. How old is your sample? (Note that ^{14}C has a half-life of 5730 years).
   A) approximately 11,500 years
   B) approximately 17,000 years
   C) approximately 23,000 years
   D) approximately 29,000 years

44. Examine the following table of characters in four different species of flower. Based on the matrix, which tree represents the MOST parsimonious explanation of relatedness among these species?

	Species A	Species B	Species C	Species
Presence of sepals	yes	yes	yes	no
Number of petals	five	five	ten	ten
Arrangement of petals	whorled	whorled	whorled	whorle
Number of carpels	ten	ten	ten	five

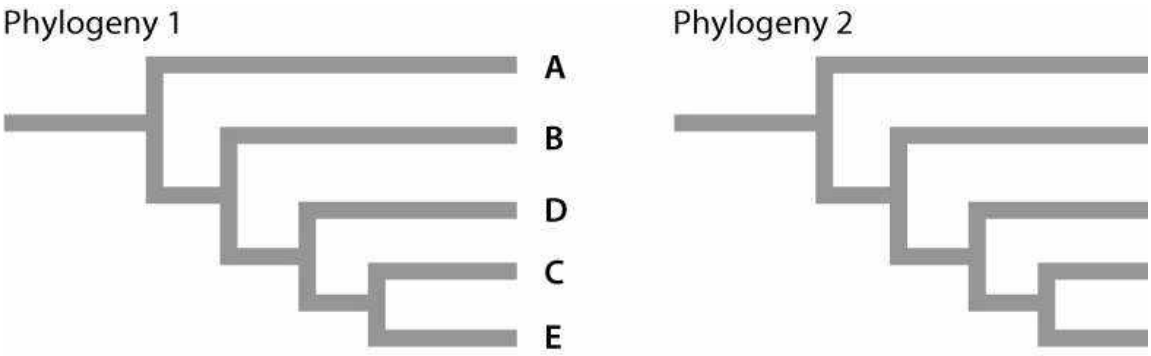


A) phylogeny 1
B) phylogeny 2
C) phylogeny 3

45. The same intron was sequenced from five different taxa (taxa A–E) whose evolutionary relationships are disputed. The data matrix given shows six variable sites (1–6, left column) in the DNA sequences obtained from each of the five species. Taxon A serves as the outgroup for this analysis.

	taxon A	taxon B	taxon C	taxon D	taxon
1	A	G	G	G	G
2	C	T	T	T	T
3	G	G	G	G	A
4	A	A	T	A	T
5	A	C	A	C	C
6	A	A	C	A	C

Which of the phylogenies below explains the relatedness between these taxa with the FEWEST evolutionary steps?



A) phylogeny I
B) phylogeny II
C) Both phylogenetic trees have the same number of evolutionary steps.

46. You are given a character matrix for four different taxa showing character states for eight different morphologic characters. How many alternative phylogenetic hypotheses can be generated with the four taxa?
A) 3
B) 12
C) 15
D) 24
E) 32

47. To be useful for phylogenetic reconstruction, a taxonomic character must exhibit which of the following properties? (Select all that apply.)
    A) It must vary among the taxa being analyzed, but not within individual taxa.
    B) It must have a genetic basis.
    C) It must be anatomical.
    D) It must be molecular (DNA or protein).
    E) None of the other answer options is correct.

48. Characters that are similar because of descent from a common ancestor are _____; characters that are similar due to convergent evolution are _____.
    A) homologous; analogous
    B) analogous; homologous

49. With the advent of tools to incorporate molecular data, phylogenetic analysis can be used to:
    A) reconstruct the evolutionary history of a group of organisms over millions of years.
    B) track the spread of a pathogen, such as a fungus or virus, from place to place.
    C) identify the origin of invasive pest species.
    D) track shipments of endangered species or their products (such as elephant ivory or bushmeat).
    E) All of these choices are correct.

50. When selecting among multiple possible phylogenetic trees that fit our data, we commonly use the principle of _____, which means we choose the _____ possible hypothesis. In phylogenetic analysis, that means selecting the tree that represents the _____ evolutionary changes or mutations.
    A) parsimony; simplest; fewest
    B) parsimony; simplest; most
    C) parsimony; most; likely
    D) phylogenetics; simplest; fewest
    E) phylogenetics; simplest; most

51. Examine the following table of characters in four different species of flower. Based on the matrix, Derek concludes that species A is sister to the remaining three species. Wilma, in contrast, argues that species D is sister to all other species. Who is CORRECT?

	Species A	Species B	Species C	Species
Presence of sepals	yes	yes	yes	no
Number of petals	five	five	ten	ten
Arrangement of petals	whorled	whorled	whorled	whorle
Number of carpels	ten	ten	ten	five

A) Derek is correct, as the tree that puts A as sister to all other species is the most parsimonious.
B) Wilma is correct, as the tree that puts D as sister to all other species is the most parsimonious.
C) Neither, because the most parsimonious tree puts species B as sister to all others.
D) We can't decide from the information given as trees with species A, B, or D as sister to all other species are equally parsimonious.

52. Examine the following table of characters in four different species of flower. Based on the matrix, which character defines a synapomorphy shared by species A and B?

	Species A	Species B	Species C	Species
Presence of sepals	yes	yes	yes	no
Number of petals	five	five	ten	ten
Arrangement of petals	whorled	whorled	whorled	whorle
Number of carpels	ten	ten	ten	five

A) presence of sepals
B) number of petals
C) arrangement of petals
D) number of carpels

53. Examine the following table of characters in four different species of flower. Based on the character matrix, which is MOST likely an ancestral trait for the group of species?

	Species A	Species B	Species C	Species
Presence of sepals	yes	yes	yes	no
Number of petals	five	five	ten	ten
Arrangement of petals	whorled	whorled	whorled	whorle
Number of carpels	ten	ten	ten	five

A) presence of sepals
B) number of petals
C) arrangement of petals
D) number of carpels

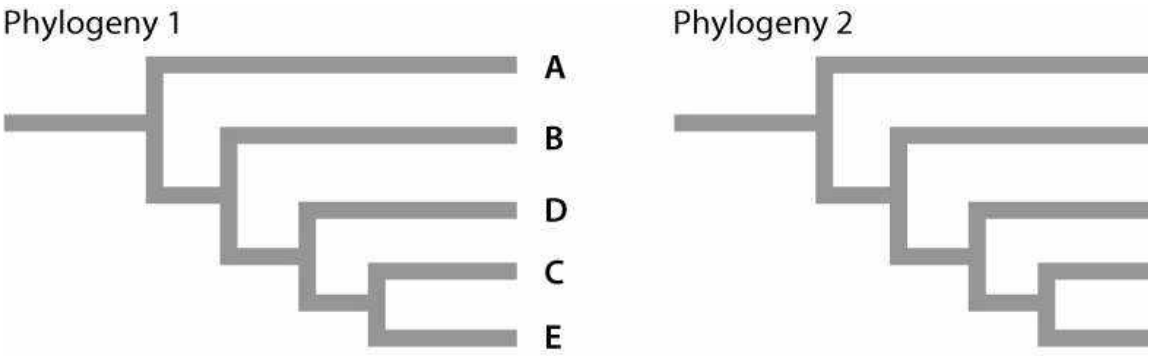
54. Streamlined bodies are common in many aquatic organisms: Dolphins, tuna, penguins, and sharks are all organisms that have streamlined bodies that reduce friction and drag. Body shape in each of these organisms would be considered an:
A) analogous character.
B) homologous character.
C) similar character.
D) natural character.

55. You find a fossil that you think is about 350 million years old. You decide to use ^{235}U to date a volcanic ash bed just below the key specimen. If you are correct, what approximate percentage of the original ^{235}U would you expect to remain in your sample?
A) 0%
B) 25%
C) 50%
D) 75%
E) 100%

56. The same intron was sequenced from five different taxa (taxa A–E) whose evolutionary relationships are disputed. The data matrix given shows six variable sites (1–6 in left column) in the DNA sequences obtained from each of the five species. Taxon A serves as the outgroup for this analysis.

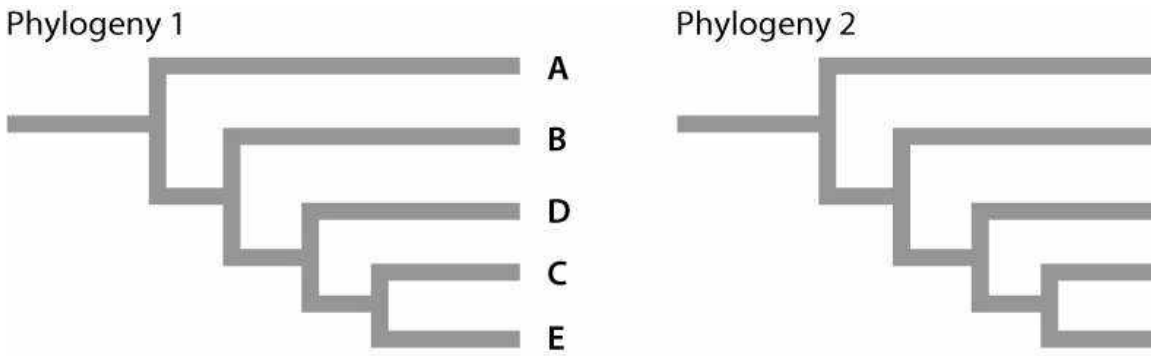
	taxon A	taxon B	taxon C	taxon D	taxon
1	A	G	G	G	G
2	C	T	T	T	T
3	G	G	G	G	A
4	A	A	T	A	T
5	A	C	A	C	C
6	A	A	C	A	C

Which of the phylogenies below explains the relatedness between these taxa with the FEWEST evolutionary steps?



A) phylogeny I
B) phylogeny II
C) Both phylogenetic trees have the same number of evolutionary steps.

57. Excluding the outgroup, taxon A, how many equivalent sister-group relationships are depicted between the two phylogenies given below?



A) one
B) two
C) three
D) four
E) There are no equivalent sister-taxa shown between the two phylogenies.

58. Characters that are similar because of descent from a common ancestor are:
A) homologous.
B) analogous.
C) examples of convergent evolution.
D) synapomorphies.

59. When comparing trees with various hypotheses of evolutionary relationships among a group of animals, the tree with _____ changes would be the preferred candidate.
A) fewest
B) three
C) four
D) most

60. Phylogenetic trees can be built using:
A) anatomical data.
B) molecular data.
C) visible characteristics only.
D) anatomical data or molecular data.

61. Which molecular detail can be used to construct phylogenetic histories?
    A) individual nucleotides
    B) amino acids
    C) RNA
    D) All of these choices are correct.

62. Why might a phylogeny based only on molecular data show a different pattern of relationships than a phylogeny of the same taxa that is based only on morphological traits? (Select all that apply.)
    A) Gene sequences always provide more data than morphological traits.
    B) Morphological analyses always provide more data because each morphological trait is the result of the expression of many genes.
    C) The molecular data may be based on the analysis of introns, which aren't expressed and don't contribute to the evolutionary history of a group of taxa.
    D) Some highly conserved genetic sequences can result in unrelated species appearing closely related in a molecular phylogeny, and not reflect the same pattern as the morphologic phylogeny.
    E) Gene sequence changes may not result in morphological changes.

63. Examine the following table of characters in four different species of flower. Based on the matrix, which character would be the least informative for resolving phylogenetic relationships between the species?

	Species A	Species B	Species C	Species
Presence of sepals	yes	yes	yes	no
Number of petals	five	five	ten	ten
Arrangement of petals	whorled	whorled	whorled	whorle
Number of carpels	ten	ten	ten	five

    A) presence of sepals
    B) number of petals
    C) arrangement of petals
    D) number of carpels

64. Examine the following table of characters in four different species of flower.

	Species A	Species B	Species C	Species
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Number of petals	five	five	ten	ten
Arrangement of petals	whorled	whorled	whorled	whorle
Number of carpels	ten	ten	ten	five

Which character would be MOST useful for identifying the sister group of species D?

A) presence of sepals
B) number of petals
C) arrangement of petals
D) number of carpels

65. Examine the following table of characters in four different species of flower.

	Species A	Species B	Species C	Species
Presence of sepals	yes	yes	yes	no
Number of petals	five	five	ten	ten
Arrangement of petals	whorled	whorled	whorled	whorle
Number of carpels	ten	ten	ten	five

Do the characters presence of sepals and number of petals together provide a unique solution to the question of phylogenetic relationships among species A, B, C, and D?

A) yes
B) no

66. To conduct a phylogenetic analysis, an outgroup is needed in order to:
    A) decide which characters are analogous and which are homologous.
    B) determine which character states are ancestral and which are derived.
    C) determine which characteristics to include in our analysis.
    D) decide which molecular data to use.
    E) All of these choices are correct.

67. The specific types of homologies used to develop phylogenies are shared derived characters or:
    A) sister groups.
    B) convergent characteristics.
    C) synapomorphies.
    D) parsimonious branches.

68. Phylogenetic reconstruction based on shared derived characters is called:
    A) synapomorphy.
    B) cladistics.
    C) monophyly.
    D) taxonomy.

69. Traits that are similar in two species as a result of common ancestry are referred to as:
    A) homologous.
    B) analogous.
    C) convergent.
    D) derived.
    E) ancestral.

70. Seals and penguins both have streamlined body forms that allow them to move through water efficiently. This similarity in body shape is MOST likely the result of:
    A) convergent evolution.
    B) shared ancestry.
    C) homology.
    D) phylogeny
    E) cladistics

71. In order to be useful for constructing a phylogeny, a character must:
    A) have a genetic basis.
    B) vary within a species.
    C) have only one state.
    D) show the same state across several species.
    E) All of these choices are correct.

72. Only homologous characters are useful in constructing phylogenetic trees.
    A) True
    B) False

73. Traits that are shared by more than one member of a group because of common ancestry are known as:
    A) synapomorphies.
    B) homologies.
    C) analogies.
    D) cladistics.
    E) alternative character states.

74. When several possible phylogenetic trees can be produced from a data set, the MOST parsimonious tree is the one that shows the:
    A) smallest number of evolutionary changes.
    B) largest number of nodes.
    C) largest number of analogous characteristics.
    D) smallest number of synapomorphies.
    E) smallest number of branches.

75. Compared with more distantly related taxa, the DNA sequences of two closely related taxa are expected to show:
    A) fewer differences because mutation rates are usually relatively constant and recently diverging species have had less time to accumulate differences.
    B) fewer differences because mutation rates slow down after speciation events so that recently diverging species have fewer mutations.
    C) fewer differences because mutation rates are highly variable and it is just by chance that recently diverging species accumulate fewer differences in DNA sequences.
    D) more differences because mutation rates are relatively constant and recently diverging species have had more time to accumulate differences.
    E) more differences because mutation rates accelerate during speciation events, leading to more changes in DNA sequences.

76. Phylogenetic trees can be used to infer character states of extinct organisms.
    A) True
    B) False

77. Both analogies and homologies are always used to create phylogenetic trees. In fact, analogies often provide more information regarding the evolutionary relationships between different species than do homologies.
    A) True
    B) False

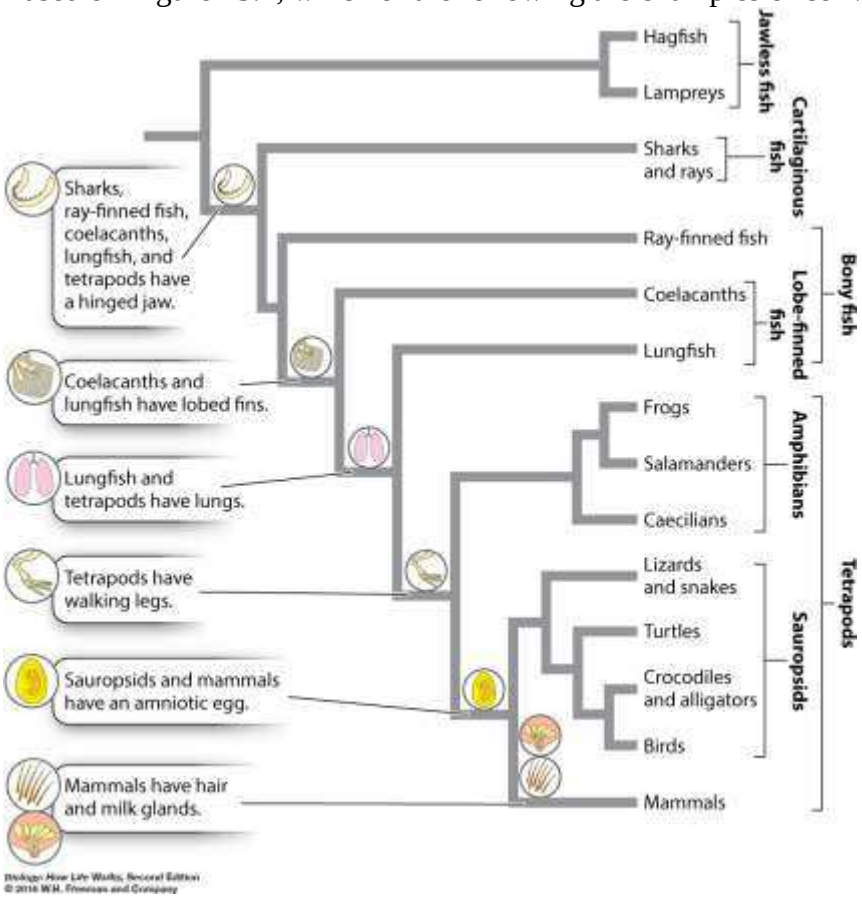
78. Imagine that a researcher has created two possible phylogenetic trees for a group of organisms one that hypothesizes that five character changes occurred in a given group, and one that predicts only two character changes occurred in the same group. If the researcher wants to choose a phylogenetic tree based on parsimony, she will pick the phylogenetic tree with two character changes as her working hypothesis.
    A) True
    B) False

79. Which of the following statements is TRUE regarding phylogenetic trees?
    A) Phylogenetic trees are only constructed based on morphological data; molecular data (even for viruses) is never used in the construction of such trees.
    B) As synapomorphies only occur for morphological characters, molecular sequence synapomorphies cannot be used to construct phylogenetic trees.
    C) Both morphological and molecular synapomorphies can be used to construct phylogenetic trees.
    D) Phylogenetic trees based on molecular sequence data always assume that the rate of evolution varies between different organisms.
    E) Phylogenetic trees are always constructed based on morphological or molecular sequence data—never both.

80. Imagine that a scientist discovers a new, flying species of mammal that resembles a winged rabbit. What can the scientist say about this organism?
    A) Without any further information, the scientist can say that bat wings and the wings of this new species are homologous.
    B) If molecular sequence data show that bats and this new species share a common ancestor not shared by other mammals, the wings of these two species would be considered homologous.
    C) If molecular sequence data show that bats and this new species do not share a common ancestor not shared by other mammals, the wings of bats and this new species would be considered homologous.
    D) If molecular sequence data show that bats and this new species share a common ancestor not shared by other mammals, the wings of these two species would be considered analogous.
    E) No data could support or disprove the hypothesis that the wings of bats and the new species are homologous.

81. Which of the following character states would be MOST helpful in identifying sister groups?
    A) character states that occur only within a single species
    B) character states that occur in all descendants of a distant common ancestor
    C) homologies that are only found in some, but not all, the members of a single group
    D) analogies found in organisms belonging to different groups, and which do not share a common ancestor

82. Based on Figure 23.7, which of the following are examples of convergent evolution?



A) wings in birds and bats
B) lungs in lungfish and turtles
C) jaws in sharks and lizards
D) the amniotic egg of crocodiles and mammals

83. Which of the following would be considered characters?
A) lungs
B) wings
C) petals
D) claws
E) All of these choices are correct.

84. What is a disadvantage of using fossils to reconstruct phylogenetic history?
A) Fossils are a physical record of organismal structure.
B) Fossils yield information about the timing and order of events in the past.
C) Fossils reveal relatedness.
D) The probability that an organism will be fossilized varies among species and environments.

85. Among the organisms listed below, which is MOST likely to be fossilized?
    A) earthworm
    B) clam
    C) house flies
    D) jellyfish

86. Why is the fossil record NOT a complete catalog of biological history?
    A) Not all organisms fossilize with equal probability.
    B) Fossilization destroys the structure of DNA.
    C) The process of fossilization often destroys anatomical features of the organisms being preserved.
    D) Fossils only preserve organisms for about 10 million years; older organisms are destroyed by geological processes.
    E) Only animals, not plants, are fossilized.

87. Among the environments listed below, in which are fossils MOST likely to form?
    A) desert
    B) tropical rainforest
    C) tundra
    D) shallow lake bed
    E) fast-flowing creek

88. Pterosaurs are an extinct group of flying reptiles. Paleontologists accept that pterosaurs evolved flight independently of birds. What evidence BEST supports such a conclusion?
    A) Pterosaurs don't have feathers.
    B) Pterosaurs have teeth, but birds don't.
    C) Phylogenetic analyses place pterosaurs as the sister group of all dinosaurs.
    D) Pterosaurs first appeared during the Triassic Period, earlier than the oldest known birds.

89. In what way have mass extinctions catalyzed evolutionary radiation?
    A) Mass extinctions wipe out poorly competing species, enabling good competitors to diversify.
    B) Mass extinctions eliminate ecologically dominant species, enabling survivors to diversify in environments with few competitors.
    C) Mass extinction events cause mutations, increasing the genetic variability of populations.
    D) Mass extinction events permanently alter environments, favoring species with novel character combinations.

90. Lungfish and lizards both have lungs. Can we conclude from this observation that lungfish are the sister group of lizards?
    A) No, lungs are an ancestral trait present in all tetrapods and lungfish.
    B) No, lungs evolved convergently in lungfish and lizards.
    C) Yes, lungs are a synapomorphy that documents the close evolutionary relatedness of lungfish and lizards.
    D) No, lungfish do not have two pairs of walking legs and so cannot be closely related to any tetrapod animals.

91. In 2027, an unmanned rover lands on Mars, scoops pieces of ancient sedimentary rock into its interior, and then makes careful chemical analyses. Back on Earth, scientists are astonished to find that the rocks contain traces of RNA, much like that in ribosomes. Some of the scientists conclude that the rover has found evidence of Martian life, while others interpret the presence of RNA as evidence that the rover was contaminated by microorganisms on Earth before launch. Statements 1–4 below list four possible outcomes of a molecular phylogenetic test of the two hypotheses. Rank the outcomes in order of INCREASING support for the hypothesis that life originated independently on Earth and Mars.

    1. The RNA found by the rover has no close resemblance to that found in terrestrial organisms.
    2. Molecular phylogenetic analyses place the Martian RNA close to that of the bacterium *E. coli*.
    3. Molecular phylogenetic analyses place the Martian RNA as a sister group to all known RNAs of bacteria, archaea and eukaryotes.
    4. Molecular phylogenetic analyses place the RNA near the bottom of the bacterial branch of the tree of life.

    A) 1, 2, 3, 4
    B) 1, 2, 4, 3
    C) 1, 3, 2, 4
    D) 1, 3, 4, 2
    E) 1, 4, 3, 2

92. The probability that an ancient species will be represented in the fossil record is a function of:
    A) the properties of the organisms themselves, such as whether or not they make hard skeletons.
    B) the properties of the environments in which they live, such as whether or not burial was likely.
    C) the properties of the climate in which they live, such as how warm or cold it was.
    D) the properties of the organisms themselves and the environments in which they live.
    E) All of these choices are correct.

93. The Burgess Shale preserves a remarkable fossil record of:
    A) delicate flowers and mushrooms from the early invasion of land plants.
    B) marine life during initial diversification of animals in the Cambrian Period 505 million years ago.
    C) plants, insects, and mammals around 50 million years ago, as the age of mammals began.
    D) the tracks of dinosaurs walking on land.
    E) molecular evidence of bacteria and other organisms.

94. During the end-Permian mass extinction:
    A) oxygen levels in the deep oceans dropped.
    B) global warming occurred as a result of volcanic eruptions.
    C) oceans were acidified as a result of volcanic eruptions.
    D) All of these choices are correct.

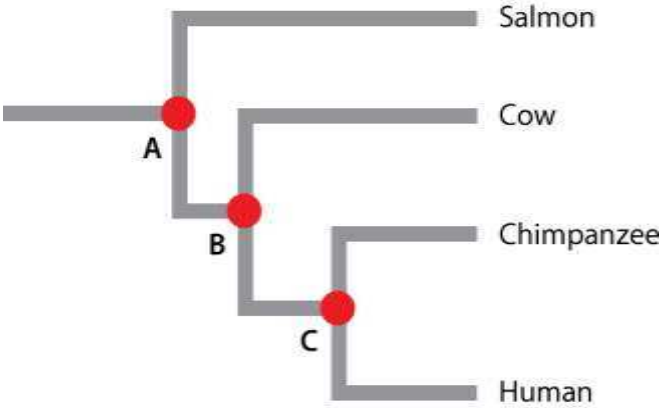
95. The remarkable fossil of the "fishapod," *Tiktaalik*, which lived about 375 million years ago, is a beautiful example of an intermediate form, having the attributes of both fish (scales, fins) and tetrapods (a flat head, mobile neck). The presence of *Tiktaalik* and other fossils of other organisms that lived around the same time shows clear evidence that tetrapods were derived from fish, implying that the grouping "fish" is paraphyletic. Imagine now that there was no fossil record. Would it still be possible to determine whether or not "fish" is paraphyletic?

96. The remarkable fossil of the "fishapod," *Tiktaalik*, which lived about 375 million years ago, is a beautiful example of an intermediate form, having the attributes of both fish (scales, fins) and tetrapods (a flat head, mobile neck). The presence of *Tiktaalik* and other fossils of other organisms that lived around the same time shows clear evidence that tetrapods were derived from fish, implying, that the grouping "fish" is paraphyletic. Imagine now that there was no fossil record. Would it still be possible to determine whether or not "fish" is paraphyletic?
    A) Yes, because a phylogeny can be constructed using morphological and molecular characters of modern fish and tetrapods.
    B) No, because without a fossil record there is no evolutionary history of fish available for study.
    C) Yes, because *Tiktaalik* is a species of coelacanth, and so phylogenetic reconstructions can be based on coelacanth characters.
    D) No, because modern fish and modern tetrapods share no synapomorphies.

97. The concordance of the two great patterns in the history of life—the branching order of the tree of life and the sequence of forms in the fossil record—is powerful evidence in support of the theory of evolution. Give an imaginary example of evidence from a comparison of phylogeny and fossils that would DISPROVE the theory of evolution.

98. The concordance of the two great patterns in the history of life—the branching order of the tree of life and the sequence of forms in the fossil record—is powerful evidence in support of the theory of evolution. Which of the following imaginary examples of evidence would DISPROVE the theory of evolution?
    A) A fossil of a mammal that is older than fossils of the first reptiles.
    B) A fossil of a DNA molecule that is older than a fossil of the first fish.
    C) Lack of evidence of a transitional form between fish and tetrapods.
    D) A fossil of a dinosaur footprint in 70-million-year-old rock.

99. The phylogeny below was generated using molecular data.



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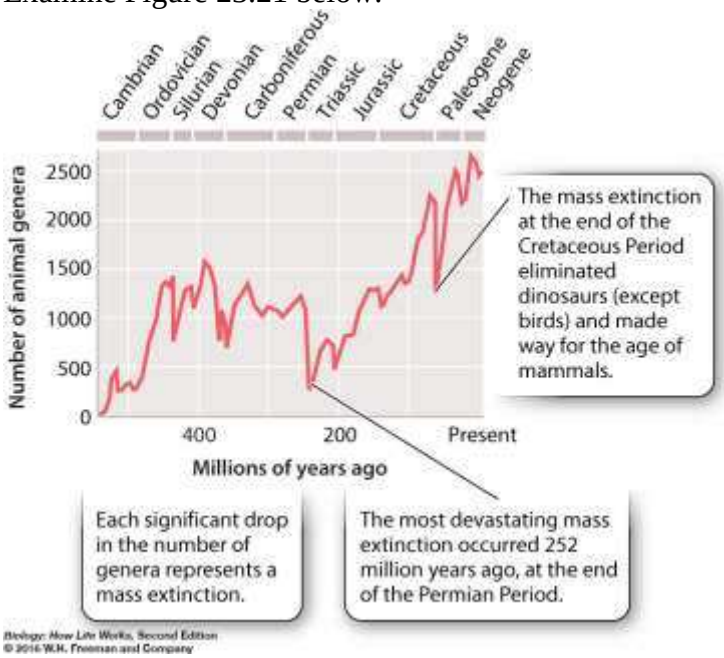
C is the node representing the common ancestor of humans and chimpanzees; B is the node representing the common ancestor of the cow and human/chimpanzee lineages; A is the node representing the common ancestor of the salmon and cow/human/chimpanzee lineages. Imagine that a researcher is interested in finding the approximate dates of A, B, and C. Give two approaches that would help resolve the timing of the nodes in the phylogeny.

100. Paleontologists did not just stumble across *Tiktaalik*, they formed a hypothesis about where they would find a transitional form between fish and tetrapods. What might have been the logical first step in deciding where to "look" for a transitional form between fish and tetrapods?
   A) They considered regions of the world where fossilization is likely to occur.
   B) They looked for sedimentary rocks that were formed in shallow waters 370–380 million years ago.
   C) They looked for sedimentary rocks that were formed in deep waters 370–380 million years ago.
   D) They looked for sedimentary rocks that also contained fossils of the first land plants.

101. The physical features and chemical composition of the rocks that contain fossils provide information about the:
   A) environment in which the fossil organisms lived.
   B) phylogenetic relationships among the fossils present.
   C) manner of the organism's death.
   D) other organisms that were present at the time that were not captured in the fossil record.

102. Examine Figure 23.21 below.



According to the figure, a mass extinction occurred at or near the end of the _____ Period.

A) Ordovician
B) Devonian
C) Permian
D) Triassic
E) All of these choices are correct.

103. The extinction of the _____ during the end-Cretaceous mass extinction allowed mammals to diversify through the process of _____.

A) ammonites; peripatric speciation.
B) dinosaurs; peripatric speciation.
C) dinosaurs; adaptive radiation.
D) ammonites; adaptive radiation.
E) cephalopods; adaptive radiation.

104. How can fossils provide evidence for macroevolutionary processes, such as the divergence of two species from a common ancestor?

A) by providing a complete record of the history of life
B) by exhibiting some features of ancestral organisms and some features of more derived organisms
C) by preserving the bones, rather than the soft parts of ancient organisms
D) by preserving a large number of organisms present in one place and one time, as is seen in Messel Shale

105. How do mass extinction events influence subsequent species composition and diversity?
   A) by immediately increasing species diversity
   B) by permanently altering climate
   C) by reducing competition among surviving organisms
   D) by eliminating smaller organisms instead of larger organisms

106. A catastrophic drop in diversity is known as a:
   A) mass extinction.
   B) reverse evolution.
   C) transition period.
   D) climate change.

107. Radiocarbon dating was an important tool used to determine the placement of *Tiktaalik* as an intermediary form between fish and tetrapods.
   A) True
   B) False

108. Why is the fossil record of marine life more complete than that of organisms living in terrestrial ecosystems?
   A) Marine habitats are places where sedimentation is more likely than erosion.
   B) Organisms that live in marine environments don't have bones or other hard body parts.
   C) Organisms that live in terrestrial habitats are evolutionarily too old to fossilize.
   D) Fossilization cannot occur without water acting to preserve body parts from decomposition.

109. What evidence of ancient organisms exists in the fossil record that is not comprised of hardened body parts? (Select all that apply.)
   A) footprints
   B) DNA extracted from the oldest fossils
   C) dung
   D) proteins extracted from ancient fossils provide evidence of their metabolism
   E) molecular fossils from lipids such as cholesterol

110. You have found fossils of a new species of ape that walks upright. After 11 additional years in the field you discover a fossil of what you think is the common ancestor of the new species of ape and all other gorillas. What types of data would give you the BEST information on the environment of this ancestral organism?
   A) gene sequencing of the new species of ape
   B) anatomical features of the new species of ape
   C) behavior of the new species of ape
   D) fossils of plants and animals found with the fossilized common ancestor
   E) anatomical features of the fossilized common ancestor

111. Recent discoveries of fossils that surprisingly retain some coloration are the result of the preservation of:
   A) preserved proteins.
   B) preserved DNA in the nucleus of a cell.
   C) preserved lipids such as cholesterol.
   D) pigment molecules.

112. Fossils' contributions to phylogenetic trees include:
   A) time calibration.
   B) records of extinct species.
   C) correlation between evolution and Earth's environmental history.
   D) All of these choices are correct.

113. Which factor increases an organism's chance of becoming a fossil?
   A) being buried soon after death
   B) having soft body features
   C) being in an environment that facilitates decay
   D) All organisms have an equal chance of being fossilized.

114. Mass extinctions:
   A) represent loss of many species in a short time.
   B) allow surviving species to proliferate.
   C) can be reconstructed from fossil records.
   D) All of these choices are correct.

115. ^{14}C dating is MOST useful in determining the age of:
   A) bone and wood in the tombs of Egyptian pharaohs.
   B) samples older than 60,000 years.
   C) samples that originally contained only small amounts of carbon.
   D) All of these choices are correct.

116. What is the FIRST event in the fossilization process?
   A) erosion of soils around the organism
   B) burial of the organism by sediments
   C) conversion of organic tissue to minerals (rock)
   D) hardening of sediments into rock.

117. What is a trace fossil?
   A) a small fossil
   B) markings in sediments that reflect the movements or burrows of organisms
   C) a fossil that is part of a series of fossils that trace the evolution of a group of species
   D) a fossil that allows scientists to trace the movement of the fossilized organism

118. The geological timescale was first developed using the fossil record, but this provided only a system of relative dating; absolute dates weren't established until the discovery of:
   A) radioactive decay.
   B) isotopes.
   C) sedimentary rocks.
   D) fossil series.

119. The LARGEST mass extinction occurred at the end of which period?
   A) Ordovician
   B) Devonian
   C) Permian
   D) Triassic
   E) Cretaceous

120. Which of the following statements is TRUE regarding fossils?
   A) Fossils can form with the same frequency in any environment. This includes lakebeds, the ocean floor, artic regions, and mountaintops.
   B) The term ”fossil“ only includes skeletal remains of organisms, and does not include things like footprints, eggs, or excrement.
   C) In the plant fossil record, fossilized flower petals are much more common than fossilized pollen.
   D) Molecular sequence data that depicts the divergence time between organisms can stand independently and never needs to be corroborated by fossil evidence.
   E) None of the other answer options is correct.

121. An incomplete fossil record is evidence that the theory of evolution is false.
   A) True
   B) False

122. We expect the fossil record to be incomplete for all of the following reasons EXCEPT:
   A) All biomolecules, including lipids and pigment molecules, decay immediately after death.
   B) Fossilization requires burial in sediment.
   C) Sediments accumulate irregularly.
   D) Organisms with hard parts tend to fossilize more readily than soft-bodied organisms.
   E) Under normal conditions, organisms are broken down by biological and physical processes.

123. Which of the following is MOST likely to fossilize?
   A) a crayfish that died in its muddy burrow by a creek
   B) a jellyfish that died and sunk to the bottom of the ocean
   C) a lizard that died on a mountainside
   D) a leaf that fell from a tree and landed on the forest floor
   E) a snail that died on a rock

124. Trace fossils include all of the following EXCEPT:
   A) the mineralized skull of an ancient mammal.
   B) the trail left by a crawling worm.
   C) the feedings grooves made by grazing snails.
   D) a dinosaur footprint.
   E) the burrow of an extinct crab.

125. In a particular layer of rock, a number of fossilized ferns are found, but no fossilized mosses are found. What conclusions can be drawn from this finding?
   A) The soft tissues of mosses may not have fossilized as readily as the more decay-resistant tissues of ferns, so it is difficult to draw any conclusions from this limited sample.
   B) Mosses and ferns did not coexist in the same environment.
   C) There are fewer species of moss than ferns.
   D) Ferns evolved earlier than mosses, so it is not surprising to find a layer with only ferns and no mosses.
   E) Ferns decompose more rapidly than mosses and thus are more likely to fossilize.

126. The half-life of ^{14}C is 5730 years. If a sample contained 100% ^{14}C and 0% ^{14}N at a point in time 17,190 years ago, then what percentage of ^{14}C would it contain today?
   A) 12.5%
   B) 25%
   C) 50%
   D) 75%
   E) 100%

127. The half-life of ^{14}C is 5730 years. Archaeologists dig up a seed that contains 0.25 parts per trillion ^{14}C. If it originally contained 1 part per trillion ^{14}C, how old is the archaeological specimen?
   A) 11,460 years
   B) 5730 years
   C) 17,190 years
   D) 22,920 years
   E) 28,650 years

128. Which of the following radioisotopes could be used to accurately date a fossil that is thought to be over 750 million years old?
   A) ^{238}U
   B) ^{14}C
   C) ^{235}U
   D) ^{235}U or ^{238}U
   E) ^{14}C or ^{235}U

129. Which of the following statements about *Archaeopteryx* is FALSE?
   A) It is the direct ancestor of modern birds.
   B) It shows a combination of reptilian and birdlike features.
   C) It provides clear evidence of the close relationship between birds and dinosaurs.
   D) It had a long, bony, reptilian tail.
   E) It had asymmetrical feathers like a modern bird.

130. The discovery of *Tiktaalik roseae* was significant for which of the following reasons?
   A) It provided evidence that terrestrial vertebrates are descended from fish.
   B) It provided evidence that birds and dinosaurs are closely related.
   C) It was the first fossil to be found with soft parts preserved.
   D) It provided evidence that the continents were once linked together.
   E) It was the first fossil from which DNA and other macromolecules were successfully extracted.

131. Dinosaurs disappeared at the end of which period?
   A) Cretaceous
   B) Permian
   C) Triassic
   D) Jurassic
   E) Cambrian

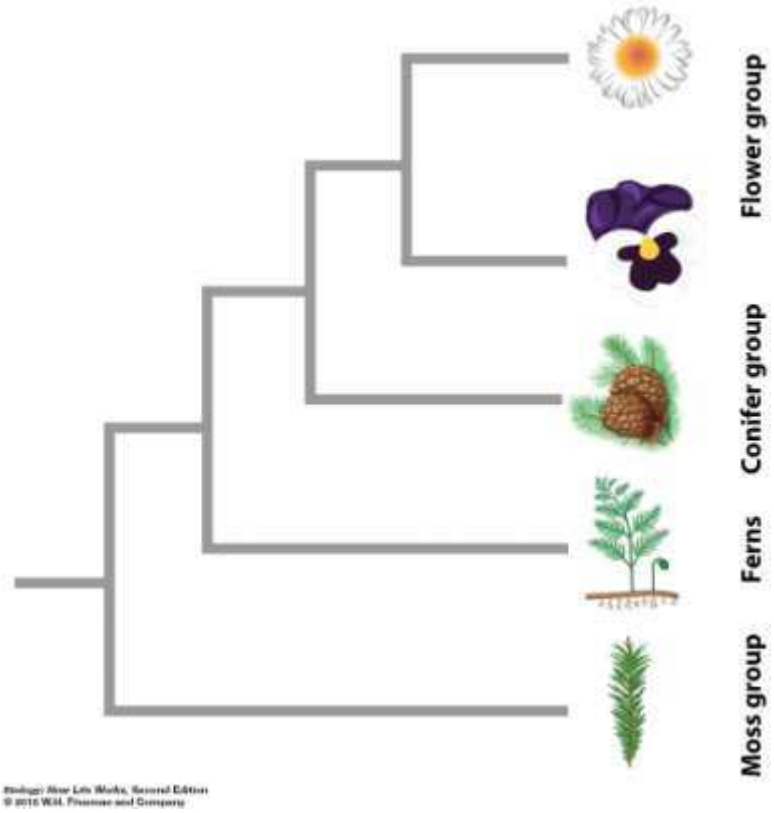
132. The Permian mass extinction is hypothesized to have been caused by volcanic eruptions resulting in:
   A) global warming, lack of oxygen in seawater, and ocean acidification.
   B) ocean acidification.
   C) lack of oxygen.
   D) global warming.
   E) global warming and lack of oxygen.

133. During the Permian extinction, what percentage of species in the ocean disappeared?
   A) 90%
   B) 25%
   C) 50%
   D) 75%
   E) 100%

134. The LARGEST documented mass extinction on Earth occurred _____ million years ago.
   A) 252
   B) 25
   C) 6.5
   D) 65
   E) 650

135. While we can use molecular clocks based on molecular sequence data to estimate the times at which various lineages diverged, we ultimately need the _____ to calibrate the clocks.
   A) fossil record
   B) character states
   C) sister groups
   D) transitional forms
   E) DNA sequences

136. The phylogeny below represents a hypothesis for the evolutionary relationships among major groups of plants. If it is correct, in what order should we predict to find the fossils of these groups, in order from oldest to youngest?



A) flower group, conifer group, ferns, moss group
B) conifer group, ferns, moss group, flower group
C) ferns, moss group, conifer group, flower group
D) moss group, ferns, conifer group, flower group
E) ferns, conifer group, moss group, flower group

137. Why don't researchers use ^{14}C to date fossils in rocks from the Cambrian Period?
A) Cambrian fossils do not contain carbon.
B) ^{14}C only formed in more recent geologic periods.
C) ^{14}C cannot provide accurate dates.
D) The amount of ^{14}C remaining in Cambrian specimens is far too small to be measured accurately.

138. The fossil record is often used to infer phylogenetic history. Which of the statements accurately supports this assumption?
   A) There are fossil representatives of every organism in the tree of life.
   B) There is a one-to-one correlation between each branch of the phylogenetic tree and fossil specimens.
   C) Events that occur early in the fossil record are represented by branching events nearer to the root of a phylogenetic tree.
   D) Events that occur early in the fossil record are represented by branching events nearer to the tips of a phylogenetic tree.
   E) Fossil record events are too old to be represented on phylogenetic trees, which reconstruct the more recent past.

139. How do fossils provide evidence of evolutionary history?
   A) Fossils provide an accurate account of the number of species that exist at any particular time.
   B) Older fossils are an excellent source of DNA from which we can construct molecular phylogenies.
   C) Fossils provide a record of extinct species.
   D) Fossils provide complete information on extinct species.

140. Select the BEST set of data for constructing the type of diagram shown below.

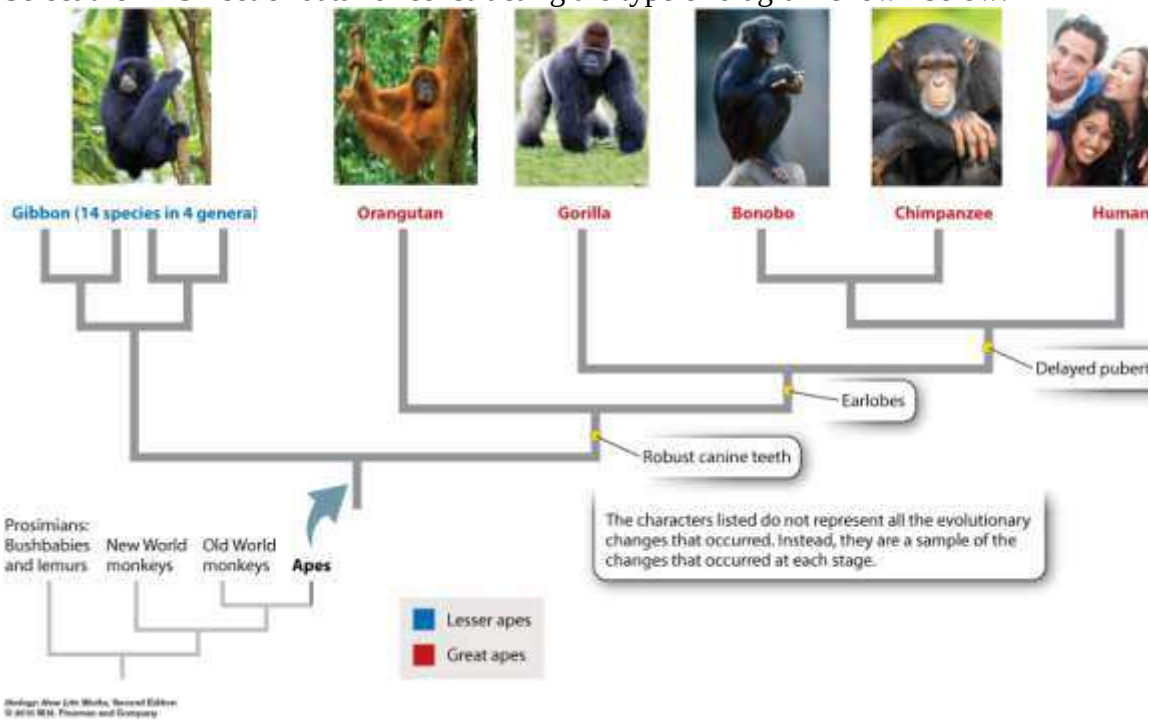


Photo sources: (left to right) Zoonar/K. Jorgensen/age fotostock; S Sailer/A Sailer/age fotostock; J & C Sohns/age fotostock; Michael Dick/ Animals Animals–Earth Scenes; FLPA/Jurgen & Christi/age fotostock; Yellow Dog Productions/Getty Images.

A) molecular data
B) morphological data of extant species
C) anatomical, physiological, and developmental studies of extant species in the fossil record
D) A combination of all of the other answer options would yield the best data set.

141. What information is provided by the fossil record that CANNOT be provided by examining living organisms?
A) a record of extinct species
B) absolute dates for when different taxa diverged
C) records of environmental conditions
D) the existence and timing of mass extinctions
E) All of these choices are correct.

142. According to the fossil record, when did the earliest animals appear on Earth?
A) 580 million years ago
B) 3 billion years ago
C) 3500 million years ago
D) 520 million years ago
E) 55 million years ago

143. Which of the following is a benefit of reconstructing evolutionary history from living organisms?
   A) A range of features can be used to generate phylogenetic hypotheses.
   B) The time dimension of speciation events can be calculated with greater certainty.
   C) Evolutionary links running through extinct species can be inferred easily.
   D) The environmental context is more easily observable.
   E) None of the other answer options is correct.

144. The fact that two independent methodologies for investigating the history of life on Earth (phylogenies and the fossil record) agree is powerful evidence of evolution.
   A) True
   B) False

145. Data from phylogenies based on living organisms and data from the fossil record are in agreement when the tree of life is examined as a whole, but are often contradictory when individual branches are examined.
   A) True
   B) False

146. Why is agreement between the fossil record and phylogenies constructed from living organisms considered to be strong evidence of evolution?
   A) It is unlikely that two independent methods of investigation would result in the same pattern by chance alone.
   B) All living organisms will eventually become fossils; therefore, evidence of their evolution will be recorded in the fossil record.
   C) Phylogenetic methods based on DNA sequences can suggest that two species are closely related, but only fossils can show direct evidence of an evolutionary relationship between species.
   D) Evolutionary processes cannot be studied directly in the laboratory alone, so it is necessary to compare living and extinct species to see evidence of evolutionary change.
   E) All of these choices are correct.

147. Phylogenetic methods based on DNA sequences and data from the fossil record both show that the evolutionary link between birds and crocodiles runs through dinosaurs.
   A) True
   B) False

148. Which of the following statements is CORRECT?
   A) The fossil record and comparative biology agree at all scales of observation.
   B) The fossil record and comparative biology agree only when individual branches of the tree of life are observed.
   C) The fossil record and comparative biology agree only when the tree of life as a whole is observed.
   D) The fossil record and comparative biology agree only when larger branches of the tree of life are observed.
   E) The fossil record and comparative biology do not agree at any scale of observation.

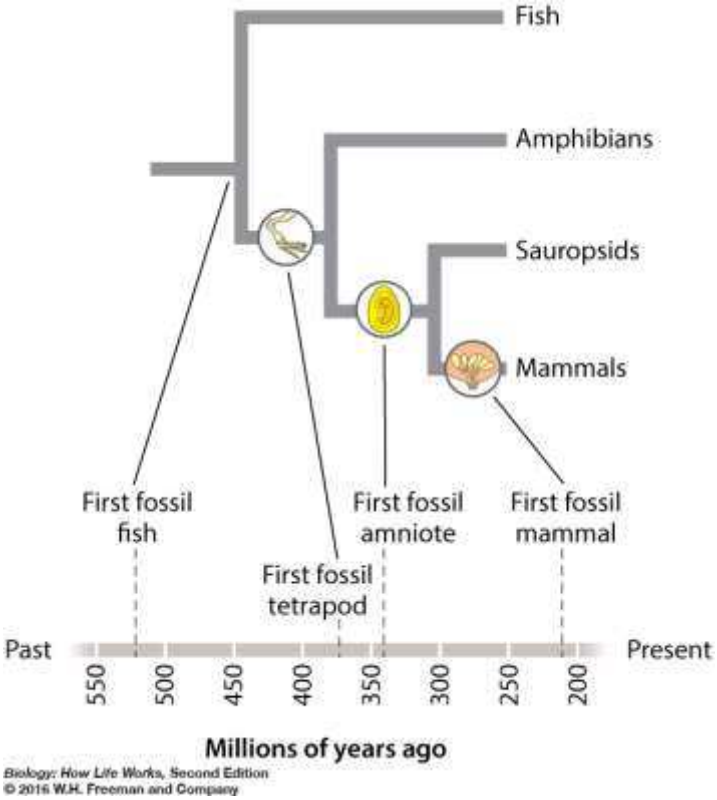
149. Data from both phylogenies and the fossil record show all of the following EXCEPT:
   A) the earliest animals appeared more recently than the earliest land plants.
   B) microorganisms diverged early in evolutionary history.
   C) flowering plants diverged more recently than algae.
   D) primates diverged more recently than tetrapod vertebrates.
   E) diversity has accumulated over time.

150. Even if the geologic record extended back only 5000 years, evidence provided by living organisms alone would support the hypothesis that mammals only diverged following the extinction of dinosaurs.
   A) True
   B) False

151. The vast diversity observed in present-day plants and animals was likely also present in the ancestors of these organisms; diversity tends to remain constant, and does not accumulate over time or in subsequent generations.
   A) True
   B) False

152. Which of the following statements is TRUE regarding the ancestors of early humans and chimpanzees (those present 6 million years ago)?
   A) The ancestors of chimpanzees likely appeared very similar (if not identical) to present-day chimpanzees.
   B) The ancestors of humans likely appeared very similar (if not identical) to present-day humans.
   C) The ancestors of humans and chimpanzees likely resembled one another, but would not appear identical to either present-day chimpanzees or humans.
   D) The ancestors of chimpanzees likely resembled present-day humans.

153. Based on the phylogenetic tree in Fig. 23.22, what character did the last common ancestor of both reptiles and mammals NOT possess?



A) lungs
B) four limbs
C) amniote embryos
D) mammary glands
E) The last common ancestor of reptiles and mammals possessed all of these traits.

154. Which of the following statements is TRUE regarding the fossil record?
A) Humans appear relatively recently in the fossil record.
B) Tetrapods appear before mammals in the fossil record.
C) Vertebrates appear after microorganisms in the fossil record.
D) Compared to other types of plants (i.e., seed plants), grasses appear relatively recently in the fossil record.
E) All of these choices are correct.

155. Evolution's patterns manifest as nested similarities□nesting occurs between molecular sequences of evolutionarily related organisms, and between the different taxa arranged in a phylogenetic tree.
A) True
B) False

Answer Key

1. C
2. A
3. A
4. C
5. B
6. C
7. A
8. D
9. A
10. B
11. A
12. C
13. B
14. B
15. D
16. A
17. A
18. B
19. A
20. A
21. B
22. A
23. A
24. A
25. A
26. D
27. A
28. A
29. A
30. A
31. A
32. B
33. A
34. C
35. A
36. A
37. A
38. A
39. A
40. D
41. D
42. C
43. D
44. B

45. B
46. C
47. A, B
48. A
49. E
50. A
51. D
52. B
53. C
54. A
55. D
56. B
57. E
58. A
59. A
60. D
61. D
62. D, E
63. C
64. B
65. B
66. B
67. C
68. B
69. A
70. A
71. A
72. A
73. A
74. A
75. A
76. A
77. B
78. A
79. C
80. B
81. C
82. A
83. E
84. D
85. B
86. A
87. D
88. C
89. B
90. A

91. D
92. D
93. B
94. D
95. Yes. Even in the absence of a fossil record, phylogenetic reconstruction (whether based on morphology or on amino acid or nucleotide sequences) would show that tetrapods are the sister group of a subgroup of all fish—i.e., that some fish are more closely related to tetrapods than they are to other fish. This indicates that the group is paraphyletic.
96. A
97. Phylogenetic analysis shows that mammals branched off from reptiles (i.e., they are modified reptiles), meaning that, if the two great patterns are concordant, we expect mammals to first appear in the fossil record *after* the first appearance of reptiles. If therefore we find mammals in the fossil record pre-dating the appearance of the first reptiles (which we don't—mammals do indeed come later in the fossil record than reptiles), we would have a discordance between the two great patterns and, therefore, evidence that the theory of evolution is wrong.
98. A
99. 1. Use the fossil record to identify ancestral forms, and date the fossils using standard paleontological methods (typically a combination of stratigraphy and isotope decay-based dating of nonsedimentary rocks).
    2. Use “molecular clock” arguments (see Chapter 21) whereby the extent of molecular sequence difference is correlated directly with the time since common ancestry. If we know approximately the rate at which mutations accumulate per unit time for a given gene or protein, it's possible to infer the time of common ancestry on the basis of the number of sequence differences observed between taxa.
100. B
101. A
102. E
103. C
104. B
105. C
106. A
107. B
108. A
109. A, E
110. D
111. D
112. D
113. A
114. D
115. A
116. B
117. B
118. A
119. C

120. E
121. B
122. A
123. A
124. A
125. A
126. A
127. A
128. D
129. A
130. A
131. A
132. A
133. A
134. A
135. A
136. D
137. D
138. C
139. C
140. D
141. A
142. A
143. A
144. A
145. B
146. A
147. B
148. A
149. A
150. B
151. B
152. C
153. D
154. E
155. A