organisms

sister taxa two lineages that diverged from the same branch point

systematics field of organizing and classifying organisms based on evolutionary relationships

taxon (plural: taxa) single level in the taxonomic classification system

taxonomic classification system hierarchical system of classifying organisms, including the classification of domain, kingdom, phylum, class, order, family, genus, and species

taxonomy science of classifying organisms

web of life phylogenetic model that attempts to incorporate the effects of horizontal gene transfer on evolution

CHAPTER SUMMARY

20.1 Organizing Life on Earth

Scientists continually gain new information that helps understand the evolutionary history of life on Earth. Each group of organisms went through its own evolutionary journey, called its phylogeny. Each organism shares relatedness with others, and based on morphologic and genetic evidence, scientists attempt to map the evolutionary pathways of all life on Earth. Historically, organisms were organized into a taxonomic classification system. However, today many scientists build phylogenetic trees to illustrate evolutionary relationships.

20.2 Determining Evolutionary Relationships

To build phylogenetic trees, scientists must collect accurate information that allows them to make evolutionary connections between organisms. Using morphologic and molecular data, scientists work to identify homologous characteristics and genes. Similarities between organisms can stem either from shared evolutionary history (homologies) or from separate evolutionary paths (analogies). Newer technologies can be used to help distinguish homologies from analogies. After homologous information is identified, scientists use cladistics to organize these events as a means to determine an evolutionary timeline. Scientists apply the concept of maximum parsimony, which states that the order of events probably occurred in the most obvious and simple way with the least amount of steps. For evolutionary events, this would be the path with the least number of major divergences that correlate with the evidence.

20.3 Perspectives on the Phylogenetic Tree

The phylogenetic tree, first used by Darwin, is the classic "tree of life" model describing phylogenetic relationships among species, and the most common model used today. New ideas about HGT and genome fusion have caused some to suggest revising the model to resemble webs or rings.

REVIEW QUESTIONS

1. Who devised a commonly used classification system?

a. Carl Linnaeus
b. Darwin
c. Plato
d. Aristotle

2. Which of the following uses a hierarchial model to classify organisms?

a. analogy
b. taxonomic classification system
c. Order
d. systematics

3. Correctly list the hierarchy of taxonomy.

a. Kingdom, Domain, Phylum, Order, Class, Family, Genus, species
b. Domain, Kingdom, Class, Phylum, Order, Family, Genus, species
c. Domain, Kingdom, Phylum, Class, Order, Family, Genus, species
d. Domain, Kingdom, Class, Phylum, Order, Family, Genus, species

4. Which of category, below the level of Kingdom, would have the next largest number of organisms?

a. Order
b. Phylum
c. Family
d. Class

5. How is systematics related to phylogeny?

a. Systematics provides guidelines that scientists use to describe the relationships of organisms.
b. Scientists use systematics programs to put together the phylogeny of an organism.
c. In systematics, scientists use combined data based on evolutionary relationships from many sources to put together the phylogeny of an organism.
d. Systematics is a process used to put together the phylogeny of an organism.

6. Which of the following is the best explanation of what systematists do?

a. Scientists in the field of systematics organize organisms by characteristics.
b. Scientists in the field of systematics provide information on how organisms are similar or different.
c. Scientists in the field of systematics contribute to building, updating, and maintaining the "tree of life."
d. Scientists in the field of systematics collect data from fossils.

7. What is the purpose of a phylogenetic tree?

a. to organize and name organisms into specific categories
b. The taxonomy is used to organize and name organisms into specific categories.
c. to show the evolutionary pathways and connections among organisms
d. to show geographic or behavioral factors

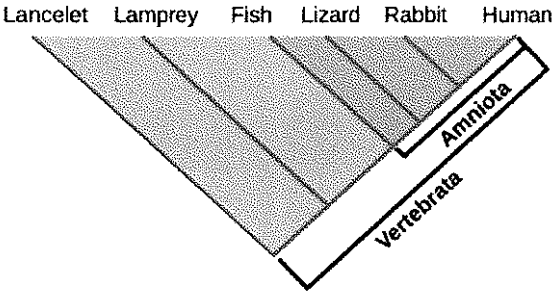
8. What does the term "rooted" mean on a phylogenetic tree diagram?

a. relationships among species do not show
b. all organisms represented in the diagram relate to a single ancestral lineage
c. a single lineage evolved into a distinct new one
d. A lineage evolved early from the root and remains unbranched.

9. Phylogeny is important to everyday life in human society. How did the research team in China use phylogeny as a guide to discover new plants that can be used to benefit people?

a. The research team used DNA to uncover phylogenetic relationships in the legume family, and they found a compound in the plant that is effective in treating cancer.
b. The research team used DNA to uncover phylogenetic relationships in the legume family, and then they identified a newly discovered plant as Dalbergia sissoo.
c. The research team used DNA to uncover phylogenetic relationships in the legume family, and they found a DNA marker that can be used to screen for plants with potential medicinal properties.
d. The research team searched all the relatives of the newly discovered plant Dlabergia sissoo to find antifungal properties.

10. Which animals in the figure belong to a clade that includes animals with hair? Which evolved first, hair or the amniotic egg?



a. Rabbit and Human-Hair evolved before the amniotic egg.
b. Rabbit-Hair evolved before the amniotic egg.
c. Rabbit and Human-Amniotic egg evolved before hair.
d. Lancelet-Hair evolved before the amniotic egg.

11. What is the largest clade in the preceding diagram?

a. Animals, Fungi, and Plants
b. Fungi
c. Diplomonads
d. Flagellates

12. Why is it important for scientists to distinguish between homologous and analogous characteristics before building phylogenetic trees?

a. Phylogenetic trees are based on evolutionary connections, so scientists can use the analogous characteristics to build the phylogenetic trees.

b. Phylogenetic trees are based on evolutionary connections, so scientists can use the homologous characteristics to build the phylogenetic trees.

c. Phylogenetic trees are based on similar functions, so scientists can use the homologous characteristics to build the phylogenetic trees.

d. Phylogenetic trees are based on similar functions, so scientists can use the homologous characteristics to build the phylogenetic trees.

13. Describe an analogous structure.

a. A penguin and a seagull both have wings. The penguin uses wings to swim while the seagull uses wings to fly.

b. Lizards and whales have similar skeleton structures, but they have a different habitat and lifestyle.

c. Birds and butterflies have wings with similar characteristics for flight even though their wings do not share an evolutionary relationship.

d. The bone structure in leg of a cat is very similar to the bone structure in the arm of a human, but the functions of the limbs are very different.

14. What is the ring of life?

a. a phylogenetic model where all three domains of life evolved from a pool of primitive prokaryotes

b. an evolutionary history and relationship of an organism or group of organisms

c. a phylogenetic model that attempts to incorporate the effects of horizontal gene transfer on evolution

d. a field of organizing and classifying organisms based on evolutionary relationships

15. Some individual prokaryotes were responsible for transferring the bacteria that caused mitochondrial development to the new eukaryotes, whereas other species transferred the bacteria that gave rise to chloroplasts. This statement best describes which model?

a. ring of life

b. tree of life

c. branches of life

d. web of life

16. Explain why the classic tree model needs to be revised.

a. The model is unable to incorporate DNA evidence.

b. The model is erroneously based on many analogous traits, which have no basis in evolutionary relationships.

c. The model cannot be experimentally verified.

d. The model does not consider the possibility that genes could be transferred between unrelated species.

17. Compare three different ways that eukaryotic cells may have evolved.

a. Some hypotheses propose that mitochondria were acquired first. Others propose that the nucleus evolved first. Still others hypothesize that prokaryotes descended from eukaryotes by the loss of genes and complexity.

b. Some hypotheses propose that eukaryotic cells are a combination of bacterial and archaeal cells. Others propose that eukaryotic cells are a combination of bacterial and fungal cells. Still others hypothesize that eukaryotic and prokaryotic cells developed independently.

c. Some hypotheses propose that mitochondria developed from bacterial cells. Others propose that they developed from archaeal cells. Still others hypothesize that bacteria developed from mitochondria that had been released from eukaryotic cells.

d. Some hypotheses propose that eukaryotic cells developed from gram-negative bacteria. Others propose that they developed from gram-positive bacteria. Still others hypothesize that both gram-positive and gram-negative bacteria contributed to the eukaryotic genome through horizontal gene transfer.

18. Explain the ring of life model.

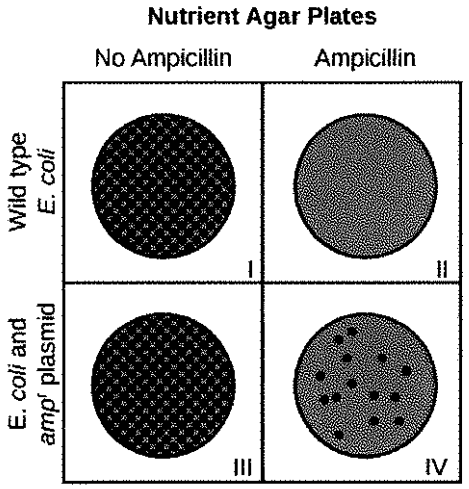
a. The ring of life model is a phylogenetic model where the three domains of life started as distinct groups that could swap genes horizontally with each other in all directions.

b. The ring of life model is a phylogenetic model where all three domains of life are said to have developed from a pool of primitive prokaryotes.

c. The ring of life model is a phylogenetic model where bacterial and archaeal cells fused to form eukaryotic cells.

d. The ring of life model is a phylogenetic model where there is only a single domain of life due to modern DNA analysis.

19.



In a transformation experiment, a sample of E. coli bacteria was mixed with a plasmid containing the gene for resistance to the antibiotic ampicillin (ampr). Plasmid was not added to the second sample. Samples were plated on nutrient agar plates, some of which were supplemented with the antibiotic ampicillin. The results of E. coli growth are summarized below. The shaded area represents extensive growth of bacteria; dots represent individual colonies of bacteria. Plates that have only ampicillin resistant bacteria include which of the following?

a. I only
b. III only
c. IV only
d. I and II

CRITICAL THINKING QUESTIONS

20. Describe how organisms are classified in the taxonomic classification system.

a. The taxonomic classification system uses a hierarchical model to organize living organisms. At each sublevel, the organisms are more similar.
b. The taxonomic classification system uses a hierarchical model to organize living organisms. At each sublevel, the number of organisms increases.
c. The categories in the taxonomic classification system are organized from smaller, more specific categories to larger categories.
d. In the hierarchal model for the taxonomic classification system, from the point of origin, the groups become less specific.

21. What is the correct way to format a two-word scientific name?

a. Italicize both words. Both words are lower case.
b. Italicize both words. The first word should be capitalized. The second word should be lower case.
c. Italicize both words. Capitalize both words.
d. Underline both words. Capitalize both words.

22. Some organisms that appear very closely related may not actually be closely related. Why is this?

a. There are cases where organisms used to be closely related but diverged from each other and no longer look closely related.
b. There are cases where organisms can interbreed making them look like a single species, when in fact they are not closely related at all.
c. There are cases where organisms evolved through convergence and appear closely related but are not.
d. There are cases when extremely distant taxa can recombine into a single group.

23. How does a phylogenetic tree relate to the passing of time?

a. A phylogenetic tree relates to the passing of time because species branch off from each other at regular time intervals.
b. A phylogenetic tree is not related to the passing of time because speciation is based on geographic changes.
c. The phylogenetic tree only shows the order in which things took place.
d. A phylogenetic tree relates to the passing of time when the diagram also shows how long ago the divergence from the common ancestor occurred.

24. Judeo-Christian religious texts explain that the Earth and all the organisms on Earth were created in seven days. Why is this not a valid scientific hypothesis?

25. Scientists use the cladistics system to organize what?

a. homologous traits
b. homoplasies
c. analogous traits
d. monophyletic groups

26. Describe how a clade relates to monophyletic group.

a. Clades vary in size depending on the number of branches.

b. All the organisms within a clade stem from a single point on the phylogenetic tree.

c. A clade shows branches that do not share a single point.

d. A clade shows groups that diverge at a different branch point.

27. Scientists apply the concept of maximum parsimony to do what?

a. describe phylogenies accurately

b. eliminate analogous traits

c. identify mutations to DNA codes

d. locate homoplasies

28. You discover a new species of animal in the rainforest. What characteristics could you use to distinguish this organism from the other organisms in the same clade based on Figure 20.11?

29. Based on the phylogenetic tree below, is the Jungle cat likely closer related to a tiger or a cougar? Why?

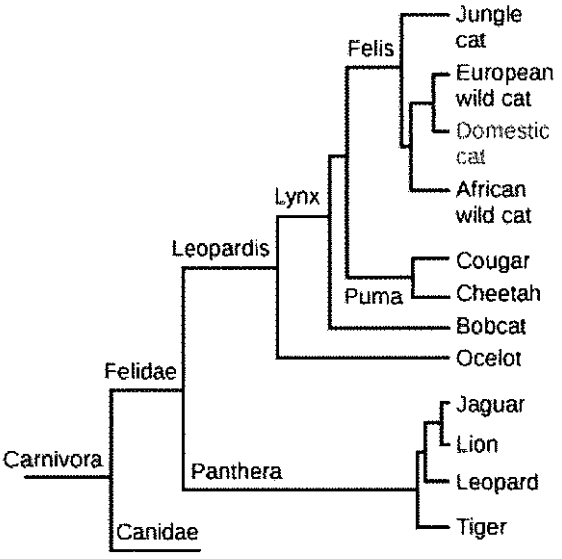


Figure 20.19

30. Two cultures of bacteria are separated by a filter that blocks the movement of cells but allows free exchange of anything smaller than a bacterial cell. On one side of the filter, a sample of penicillin resistant cells in culture broth is added, on the second side of the tube, a culture of penicillin sensitive cells in culture is added. After 24 hours, resistant cells appear on the side with the cells sensitive to penicillin. Which three genetic mechanisms can account for appearance of the penicillin resistant cells?

a. transformation, transduction, and conjugation

b. transformation, transduction, and mutation

c. transformation, conjugation, and mutation

d. transduction, conjugation, and mutation

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31. What evolutionary question is better addressed by the fig-shaped evolutionary tree in Figure 20.17, as opposed to the more typical, single-trunk phylogenetic tree in Figure 20.2?

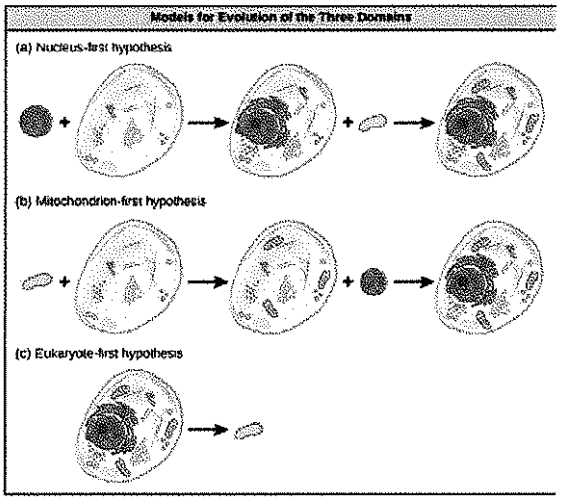
a. What was the single organism from which all other forms of life on Earth arose?

b. Did animals evolve from fungi?

c. In which species of eukaryote did chloroplasts first appear?

d. Were chloroplasts and mitochondria transferred to eukaryotic cells through horizontal gene transfer?

32.



Which question, relating to the endosymbiotic hypothesis and the evolution of eukaryotes, is not answered by the eukaryote-first hypothesis, based on the figures?

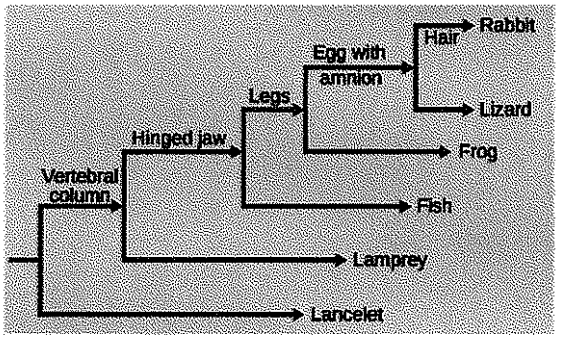
a. Which evolved first, the nucleus or prokaryotes?

b. Which evolved first, mitochondria or prokaryotes?

c. How and when did the nucleus evolve in eukaryotes?

d. How and when did prokaryotes evolve?

33.



The phylogeny above shows the evolution of traits in vertebrates. Based on this phylogeny, a student asks "Does this mean that lizards, frogs and rabbits all possessed hair and an egg with amnion at some point in their evolution?" Based on the phylogeny, how should you respond to the student?

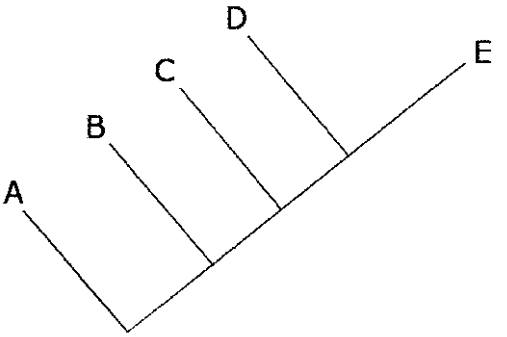
a. Hair and an amniotic egg were both possessed by all three species at some point in their evolution.

b. Hair is only a characteristic found in the rabbit evolutionary history. The amniotic egg was possessed by both the rabbit and lizard, but not frogs, at some point in their evolutionary history.

c. Hair is a characteristic only found in the rabbit evolutionary history. The amniotic egg was possessed by all three species at some point in their evolutionary history.

d. Hair was possessed by all three species at some point in their evolutionary history. The amniotic egg was possessed by both the lizard and frog, but not the rabbit at some point in their evolutionary history.

34.



The tree above shows the phylogenetic relationships between four species. A scientist wishes to perform a genetic analysis on all four species in which she determines the number of genetic similarities between all four species. What would she likely find regarding the genetic similarities between species A, B, D and E?

a. Species D and E would share more genetic similarities with each other than with species A and B, and vice versa.

b. Species A and E would share more genetic similarities with each other than with species B and D, and vice versa.

c. Species D and A would share more genetic similarities with each other than with species A and B, and vice versa.

d. Species D and B would share more genetic similarities with each other than with species A and E.

35. What is the aim of scientists applying the maximum parsimony concept when creating phylogenetic trees?

a. The scientists spend more time creating the phylogenetic table.

b. Scientists find the shortest tree with the smallest number of changes.

c. A complex, detailed phylogenetic tree diagram is created.

d. The scientists spend more time researching the data for evolutionary connections.

36. Dolphins and fish have similar body shapes. Is this feature more likely a homologous or analogous trait? Explain your answer.

a. Analogous-Dolphins are mammals and fish are not, thus their evolutionary paths are quite separate. They have similar body shapes because of their similar environment.

b. Analogous-Dolphins and fish are both vertebrates, thus they share an evolutionary history, causing them to have similar body shapes.

c. Homologous-Dolphins and fish are both vertebrates, thus they have a similar recent evolutionary history, causing them to have similar body shapes.

d. Homologous-Dolphins are mammals and fish are not, thus their evolutionary paths are quite separate. They have similar body shapes because of their similar environment.

37. What effect has the advancement of DNA technology had on determining phylogeny?

a. Morphologic and molecular information often disagree.

b. Scientists are struggling with molecular systematics.

c. Information is not reliable because organisms appear to be closely related when they are not.

d. Computer programs help determine relatedness using DNA sequencing, and morphologic and molecular information is more effective in determining phylogeny.

38. Describe what maximum parsimony is used for in evolutionary biology.

a. Maximum parsimony hypothesizes that organisms that share the most traits are the most likely to share a common ancestor.

b. Maximum parsimony hypothesizes that organisms that share a common ancestor are more likely to have many traits in common.

c. Maximum parsimony hypothesizes that events occurred in the simplest, most obvious way, and the pathway of evolution probably includes the fewest major events that coincide with the evidence at hand.

d. Maximum parsimony hypothesizes that organisms that display homologous structures are closely related, while organisms that display analogous structures must have diverged much farther in the past.

39. The emu in Australia and ostrich in Africa are flightless birds that look similar. One proposed hypothesis was the birds descend from an early common ancestor that spread when the continents were connected. DNA analysis shows that emus and ostriches share more genetic homology with flying birds which live in the same region than with each other. What is the best explanation for these findings?

a. This is an example of an early shared ancestor.

b. This is an example of convergent evolution.

c. This is an example of random DNA homology.

d. This is an example of divergent evolution.

40. A scientist decides to investigate the evolutionary connection between closely related bacteria. Which gene would be a good choice to use for establishing relatedness, a very well conserved gene or a poorly conserved sequence? Explain your reasoning.

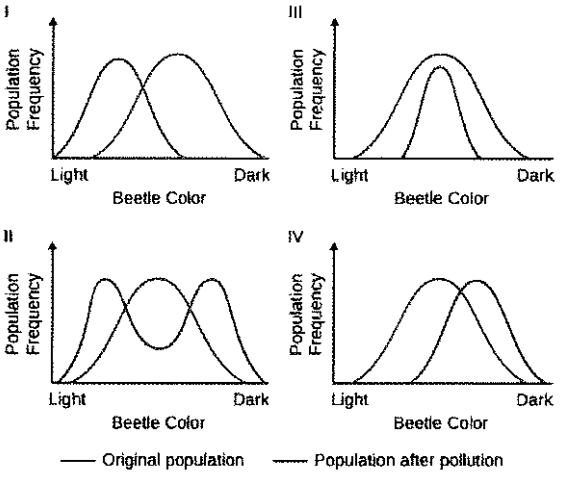
a. A very well conserved gene would be a good choice, because well conserved genes undergo sufficient changes during relatively short times, which allows for the study of recent evolutionary events. Well-conserved genes do not undergo changes during short durations.

b. A poorly conserved gene would be a good choice, because poorly conserved genes show sequence similarity, which is used as evidence of evolutionary relationships between sequences.

c. A poorly conserved gene would be a good choice, because poorly conserved genes undergo sufficient changes during relatively short times, which allows for the study of recent evolutionary events.

d. A very well conserved gene would be a good choice, because well conserved genes show sequence similarity, which is used as evidence of evolutionary relationships between sequences.

41.



In a hypothetical population of beetles, there is a wide variety of color, matching the range of coloration of the tree trunks on which the beetles hide from predators. The graphs below illustrate four possible changes in the beetle population as a result of a change in the environment due to pollution that darkened the tree trunks. What would be the most likely change in the coloration of the beetle

population after pollution and why?

a. The coloration range shifted toward more light-colored beetles, as in diagram I. The pollution helped the predators find the darkened tree trunks.

b. The coloration in the population split into two extremes, as in diagram II. Both the light-colored and the dark-colored beetles were able to hide on the darker tree trunks.

c. The coloration range became narrower, as in diagram III. The predators selected beetles at the color extremes.

d. The coloration in the population shifted toward more dark-colored beetles, as in diagram IV. The light-colored beetles were found more easily by the predators than were the dark-colored beetles.

42. A population of rodents settles on the shore of an island close to the Arctic Circle. The landscape consists mainly of rocks. If the individuals are too large, they cannot hide in crevices to escape hawks. On the other hand, small bodies do not maintain internal temperature in cold weather. Show diagrammatically the change in the population and explain what selective pressures took place.

a. directional selection

b. stabilizing selection

c. disruptive selection

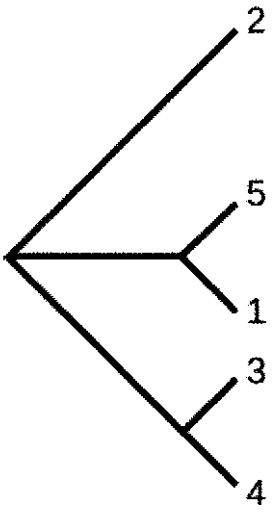
d. diversifying selection

43. Five new species of bacteria were discovered in Antarctic ice core samples. The nucleotide (base sequences of rRNA subunits were determined for the new species. The table below shows the number of nucleotide differences between the species.

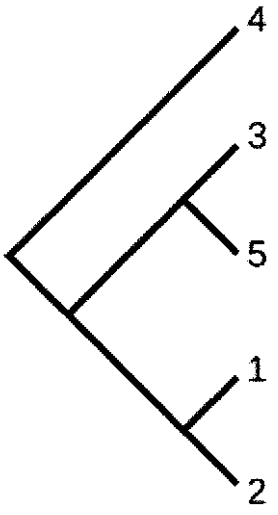
Species	1	2	3	4	5
1	-	3	19	18	27
2		-	19	18	26
3			-	1	27
4				-	27

Which of the following phylogenetic trees is most consistent with the data?

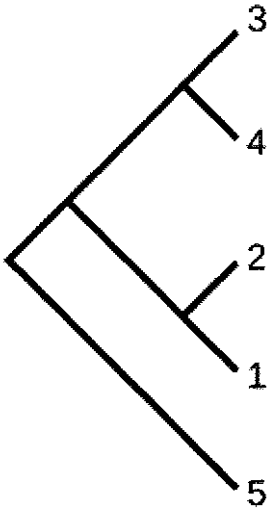
a.



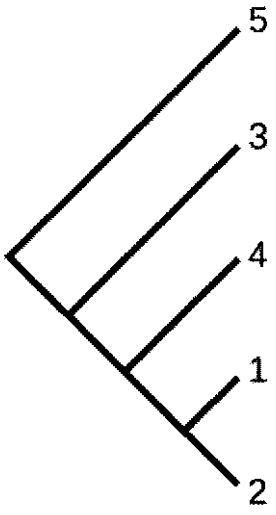
b.



c.



d.



44. Draw the phylogenetic tree for the species below. Identify where on the tree each feature evolved.

	Amniotic Egg	Endotherm	Feathers	Lungs	Vertebrae	Notochord
Snake	Y	N	N	Y	Y	Y
Ostrich	Y	Y	Y	Y	Y	Y
Shark	N	N	N	N	Y	Y
Frog	N	N	N	Y	Y	Y
Lancelet	N	N	N	N	N	Y

Figure 20.20

a. The ostrich branched off first, followed by the snake, then the frog, then the shark and then the lancelet.

b. The shark branched off first, followed by the lancelet, then the frog, then the ostrich and then the snake.

c. The lancelet branched off first, followed by the shark, then the frog, then the snake and then the ostrich.

d. The lancelet branched off first, followed by the shark, then the ostrich, then the snake and then the frog.

45. Barbara McClintock discovered transposons while working on maize genetics. What are the transposons composed of when they are able to shift from one location to another?

a. segments of RNA

b. Plasmids

c. segments of DNA

d. proteins

46. What is Horizontal Gene Transfer (HGT)?

a. the proposal that eukaryotes developed a nucleus first, and then their mitochondrion

b. the transmission of genetic material from one species to another through mechanisms other than from parent to offspring

c. the fusion of two prokaryotic genomes

d. the division of kingdom in the taxonomic classification

47. What is referred to as the transfer of genes by a mechanism that does not involve asexual reproduction?

a. web of life

b. meiosis

c. gene fusion

d. horizontal gene transfer

48. Which of the following describes small, virus-like particles that act as a mechanism of gene transfer between prokaryotes?

a. gene transfer agents

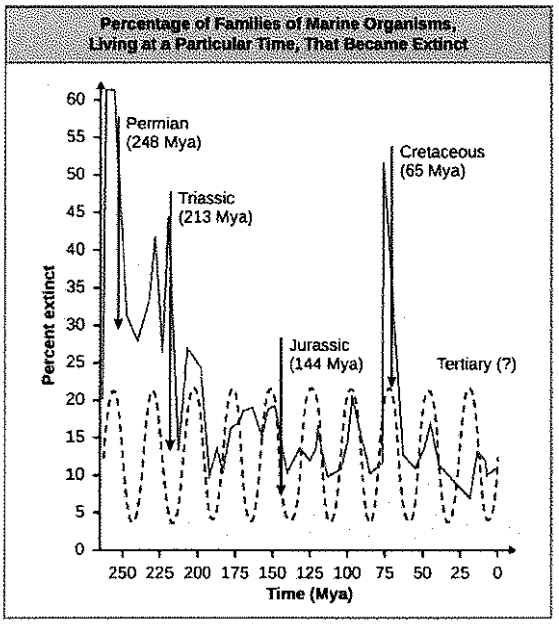
b. horizontal gene transfer

c. vertical gene transfer

d. basal taxon

SCIENCE PRACTICE CHALLENGE QUESTIONS

49.



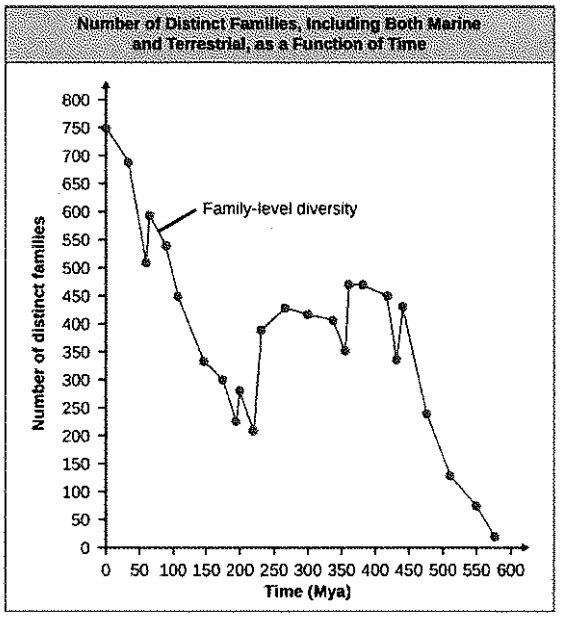


Figure 20.21

The figure shows a plot of the fraction, as a percentage, of families of marine organisms, living at a particular point in time that became extinct (vanished from the fossil record) in the next geological moment. These mass extinctions mark the ends of geologic periods. For example, the Triassic period ended around 213 million years ago (Mya).

A. The fact that evolution is an ongoing process is illustrated by these data. Whether the process displays a pattern involving regular intervals is a question that has been raised. Of those who believe periodicity is present, a period of 26 million years is favored. A wave with this periodicity is drawn on the figure. **Evaluate** the evidence provided in terms of agreement and disagreement with the marine extinction record.

The Cretaceous and Jurassic were periods of warm landmasses covered by a shallow sea. The ends of these periods are known to be due to asteroids that left a sedimentary trace. At the end of the Triassic, there is no evidence of an asteroid impact. Instead, there was massive volcanism associated with the opening of the Atlantic Ocean, a four-fold increase in carbon dioxide, and a 3–6 °C temperature rise (A. Marzoli et al., *Science*, 1999). Macrofossil, spore, and pollen data show that marine animal species declined much more than marine plant species (L. Mander et al., *Proc Natl Acad Sci*, 2010). The cause of the end of the Permian period is less uncertain, but an 8-°C temperature rise has been established (McElwain and Punyasena, *Trends in Ecology and Evolution*, 2007). Both terrestrial and marine taxa were affected.

The graph estimates the number of distinct families, including both marine and terrestrial, as a function of time before the present. Note that the time scale for this graph is much longer than that of the previous graph.

B. **Analyze** this graph by:

- identifying times of mass extinctions
- posing a question regarding any difference between the graph of extinctions of marine life and the graph of family-level diversity
- explaining the slope of the graph of family diversity following a mass extinction event

50.