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CHAPTER 1: Adaptation by Natural Selection

MULTIPLE CHOICE

1. Darwin originally went to school to become a _____ but ended up at _____ and after graduation studied _____.
   a. doctor; Cambridge; natural history
   b. ship's captain; Portsmouth navy yard; sailing
   c. preacher; University of Edinburgh; religion
   d. doctor; Harvard University; genetics

   ANS: A DIF: Moderate REF: Darwin's Theory of Adaptation
   OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Remembering

2. While on the Galápagos, Darwin observed variation among finches. These observations
   a. helped lead Dárwin to move away from the concept of species as unchanging entities.
   b. caused Darwin to assert that the ability of a population to expand is infinite.
   c. confused Darwin, but he was later informed by the Grants, who were experts on birds, what he was seeing.
   d. led to Darwin's formulation of the theory of natural selection, which he published while still in the Galápagos.

   ANS: A DIF: Moderate REF: Darwin's Theory of Adaptation
   OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Remembering

3. Adaptations are defined as the components of an individual organism that
   a. allow it to survive and reproduce.
   b. allow it to evolve more rapidly.
   c. occur by random chance alone.
   d. absolutely never change.

   ANS: A DIF: Moderate REF: Darwin's Theory of Adaptation
   OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Remembering

4. What is the significance of the human eye in the history of research on evolution?
   a. William Paley proved that since the human eye was clearly designed for seeing, it was evidence for a heavenly designer.
   b. Human eyes are far more advanced than the eyes of other mammals and are an example of rapid, recent evolution.
   c. Differences between human eyes and other animals' eyes are explained as different adaptations shaped by natural selection.
   d. Since the human eye is made of soft tissue, and has no fossil record, the study of the eye does not inform evolutionary thinking.

   ANS: C DIF: Moderate REF: Explaining Adaptation before Darwin
   OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Applying

5. Influential nineteenth-century scientists like Charles Darwin concluded that the complex adaptations we see in plants and animals are problematic and require a special explanation because
   a. a divine creator designed them.
   b. it is very unlikely that they arose by random chance alone.
   c. they occur in most plants and animals.

d. they have no real function.

ANS: B DIF: Easy REF: Explaining Adaptation before Darwin
OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Understanding

6. Charles Darwin is known for his revolutionary argument that
   a. plants and animals are not designed by God and do not change over time.
   b. plants and animals change slowly over time.
   c. fossil plants and animals changed, but existing plants and animals do not.
   d. plants and animals are created by chance and then evolve through divine intervention.

   ANS: B DIF: Easy REF: Darwin's Theory of Adaptation
   OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Remembering

7. A key observation that Charles Darwin incorporated into his theory of adaptation by natural selection was that
   a. any given environment can support only a certain number of individuals.
   b. adaptations appear to arise fully formed every now and then, as a key driver of evolution.
   c. individuals within a species tend to cooperate for the survival of the species.
   d. no matter how limiting the resources in a given environment are, individuals can always find a way to survive.

   ANS: A DIF: Moderate REF: Darwin's Theory of Adaptation
   OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
   MSC: Remembering

8. Charles Darwin, when developing his theory of adaptation by natural selection, incorporated the observation that
   a. offspring are adapted to avoid resembling their parents in order to avoid mate confusion.
   b. offspring tend to resemble their parents.
   c. all competition between individuals within a species is over mates.
   d. variation in offspring is shaped by the behavior of the parents during their lifetimes.

   ANS: B DIF: Moderate REF: Darwin's Theory of Adaptation
   OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
   MSC: Remembering

9. Which of the following postulates makes up Darwin's theory of adaptation?
   a. The total resources in a given environment tends to expand as the number of individuals using those resources increases.
   b. Only noninherited variation has a long-term impact on evolutionary change.
   c. Regardless of variation in parents, genetic mixing makes offspring very similar to each other across a species.
   d. Individuals vary in ways that sometimes affect survival or reproduction.

   ANS: D DIF: Moderate REF: Darwin's Theory of Adaptation
   OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
   MSC: Remembering

10. For natural selection to occur, variation must exist. This is true because without variation
    a. there is no way for change to occur between generations.
    b. the one trait that exists is always advantageous, and change is not necessary.
    c. there is no competition among individuals.

d. traits are never inherited by offspring.

ANS: A DIF: Difficult REF: Darwin's Theory of Adaptation
OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
MSC: Understanding

11. Even though natural selection was named after the artificial selection that plant and animal breeders use, it really refers to the
    a. survival of the physically fit.
    b. reproduction of traits from generation to generation.
    c. selective retention of variation in a population.
    d. variable ability of species to survive and reproduce.

ANS: C DIF: Difficult REF: Darwin's Theory of Adaptation
OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
MSC: Understanding

12. During 1976 on the Galápagos Island of Daphne Major, Peter and Rosemary Grant found evidence of natural selection by adaptation when they observed that
    a. finches with shallow beaks were less likely to survive and reproduce than finches with deep beaks.
    b. finch beak size had no effect on survival rates.
    c. many more small seeds were available for the finches to eat.
    d. more finches with deep beaks died than finches with shallow beaks.

ANS: A DIF: Moderate REF: Darwin's Theory of Adaptation
OBJ: D. Explain why natural selection can produce change or cause species to remain the same over time. MSC: Applying

13. Why did natural selection act on the medium ground finch on Daphne Major?
    a. Birds with medium beak sizes experienced higher mortality.
    b. A drought changed the environment where the finches lived.
    c. Offspring of finches with small beaks did not survive the juvenile period.
    d. The population reached equilibrium.

ANS: B DIF: Moderate REF: Darwin's Theory of Adaptation
OBJ: D. Explain why natural selection can produce change or cause species to remain the same over time. MSC: Applying

14. Which of the following is an example of directional selection on size?
    a. Both small and large individuals survive.
    b. Only large individuals survive.
    c. The proportion of small and large individuals remains the same.
    d. Neither small nor large individuals survive.

ANS: B DIF: Easy REF: Darwin's Theory of Adaptation
OBJ: D. Explain why natural selection can produce change or cause species to remain the same over time. MSC: Applying

15. Which of the following is an example of stabilizing selection on size?
    a. Both small and large individuals survive, but medium individuals die off.
    b. Only large individuals survive, thus stabilizing the species in the next generation.
    c. The proportion of small and large individuals remains the same.
    d. Large and small individuals are selected against to a similar degree.

ANS: D DIF: Moderate REF: Darwin's Theory of Adaptation

OBJ: D. Explain why natural selection can produce change or cause species to remain the same over time. MSC: Applying

16. When the Daphne Major finches reach a point where the costs of having a beak larger than average size outweigh the benefits, beak size will begin to stay the same, and the population will achieve a(n) _____ state.
    a. direction
    b. trend
    c. equilibrium
    d. drift

    ANS: C DIF: Easy REF: Darwin's Theory of Adaptation
    OBJ: D. Explain why natural selection can produce change or cause species to remain the same over time. MSC: Remembering

17. If a population is in stasis, then
    a. the population is in its natural state.
    b. natural selection is not acting on the population.
    c. the most common type of individual is consistently favored by stabilizing selection.
    d. the most common type of individual is consistently favored by disruptive selection.

    ANS: C DIF: Moderate REF: Darwin's Theory of Adaptation
    OBJ: D. Explain why natural selection can produce change or cause species to remain the same over time. MSC: Understanding

18. After a drought, a scientist collects dead birds and finds that most of the individuals that did not survive to adulthood have either small or large beaks. Given this pattern, how do you expect selection is likely acting on the population?
    a. Selection will not change the mean beak size.
    b. Selection will make the mean beak size in the population smaller.
    c. Selection will make the mean beak size in the population larger.
    d. The entire population will die out.

    ANS: A DIF: Moderate REF: Darwin's Theory of Adaptation
    OBJ: D. Explain why natural selection can produce change or cause species to remain the same over time. MSC: Analyzing

19. Species are populations of
    a. unrelated individuals that are best adapted to their environment.
    b. individuals that maintain a fixed set of characteristics.
    c. individuals that may vary and that may or may not change through time.
    d. individuals that cannot be modified or go extinct.

    ANS: C DIF: Moderate REF: Darwin's Theory of Adaptation
    OBJ: F. Assess why natural selection usually works at the level of the individual, not at the level of the group or species. MSC: Understanding

20. Natural selection usually acts upon and produces adaptations at the level of the
    a. gene.
    b. individual.
    c. group.
    d. species.

    ANS: B DIF: Easy REF: Darwin's Theory of Adaptation
    OBJ: F. Assess why natural selection usually works at the level of the individual, not at the level of the group or species. MSC: Remembering

21. Natural selection generally produces adaptations that are
    a. harmful to both individuals and groups.

b. helpful to individuals but harmful to groups.
c. harmful to individuals but helpful to groups.
d. not successful unless every member of the group survives and reproduces.

ANS: B DIF: Moderate REF: Darwin's Theory of Adaptation
OBJ: F. Assess why natural selection usually works at the level of the individual, not at the level of the group or species. MSC: Understanding

22. Fecundity is defined as the ability of a(n)
a. population to have variation.
b. individual to compete for resources.
c. individual to survive to adulthood.
d. individual to produce offspring.

ANS: D DIF: Easy REF: Darwin's Theory of Adaptation
OBJ: F. Assess why natural selection usually works at the level of the individual, not at the level of the group or species. MSC: Remembering

23. When all females have high fecundity, a population can be driven to extinction. This occurs because of
a. natural selection.
b. convergence.
c. blending inheritance.
d. continuous variation.

ANS: A DIF: Difficult REF: Darwin's Theory of Adaptation
OBJ: F. Assess why natural selection usually works at the level of the individual, not at the level of the group or species. MSC: Applying

24. Despite its detrimental nature, cannibalism can evolve in a wide range of species by natural selection if
a. cannibalistic groups are ferocious enough to scare predators away.
b. individuals who cannibalize have higher fitness than those who do not.
c. natural selection is always immoral.
d. cannibalistic individuals kill off the rest of their population and have no mates left with which to reproduce.

ANS: B DIF: Moderate REF: Darwin's Theory of Adaptation
OBJ: F. Assess why natural selection usually works at the level of the individual, not at the level of the group or species. MSC: Analyzing

25. It is difficult to imagine how only part of an adaptation could function, but Darwin explained this. How would he answer the question, "What good is 5% of an eye?"
a. Once an organism has the first 5% of an adaptation, the rest will quickly evolve.
b. Five percent of an eye is always better than a full eye since it is easier to grow. The difficulty is in explaining fully formed eyes.
c. Since variation is random, we don't expect to see more than about 5% of an eye in any species.
d. Five percent of an eye, perhaps a simple light-sensitive spot, is often better than having no eye at all.

ANS: D DIF: Moderate REF: Darwin's Theory of Adaptation
OBJ: F. Assess why natural selection usually works at the level of the individual, not at the level of the group or species. MSC: Analyzing

26. Continuous variation occurs when
a. no real variation is apparent between forms.
b. variants come in distinct forms.
c. variants come in a smooth distribution from one extreme to another.
d. only one extreme variant exists.

ANS: C DIF: Easy REF: The Evolution of Complex Adaptations

OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Remembering

27. Discontinuous variation occurs when
    a. no real variation is apparent between forms.
    b. variants come in distinct forms.
    c. variants come in a smooth distribution from one extreme to another.
    d. only one extreme variant exists.

    ANS: B DIF: Easy REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Remembering

28. Achondroplasia is a genetic adaptation that causes affected individuals to be much shorter than other people. This adaptation is an example of
    a. convergence.
    b. gene flow.
    c. discontinuous variation.
    d. outbreeding.

    ANS: C DIF: Easy REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Remembering

29. Many of Darwin's contemporaries argued that discontinuous variation is the reason that complex traits evolve. However, Darwin reasoned that discontinuous traits do not play a major role because
    a. since they lack continuity, discontinuous traits would be rapidly selected against.
    b. discontinuous traits, although common, are rarely inherited.
    c. the probability of several novel mutations that work together arising at once is so high that there are mechanisms that immediately destroy them.
    d. the probability of several novel mutations that work together to make a functioning trait arising all at once is almost zero.

    ANS: D DIF: Moderate REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

30. Discontinuous variation is unlikely to lead to new species because
    a. rapid changes are never found in the fossil record.
    b. complex adaptations require multiple simultaneous mutations that work together.
    c. selection cannot act on discontinuous variation.
    d. it allows for only small incremental changes.

    ANS: B DIF: Moderate REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

31. Darwin believed that when a new species arises, it does so by
    a. immediately achieving a distinct, discontinuous form.
    b. achieving perfection through natural selection in the first try.
    c. gradually accumulating small changes.
    d. following God's will.

    ANS: C DIF: Moderate REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

32. How do complex adaptations usually evolve?
    a. by a single large step due to a highly adaptive mutation
    b. by many small steps, but only when each is an improvement over the last step
    c. by many small steps, but only when each has a minimal effect on fitness
    d. by single large steps, but only when natural selection is strong

    ANS: B DIF: Moderate REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

33. Which of the following was likely the first adaptation to occur during the evolution of the human eye?
    a. a protective cover and internal structures
    b. a depression where information about light and light movement is collected
    c. a simple, light-sensitive photo receptor
    d. neural machinery for image processing

    ANS: C DIF: Difficult REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Analyzing

34. A complex adaptation like the human eye exists in its present form because
    a. past organisms evolved and utilized a transitional form of the modern eye.
    b. extreme forms of variation allowed it to evolve in a single jump.
    c. it was created by a chance mutation.
    d. many organisms have eyes.

    ANS: A DIF: Easy REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Applying

35. Convergent evolution occurs
    a. when all members of a species become more similar.
    b. as a result of stabilizing selection.
    c. when natural selection produces similar adaptations independently in different species.
    d. when individuals have equal fitness.

    ANS: C DIF: Moderate REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Remembering

36. Convergent evolution provides evidence that complex adaptations are not a matter of mere coincidence because
    a. evolution always occurs in very different ways.
    b. the same process of evolution can occur independently in very different species.
    c. the process of evolution is biologically determined and not flexible.
    d. no two species ever end up with similar traits.

    ANS: B DIF: Easy REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

37. The body morphology of the marsupial wolf of Tasmania is very similar to that of the placental wolves of Eurasia. This is an example of
    a. blending inheritance.
    b. convergent evolution.
    c. essentialism.
    d. continuous variation.

ANS: B DIF: Moderate REF: The Evolution of Complex Adaptations
OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Applying

38. A South American marsupial cat and a North American placental cat existed 10,000 years ago and shared a tree shrew–like common ancestor about 120 million years before that. Both of these animals evolved a saber-toothed adaptation. What does the presence of this complex trait mean?
    a. Tree shrews have saber teeth.
    b. The same complex adaptation evolved twice independently.
    c. Saber teeth are very common.
    d. North American and South American cat populations were interbreeding.

    ANS: B DIF: Difficult REF: The Evolution of Complex Adaptations
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Analyzing

39. How fast does evolution by natural selection take place?
    a. It is such a slow process that a single adaptation requires millions of years.
    b. It is so slow that it cannot be seen in the fossil record.
    c. It is fast enough that several new species can evolve from other forms in a few million years.
    d. It is so rapid that new species often evolve in a matter of decades.

    ANS: C DIF: Moderate REF: Rates of Evolutionary Change
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

40. Using the rate of change that the Grants observed in the medium ground finch, and assuming a selection event only occurs once every century, how rapidly would you predict that a species of finch like the large ground finch could evolve?
    a. It would take millions of years for only beak size to evolve.
    b. The medium ground finch could evolve into the large ground finch in 20 years.
    c. Natural selection could produce a new species of ground finch in a few thousand years.
    d. Because selection generally pushes constantly in one direction, a new species of ground finch could evolve in a single century.

    ANS: C DIF: Difficult REF: Rates of Evolutionary Change
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Applying

41. What does the Grants' study of medium ground finches tell us about evolution by means of natural selection?
    a. New species cannot form.
    b. A new species can form only when natural selection operates consistently in one direction for a few million years.
    c. Evolution can change only single traits within a species.
    d. New species normally take thousands to millions of years to arise because natural selection pressures operate in fits and starts.

    ANS: D DIF: Moderate REF: Rates of Evolutionary Change
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

42. What is unique about evolution by means of artificial selection (for example, domestic dogs)?
    a. It takes longer because there is no selection pressure.

b. Stabilizing selection commonly occurs.
c. Selection pressure occurs in fits and starts.
d. It can occur rapidly because selection pressure is constant.

ANS: D DIF: Easy REF: Rates of Evolutionary Change
OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

43. Which of the following is an example of selection producing complex evolutionary changes in a remarkably short period of time?
a. Using artificial selection, people intentionally caused dairy cattle, which varied in their milk production, to produce the maximum amount genetically possible.
b. A study of fish from the genus *Poeciliopsis* shows that short generation times allowed three different types of placenta to evolve in less than 2.4 million years.
c. Richard Dawkins was able to produce most of one of Shakespeare's sonnets using only trained monkeys and small candies as rewards.
d. The fossil record indicates that the human brain took 2 million years to double in size.

ANS: B DIF: Moderate REF: Rates of Evolutionary Change
OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Applying

44. Theoretical studies of the evolution of the eye revealed that
a. approximately 1,800 incremental changes of 1% could allow the eye to evolve from a single photo receptor to a spherical gradient lens.
b. it would take more than 10 million years for the eye to evolve in an aquatic species with a short generation time.
c. it was built by artificial selection in no more than 500 years.
d. after 1,800 changes, an eye would still be in the photo receptor phase.

ANS: A DIF: Difficult REF: Rates of Evolutionary Change
OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Remembering

45. One of the things that Darwin had difficulty explaining was how inheritance worked. Why was inheritance so difficult for Darwin?
a. The prevailing theory of inheritance was based on random mating.
b. The prevailing theory of inheritance was incompatible with the maintenance of variation.
c. The prevailing theory of inheritance implied that variation was not inherited from parents.
d. The prevailing theory of inheritance implied that too much variation exists for natural selection to operate.

ANS: B DIF: Easy REF: Darwin's Difficulties Explaining Variation
OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
MSC: Understanding

46. Which of the following is an example of blending inheritance?
a. A tall individual marries a short individual, and all of their offspring are intermediate in height.
b. All of the domestic breeds of dogs that are alive today are descended from a wolf ancestor.
c. Offspring from two unrelated species of cats have similar saber-toothed adaptations.
d. A red-headed individual marries an individual with black hair, and all of their offspring have black hair.

ANS: A DIF: Moderate REF: Darwin's Difficulties Explaining Variation

OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
MSC: Applying

47. Darwin could not convince many of his contemporaries of natural selection because
    a. Darwin thought that discontinuous variation was important for evolution.
    b. they believed in genetic inheritance.
    c. Darwin believed in blending inheritance, which reduces variation.
    d. they believed that traits were inherited from only one parent.

    ANS: C DIF: Moderate REF: Darwin's Difficulties Explaining Variation
    OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
    MSC: Remembering

48. Which of the following provides an example of why Jenkin called Darwin's ideas incompatible?
    a. Tall and short individuals are not able to breed with one another because they look different.
    b. If tall and short individuals breed with one another, all of their offspring will be short, and variation will disappear.
    c. If tall and short individuals breed with one another, all of their offspring will be tall, and variation will disappear.
    d. If tall and short individuals breed with one another, all offspring will be intermediate in height, and variation will disappear.

    ANS: D DIF: Moderate REF: The Evolution of Complex Adaptations
    OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
    MSC: Applying

49. Based on blending inheritance, which Darwin and his contemporaries believed, if a finch with a large beak depth mates with a finch with a small beak depth, then the offspring will have beaks with _____ depth.
    a. small
    b. medium
    c. large
    d. random

    ANS: B DIF: Moderate REF: Darwin's Difficulties Explaining Variation
    OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
    MSC: Applying

50. Why was natural selection difficult for Darwin to fully explain?
    a. Natural selection tends to reduce variation.
    b. Natural selection acts by removing only variants of the highest fitness.
    c. Natural selection acts by removing only variants of the lowest fitness.
    d. Natural selection does not actually remove any variants in real life.

    ANS: A DIF: Moderate REF: Darwin's Difficulties Explaining Variation
    OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
    MSC: Remembering

51. Most of Darwin's contemporaries believed
    a. species evolved, and new species arise by discontinuous variation.
    b. species evolved, and new species arise by small steps.
    c. natural selection explained much of the variation we see in nature, even though selection actually reduces variation.
    d. new species only arise by artificial selection.

    ANS: A DIF: Moderate REF: Darwin's Difficulties Explaining Variation

OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Remembering

52. Why did Darwin's contemporaries believe that natural selection could not move a population beyond its initial range of variation?
    a. because selection cannot permanently change a population
    b. because selection does not produce new variants
    c. because selection can only act to stabilize variants
    d. because small increments of change are highly advantageous and cannot be bred out through blending

    ANS: B DIF: Moderate REF: Darwin's Difficulties Explaining Variation
    OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Remembering

53. What is the difference between a fish eye and a mammal's eye, and in what way might this be explained?
    a. The fish eye has only one light-bending element; the mammal eye has two. This is because the human eye is more advanced than the fish eye.
    b. Fish eyes have multiple light-bending elements in order to see in water, while mammal eyes have only one.
    c. The fish eye has only one light-bending element; the mammal eye has two. This allows fish to have more light-gathering ability and mammals to have greater distance vision.
    d. Mammals have two light-bending elements, while the fish eye makes use of the surrounding water to act as a second "lens," so it can have only one light-bending element.

    ANS: C DIF: Difficult REF: Explaining Adaptation before Darwin
    OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

54. Darwin proposed that three conditions of life underlie the reason that species change through time adaptively. They are as follows:
    a. Populations grow beyond what the environment can handle; organisms vary; and some of the variation is genetic.
    b. Populations are adapted to avoid growing beyond what the environment can handle; organisms vary; and some of the variation is genetic.
    c. Populations maintain equilibrium; species are immutable; and most of the individuals in a species are the same.
    d. Populations grow beyond what the environment can handle; organisms vary; and variation that is acquired in life can be passed on genetically.

    ANS: A DIF: Moderate REF: Darwin's Theory of Adaptation
    OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Understanding

55. Darwin understood that
    a. populations of organisms will grow until they are checked by the limited supply of resources in the environment.
    b. populations of organisms will grow until individuals stop reproducing in order to control population.
    c. populations of organisms maintain a steady state, just below the maximum allowed by the environment.
    d. as soon as a population has filled its environment, it will evolve into a new species.

    ANS: A DIF: Moderate REF: Darwin's Theory of Adaptation

OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Applying

ESSAY

1. Charles Darwin did not always agree with his contemporaries. What were some of his revolutionary ideas? Describe how these ideas were different from the mainstream beliefs of the nineteenth century. Lastly, discuss why we are still talking about these ideas today.

   ANS:
   To answer this question, students must be able to discuss how Darwin helped develop the following ideas:

   a. Before Darwin, there was no mechanistic explanation for how organisms adapt to their environmental circumstances.
   b. Before Darwin, most people believed that adaptations were the result of divine creation.
   c. Before Darwin, naturalists upheld that populations changed rapidly rather than gradually.

   DIF: Moderate REF: Explaining Adaptation before Darwin | Darwin's Theory of Adaptation
   OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Understanding | Evaluating

2. What three conditions did Darwin conclude are necessary for natural selection to take place? Support your answer by either providing a real example from the chapter or coming up with a reasonable hypothetical example of how evolution operates. Be sure to discuss the role of the environment in your answer.

   ANS:
   To answer this question, students must be able to reiterate and understand the three postulates presented in the chapter:

   a. The ability of a population to expand is infinite, but the ability of any environment to support that population is finite. This results in competition for resources.
   b. Organisms within populations vary, and this variation affects the ability of an individual to survive and reproduce. This is because some variants will be more successful when competing for limited resources. Such variants will have greater reproductive success, and more of their offspring will have the opportunity to survive to reproductive age.
   c. This variation is transmitted from parents to offspring. The resulting offspring share the traits that make them more competitive in the current environment.

   The example that is most thoroughly explained in the chapter is the effect of drought on the finches (*Geospiza fortis*) of the island of Daphne Major in the Galápagos. In this example, drought resulted in larger, harder-to-open seeds and favored larger, deeper beaks. It is important to note that a change in the environment determined the direction of selection. Those individuals with larger beaks were able to survive to reproductive age. Overall, their survival and reproduction resulted in an increased mean beak depth within the population.

   DIF: Easy REF: Darwin's Theory of Adaptation
   OBJ: B. Explain how competition, variation, and heritability lead to evolution by natural selection.
   MSC: Applying

3. Under what circumstances is selection not directional? Illustrate your answer with at least one example. Use your answer to explain why scientists must understand stabilizing selection in order to accurately describe evolutionary processes.

ANS:
Dramatic changes in the environment (like drought) create the selective pressures that favor certain traits. However, it is important to keep in mind that environmental change is random and can quickly shift back and forth. The chapter discusses how drought in the Galápagos selected for deep-beaked finches. Because drought events are sporadic, the cost of having a deep beak could quickly outweigh its benefits. To develop a deep beak, a juvenile must acquire more food resources. Because of this cost, selection can act both for and against this trait, resulting in an equilibrium state for deep beaks. They will remain in this state until an environmental pressure (like drought) acts heavily in favor of deep beaks again. Recognizing this sort of stabilizing selection is important to scientists because it explains why some complex traits take a long time to evolve whereas others arise quickly.

DIF: Moderate REF: Darwin's Theory of Adaptation
OBJ: D. Explain why natural selection can produce change or cause species to remain the same over time. MSC: Applying

4. Do adaptations always benefit the individual, group, population, or species? Why or why not? Use real or hypothetical examples to illustrate your answer.

ANS:
To answer this question, students need to understand the level at which natural selection operates. Because natural selection acts on the individual, it is the individual's reproductive success that is affected in a positive manner. What is beneficial to an individual is not necessarily beneficial to the group, population, or species. This is especially true because each individual is competing against other members of the group, population, or species for access to resources. As such, some individuals in a group may experience reduced reproductive success. The main example presented in the chapter is high-fecundity females. These females experience increased reproductive success but inflate the size of their population to the point that it exceeds the carrying capacity.

DIF: Moderate REF: Darwin's Theory of Adaptation
OBJ: F. Assess why natural selection usually works at the level of the individual, not at the level of the group or species. MSC: Applying

5. How does natural selection produce complex, functionally integrated adaptations like the human eye?

ANS:
Natural selection produces complex, functionally integrated adaptations like the human eye through the accumulation of small changes. These changes need only be slight improvements over the previous variants. If selection is cumulative, then it takes only a limited number of steps for a complex adaptation to arise. The chapter discusses the limited number of steps that it takes for a simple, light-sensitive photo receptor to evolve into a functional eye. First, the depression where the photo receptor is located becomes deeper. This step allows for the perception of directionality. As the depression becomes deeper, directional perception is enhanced. Eventually, the organism can perceive images. The last step in the process is the addition of complex neural elaborations, a cover, and, eventually, a lens.

DIF: Difficult REF: The Evolution of Complex Adaptations
OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

6. What is convergent evolution? Using examples from your text, explain why convergent evolution provides evidence that complex adaptations do not occur by random chance alone.

ANS:

Students should recognize that convergent evolution occurs when distantly related taxa exhibit similar adaptations, while the common ancestor of those taxa lacked that feature. Because these organisms do not share a recent common ancestor, convergent adaptations are not a result of shared history. Instead, convergent adaptations are the result of similar selective pressures (that is, environmental conditions), which make similar traits advantageous. Therefore, convergent traits are nonrandomly favored by natural selection in both circumstances. The chapter provides the following examples of convergent evolution: (1) placental and marsupial wolves and cats and (2) the development of eyes in fish, mollusks, and other aquatic organisms.

DIF: Moderate REF: The Evolution of Complex Adaptations
OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Applying

7. When does selection produce evolutionary change relatively quickly? Provide at least two pieces of evidence to support your answer.

ANS:
Selection can produce evolutionary change relatively quickly if (1) a strong directional selection pressure acts constantly on a population, (2) artificial selection pressures act constantly on a population, or (3) generation times are short. The chapter provides several examples of rapid evolutionary change, including the following:

- Beak size in Galápagos finches: Medium finches could reach the body size of large finches in 30–46 years if a directional selection pressure continued to act on the population over that entire time period.
- Red deer on Jersey Island: Because of rising sea levels, red deer were isolated on Jersey Island for 6,000 years. During this time, they underwent a reduction in body size.
- Domestication of dogs: Dogs have been artificially selected for 15,000 years or more. However, some domestic dog breeds developed over the course of hundreds of years.
- Fish within the genus *Poeciliopsis*: Three lineages within this genus independently evolved a system of "placentation" over the course of 2.4 million years.
- A simulation of the evolution of the eye: This simulation only required approximately 1,800 steps. It shows that in species with short generation times, complex traits can arise over brief periods of time.
- The theoretical example of illiterate monkeys typing "Methinks it is like a weasel": the cumulative changes that occurred and were favored took only 43 trials. If we consider that each trial represents a generation, even long generation times can lead to speedy evolutionary change.

DIF: Moderate REF: Rates of Evolutionary Change
OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Applying

8. How has an understanding of artificial selection aided our current comprehension of natural selection?

ANS:
Darwin drew from principles of artificial selection to explain natural selection. Artificial selection occurs when humans decide what characteristics of a domesticated animal or plant are desirable (for example, black spots on a white dog in Dalmatians, long ears in basset hounds, large kernels on corn, or large bodies in cows). Humans select for these desired characteristics by frequently mating the individuals that have them. As a result, the number of offspring with desirable characteristics increases. Artificial selection is useful in explaining natural selection because the principles are similar. With natural selection, the environment determines which characteristics are preferred, individuals with those preferred characteristics mate and produce more offspring, and preferred characteristics become more widely represented.

DIF: Moderate REF: Rates of Evolutionary Change
OBJ: E. Describe how natural selection can produce very complex adaptations such as the human eye. MSC: Understanding

9. What major difficulty did Darwin have with his theory of natural selection?

ANS:
Darwin had difficulty reconciling his theory of natural selection with the postulate that organisms within a population vary, and this variation affects the ability of individuals to survive and reproduce:

- Darwin could not explain how variation is maintained. He adopted the idea of blending inheritance because Gregor Mendel had not yet completed his work on genetic recombination.
- The results of blending inheritance contradict the postulate that organisms within a population vary. Ultimately, when characteristics are blended, all offspring take on a blended form, and variation is reduced. The results of natural selection also contradict the postulate that organisms within a population vary. When natural selection reduces the prevalence of unfavorable traits, variation is either greatly reduced or eliminated. If variation does not exist, then there can be no further selection. This last sentence is a crucial concept.
- Darwin could not explain how new variation arose.

DIF: Easy REF: Darwin's Difficulties Explaining Variation
OBJ: A. Describe why our modern understanding of the diversity of life is based on the ideas of Charles Darwin. MSC: Remembering