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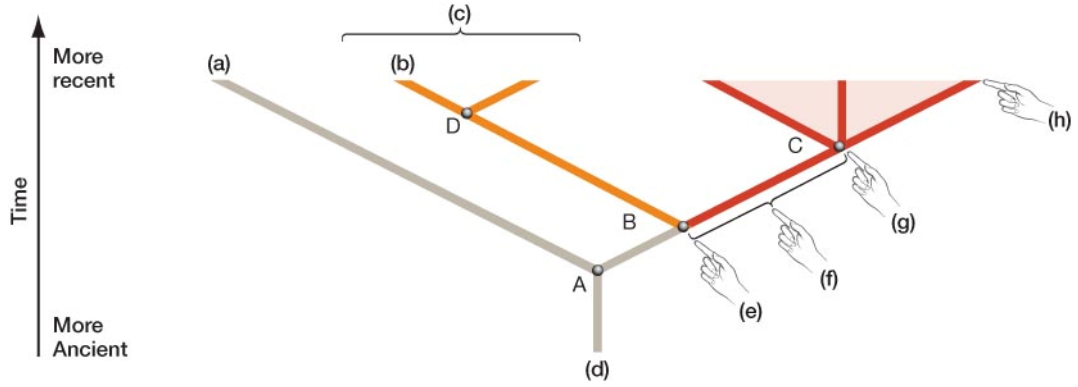
***Biological Science,* 3e**
Chapter Quiz – 27

1. In the following diagram of a phylogenetic tree, match the letters (a)–(h) with the correct part listed below:



_____ branch
_____ node
_____ outgroup
_____ polytomy
_____ root
_____ sister taxa
_____ taxon
_____ tip

2. How many monophyletic groups are represented in the diagram above, when the outgroup (a) is excluded?
HINT: How many lineages can be seen based on common ancestry?
a. one
Incorrect. There are three monophyletic clades on the tree: (1) with the common ancestor D, (2) with the common ancestor G, and (3) with the common ancestor B.
b. two
Incorrect. There are three monophyletic clades on the tree: (1) with the common ancestor D, (2) with the common ancestor G, and (3) with the common ancestor B.
c. three
Correct. There are three monophyletic clades on the tree: (1) with the common ancestor D, (2) with the common ancestor G, and (3) with the common ancestor B.
d. four
Incorrect. There are three monophyletic clades on the tree: (1) with the common ancestor D, (2) with the common ancestor G, and (3) with the common ancestor B. You may have chosen this answer by trying to include the monophyletic group with the common ancestor A; however, because the terminal taxon (a) is excluded, the group formed would contain some, but not all, of the descendants of the common ancestor.

3. Cladistic methods of phylogenetics depend upon _____.

HINT: What is the key difference between phenetic and cladistic approaches?

a. computing genetic distances among a group of species using phenotypic data

Incorrect. This technique is not unique to the cladistic method.

b. using gene sequence data to compute nearest neighbor distances

Incorrect. This technique could be done using either cladistic or phenetic methods.

c. identifying monophyletic groups based on shared, derived characters

Correct. Using synapomorphies—shared, derived traits—in phylogenetic reconstruction is the key feature of cladistics.

d. using numerical methods to compute overall similarity using both ancestral and derived traits

Incorrect. This is the phenetic method, not cladistics.

4. Which of the following statements most accurately explains why analogous traits are not informative for constructing phylogenetic trees?

HINT: What is the difference between homologous and analogous traits?

a. Analogous traits define monophyletic groups because they define synapomorphies.

Incorrect. Homologous traits define synapomorphies, and monophyletic groups are defined by the shared derived characters they possess.

b. Analogous traits typically evolve due to adaptations of different organisms to the same habitat (i.e., aquatic environments). Organisms in similar habitats are likely related phylogenetically.

Incorrect. Species from very diverse lineages live in the same habitat. Convergent evolution may result in similar characteristics in two groups, but this is the result of natual selection in one lineage, not a result of common ancestry.

c. Analogous traits develop from homologous structures, and are therefore useful in constructing phylogenies.

Incorrect. Analogous traits do not evolve from homologous structures, and have no utility in defining monophyletic groups.

d. Analogous traits represent convergent evolution, and do not represent synapomorphies defining a monophyletic group.

Correct. Analogous traits are not the result of shared ancestry, but are the result of convergent evolution.

5. Why is the molecular clock so useful in phylogenetics?

HINT: Consider the types of genetic changes that are used to calculate the molecular clock.

a. The molecular clock is based on nonsense mutations. Comparing genes with stop codons provides a powerful comparison between different lineages. This feature of mutation allows the timing of divergence between two lineages.

Incorrect. Nonsense mutations result in a stop codon within an mRNA. The molecular clock is based on DNA changes that do not affect protein function.

b. The molecular clock is based on silent mutations because they are random and natural selection does not act upon them. This feature allows the timing of divergence between different lineages.

Correct. Silent mutations may reach fixation due to drift. Because drift is a random process, silent mutations should accumulate in a steady "clock-like" fashion between lineages. Researchers can use the number of accumulated differences to estimate the time since divergence of two lineages.

c. The molecular clock is based on missense mutations. Researchers can use the number of different amino acids in a protein to time the divergence between two lineages.

Incorrect. Selection could act on alternate proteins resulting from different missense mutations differently. These changes would not occur at a steady rate, and would have utility for timing divergence events.

d. The molecular clock is based on gene duplication events.

Incorrect. Gene duplication events have occurred many times over evolutionary history, but the rate at which they occur is unknown. Although gene duplication can be used to determine relatedness between some organisms, it is not as useful as neutral genetic changes when timing divergence events.

6. Why are most fossils found in sedimentary rock?

HINT: Think about the conditions necessary for fossil formation.

a. Fossils form in sedimentary rock because they are dried out while exposed on the surface to the elements, and then are slowly covered with more sedimentary layers.

Incorrect. If a tree or animal lies on the surface, it will quickly be decomposed or weathered away by the elements.

b. Sedimentary rock is formed in habitats where there are high sedimentation rates. Anything that was deposited would be quickly buried, and decomposition would be low in the anoxic environment.

Correct. Rapid burial and slow decomposition are ideal for fossilization to occur. Environments like stream beds, beaches, or mudflats are ideal for fossilization to occur because sediments can bury something rapidly and the environment typically has low oxygen.

c. Fossils typically form in moist, tropical environments because that is where some of the the highest levels of biodiversity can be observed. Because of the high number of organisms that live there, it is likely that at least a small number of those organisms will be fossilized.

Incorrect. Although common organisms are more likely to fossilize than rare ones, burial is not common in forest environments.

d. Fossils form in sedimentary rock because it helps to harden soft body parts of certain organisms. This is why there are so many fossils of worms in the fossil record.

Incorrect. Soft-bodied forms are not fossilized easily. Trace fossils (i.e., burrows of worms) are more likely to be fossilized as they are filled with sedimentation slowly over time.

7. Why are the Doushantuo, Ediacaran, and Burgess Shale fossil deposits so unusual?

HINT: Why are fossils from the Precambrian so rare?

a. They preserve a diverse array of microorganisms that we believe gave rise to multicellular life at the start of the Cambrian period.

Incorrect. Although microorganisms are present, this is not what makes these fossil deposits unique.

b. They capture a wide range of soft-bodied organisms that are rarely preserved in the fossil record at a time when the diversity of metazoans was greatly increasing.

Correct. The preservation of soft-bodied organisms requires unusually fine sediments and rapid burial; throughout the fossil record, soft-bodied specimens are very rare.

c. These assemblages show precisely how animals began as single-celled organisms, then became two-celled, then four-celled, and so on, to become the multicellular forms we know today.

Incorrect. The Doushantuo fossils include specimens from a single cell to a multicellular blastula; however, this is a developmental progression, not an evolutionary event.

d. These fossils record the origin of animals from seaweeds and other photosynthetic organisms.

Incorrect. Animals may have originated from photosynthetic protists; however, this transition is not recorded in these fossil beds.

8. Fossils of organisms from the Precambrian are extraordinarily rare, but many species are found in the Burgess Shale deposits. Which of the following best describes the Burgess Shale organisms?

HINT: What phyla were present 525–515 million years ago?

a. mostly bacteria and simple one-celled plants and animals

Incorrect. These organisms are certainly present, but there are a lot more organisms.

b. primarily sponges, algae, and seaweeds

Incorrect. These organisms are in the deposits, but there are other phyla present.

c. arthropods, mollusks, chordates, and a variety of soft-bodied organisms

Correct. The variety of arthropods, and the presence of almost all modern-day phyla, is probably the outstanding feature of the Burgess Shale.

d. jellyfish and sponges, along with some tracks of various other organisms

Incorrect. These organisms are present, but other phyla are represented.

9. Which of the following observations is *not* consistent with the hypothesis that increasing metazoan complexity is associated with an increase in the number of *Hox* loci?

HINT: Consider the pattern of changes in the *Hox* loci within and among the phyla.

a. Within phyla, there is no correspondence between the number of *Hox* genes and complexity.

Correct. The pattern seems to hold across phyla but not within phyla.

b. Phyla that branch off early, such as sponges and cnidarians, have simple body plans with relatively few *Hox* loci.

Incorrect. This pattern *is* consistent with the hypothesis.

c. *Hox* loci are similar in structure and DNA sequence and are grouped in clusters. Hence, they are assumed to have arisen through duplication. When a new *Hox* gene appears within a lineage, most of the descendant taxa have a homologous *Hox* locus.

Incorrect. These loci *do* seem to have arisen through duplication, probably as a result of unequal crossing over.

d. In vertebrates, the *Hox* clusters themselves appear to be duplicated several times.

Incorrect. The duplication of clusters suggests crossing over between nonhomologous chromosomes.

10. What is one genetic hypothesis proposed for the rapid diversification of body plans during the Cambrian period?

HINT: What genetic changes are correlated with the appearance of new phyla?

a. Many mutations accumulated due to high exposure to UV radiation, creating many new kinds of organisms.

Incorrect. Chances are the mutations induced by UV light typically result in thymine dimers, but they are not associated with gene duplication and are not likely to be associated with the origin of new phyla.

b. Reproductive isolation was nearly nonexistent; many "species" interbred to form hybrids that went on to become new species.

Incorrect. Even if true, this does not account for the origin of new body plans.

c. New genes appeared in many different organisms through a mechanism that has not been identified. These are associated with new body plans.

Incorrect. Biologists actually do have a good idea of where new genes come from.

d. Several duplications of the homeotic genes that control major body plans apparently arose about 540 million years ago, creating new body plans and appendage configurations.

Correct. The homeotic genes are major regulators of development and so are likely to be implicated in the evolution of new body plans. Gene duplications would provide a second "copy" of information that natural selection could act upon to generate new body plans.

11. Why are gene duplications, such as those in the *Hox* loci, often associated with evolutionary divergence?

HINT: What evolutionary opportunity becomes available with the evolution of an extra copy of a gene?

a. When there is only one copy of a gene, natural selection may purge a mutation, preventing it from evolving a new function. With a second copy, selection may be relaxed on that one copy, because the first copy is producing all necessary gene products, and mutations conferring new properties may accumulate in the second copy.

Correct. Having an extra copy of a gene allows an organism to retain the function with one copy, but to "experiment" through mutations with the second copy.

b. Two copies of a gene mean twice as much gene product; as a result, rate limitations are relaxed and the organism can evolve a new body plan.

Incorrect. This is potentially a factor, but it is not obvious how more of a gene product would cause speciation.

c. Gene duplications arise in response to natural selection for diversification within a lineage. When a new species needs a new gene to adapt to a novel environment, it can produce a gene duplication to enable its adaptation.

Incorrect. Gene duplications, like other types of mutation, are chance events. Species are not able to develop a trait based on "need."

d. Gene duplications arise through hybridization of two species, giving rise to a new species; the combined genome carries two copies of a gene instead of one.

Incorrect. In some cases this is true, but it would be the hybridization that created the new species, and two copies of the gene, through allopolyploidy (Chapter 25), not a gene duplication event.

12. Which of the following events best illustrates an adaptive radiation?
HINT: Consider the pattern of speciation associated with adaptive radiations.
a. A fishless lake is colonized by a single fish species, which over a few thousand years gives rise to several species, each with a series of unique feeding adaptations.
Correct. This describes the situation in the African Rift lakes, where cichlid fishes have undergone a spectacular radiation, after a single colonization event, over the last 12,000 years.
b. A small group of tree-dwelling lizards of a single species migrates to an uninhabited, treeless island and adapts to use the open grassland habitat.
Incorrect. This is simple adaptation within a species; this scenario does not result in multiple lineages exploiting many habitats from a single colonization event.
c. A population of a cricket species takes up residence in a cave. Over many generations, the cave crickets eventually lose their eyes, like many other cave-dwelling animals.
Incorrect. This is a case of adaptation resulting in convergent evolution, the loss of eyes.
d. A colonizing species of fruit fly takes up residence on a new continent and displaces two closely related native species.
Incorrect. Here we see simple ecological displacement, but not speciation.

13. In the study of *Anolis* lizards that colonized various Caribbean islands, similar habitats and ecological types were found on Hispaniola and Jamaica. What observation suggested that adaptive radiations occur in response to habitat availability and the absence of competitors?

HINT: Think about the interpretation of the phylogenies in Figure 26.16.

a. Different islands were initially colonized by different species that differed in habitat preference, but in both cases subsequent speciation produced a range of ecological specialists occupying similar habitat niches. The phylogeny for each island was unique, but species evolved having similar sets of adaptations for each habitat.

Correct. The pattern is that each island ended up with a unique set of species, but those species had convergent adaptations for life in a particular habitat.

b. The first colonists on every island were always the same species, a twig-dwelling specialist. However, in every case, that species gave rise to the same set of other species that specialized on different habitats. The phylogeny for each island had the same root and the same pattern of speciation.

Incorrect. Each island had a different colonist that was initially adapted to a specific habitat.

c. Each island was initially colonized by a different species that occupied its preferred habitat. Subsequent colonizing species were successful only if they could use an unoccupied habitat type. The phylogeny for each island was the same throughout the region because no evolution occurred, only colonization.

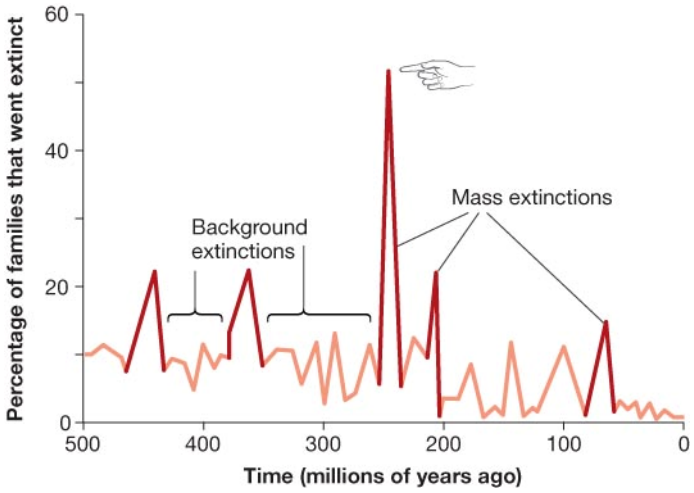
Incorrect. The anoles found on a given island all shared a common ancestor; however, on each island, that ancestor was different. The interpretation is that the ancestral species was the only colonist on the island.

d. Each island was colonized by a different species initially, and that species underwent a radiation, giving rise to new species that occupied different habitat types. There was no similarity, however, in the adaptations from one island to another. The phylogeny for each island was completely unique and totally unlike that of any other island.

Incorrect. Each island has a similar set of anoles with morphological adaptations to a similar set of habitats; however, the species and their pattern of relationships are different on each island.

14. Why are morphological innovations often associated with adaptive radiations?
HINT: What characteristics of habitats promote adaptive radiation?
a. Morphological innovations often allow a species to replace competitors.
Incorrect. This may be the case, but it does not address why innovations may cause speciation.
b. Morphological innovations can open up new adaptive options that allow a species to colonize an underused resource.
Correct. Normally, competition for limited resources limits the success of variants; a key innovation creates a new resource and allows variants able to exploit that resource time to diverge before competition becomes too intense.
c. Morphological innovations disrupt natural selection, forcing species to find new adaptations.
Incorrect. Morphological innovations form the basis for new adaptations, and species do not "find" new adaptations.
d. Morphological innovations prevent adaptive radiations most of the time.
Incorrect. Morphological innovations allow adaptive radiations. Morphological innovation provides raw material for natural selection to act upon so organisms can exploit new habitats and radiate in new environments.

15. This figure shows the pattern of extinction of families over the last 550 million years. What is the most likely reason that a similar dataset at the species level has not been compiled?
HINT: What are the limitations of using the fossil record to trace species?



a. Paleontologists just don't have the time to count up species over that time period.
Incorrect. Many fossils are not of entire organisms. For some, classification can only occur to the family level.
b. Species are difficult to identify in the fossil record; for example, the shells of two different species of mollusks that are preserved in the fossil record may look identical and so would be considered a single fossil "species."
Correct. Recall that biological species are defined by patterns of interbreeding; many biological species have similar morphologies but do not interbreed. The differences in behavior, physiology, and morphology that define such species are not preserved in the fossil record.
c. Species do not go extinct in the fossil record as often as families do, so one would not notice the pattern of mass extinctions if one were just counting species.
Incorrect. Families are groups of species; for a family to go extinct, all of the species within that family would have to go extinct.
d. Families are a more basic unit of evolutionary change than species, and hence are a more appropriate subject for paleontological study.
Incorrect. Families are a taxonomic convenience and nothing more. The species is a fundamental unit of evolution.

16. Which of the following statements represents an important contrast between background extinctions and mass extinctions?
HINT: What effect does adaptation have on extinction?
a. Background extinctions occur only sporadically, whereas mass extinctions happen on a regular, periodic basis.
Incorrect. Background extinctions happen all the time; efforts to detect periodicity in mass extinctions have not been successful.
b. Background extinctions are caused by rapid changes in the environment, whereas mass extinctions occur primarily in response to biological competition.
Incorrect. Background extinctions may be due to environmental changes or to competition, but mass extinctions are almost always associated with dramatic environmental changes.
c. During mass extinctions, adaptations for survival and competition make little difference in the likelihood of extinction, whereas the opposite is true of background extinctions.
Correct. Adaptations that make an animal a better forager or a plant a better competitor for space are unlikely to be of any benefit when an asteroid hits the Earth and causes continent-wide fires that destroy most habitats.
d. Mass extinctions, such as the Cretaceous-Tertiary (K-T) event, tend to take out large-bodied organisms, whereas smaller organisms tend to be removed by background extinction.
Incorrect. Although there are reasons to think that large-bodied organisms might be more susceptible to extinction, the data do not support this contention.

17. Which of the following events has been associated with the extinction of the dinosaurs at the end of the Cretaceous 65 million years ago?
HINT: What caused the massive environmental change that precipitated the K-T event?
a. A worldwide change in climate caused by increased carbon dioxide in the atmosphere led to melting of the ice caps and dramatic changes in sea level.
Incorrect. A change in carbon dioxide level is often associated with global climate change, but this is not the cause of the K-T extinction.
b. An outbreak of a highly pathogenic virus occurred, against which reptiles had no defense but to which mammals were apparently immune.
Incorrect. An imaginative choice, but mass extinctions are caused by environmental changes, not biotic challenges.
c. An asteroid impact caused fires, acid rain, and a massive dust cloud that blocked sunlight for some time, causing rapid global cooling and low plant productivity.
Correct. The asteroid hypothesis was viewed as outlandish at first, but many separate lines of evidence support it.
d. An outbreak of global volcanic activity occurred that both directly, through eruption of magma, and indirectly, through ash clouds blocking the sun, caused massive mortality in plants and animals
Incorrect. Volcanic activity could cause dramatic environmental change, but it was not the primary cause of the K-T event.

18. Which of the following statements best represents current thinking about the rise of the mammals after the K-T extinction?

HINT: What were mammals like before the extinction, and how did they change in the millennia following the event?

a. Mammalian diversity increased dramatically prior to the impact, but the population sizes of every species remained small until after the dinosaurs were extinct.

Incorrect. Prior to the extinction, the only mammals were small shrewlike creatures.

b. Mammals were inherently better competitors than the dinosaurs; the K-T impact simply speeded up the replacement, which was already well under way.

Incorrect. Mammalian populations were held in check by the dinosaurs for thousands of years prior to the extinction.

c. By chance, the K-T impact caused extinction of the dinosaurs but did not greatly affect the small, nocturnal, scavenging mammals. The release from competition allowed the mammals to diversify.

Correct. Mass extinctions open up habitat by taking out competitors. Which species evolve to fill that habitat seems to be largely a chance event

d. Both mammals and dinosaurs survived the asteroid, but the mammals were much better adapted to the new environments created by the impact and therefore underwent adaptive radiation.

Incorrect. The data suggest that mammals were lucky and that chance, not adaptation, explains their radiation.

19. Which of the following events did *not* take place during the biotic recovery from the K-T extinctions?

HINT: How did patterns of diversity change after the event?

a. Many woody and flowering plant species were lost in the K-T event and were replaced by a radiation of fern species.

Incorrect. This statement is true; the fossil record shows a dramatic global increase in the number and diversity of fern species and a drop in angiosperm diversity following the K-T event.

b. Mammals survived and radiated after the K-T event; all major orders appeared within 5 to 10 million years, replacing the dinosaurs and marine reptiles.

Incorrect. This statement is true; mammals took over the niches emptied by the loss of the dinosaurs.

c. All large-bodied reptiles died out in the extinction and were replaced by smaller-bodied species of dinosaurs and crocodiles.

Correct. This statement is false. Both large and small dinosaur species died out, whereas large-bodied crocodiles and alligators survived.

d. Many marine invertebrates, such as clams and snails, were greatly reduced in diversity by the K-T event; new species took 4–8 million years to evolve and replace the extinct species.

Incorrect. This statement is true; speciation leading to recovery of species diversity takes a long time following a mass extinction.