Chapter 02: Early Evolutionary Ideas and Darwin s Insight

MULTIPLE CHOICE

1. Rather than rely on creation myths to explain the natural world, early Greek philosophers were among the first to
   a. quantify the inheritance of genetic traits through sexual reproduction.
   b. describe the heavenly bodies as gods or personages.
   c. develop a philosophy of a natural world driven by physical laws used to explain the world around them.
   d. understand that our planet is much, much older than previously determined.

   ANS: C DIF: Easy REF: 2.1
   OBJ: 2.1.a. Explain the importance of the early Greeks' shift away from super natural explanations of natural phenomena. MSC: Remembering

2. Early Greek philosophers failed to exploit one of the greatest advantages of methodological naturalism, which is the ability to
   a. test hypotheses through observation and sometimes manipulation.
   b. formulate principles of science without having facts obtained through experimentation.
   c. formulate hypotheses without verification.
   d. interpret supernatural observations.

   ANS: A DIF: Moderate REF: 2.1
   OBJ: 2.1.a. Explain the importance of the early Greeks' shift away from super natural explanations of natural phenomena. MSC: Remembering

3. Unlike the other Greek philosophers before him, Aristotle made the connection between the use of logic in hypothesis formation and
   a. the influence of supernatural forces.
   b. the development of a philosophy of a natural world driven by physical laws.
   c. the significance of testing those hypotheses.
   d. explaining natural phenomena using celestial formations.

   ANS: C DIF: Moderate REF: 2.1
   OBJ: 2.1.a. Explain the importance of the early Greeks' shift away from super natural explanations of natural phenomena. MSC: Remembering

4. After Aristotle, one advance in scientific methodology came through the use of logic. This allowed thinkers to
   a. formulate and test hypotheses without evidence collected through observations of the natural world.
   b. move carefully from facts to general principles by applying logical and mathematical laws.
   c. bypass data collection in the formulation of new ideas.
   d. review and critique the work of others through the application of logic.

   ANS: B DIF: Moderate REF: 2.1
   OBJ: 2.1.a. Explain the importance of the early Greeks' shift away from super natural explanations of natural phenomena. MSC: Understanding

5. What is a scientific hypothesis?
   a. a way to describe nature
   b. an educated guess
   c. a conclusion regarding observations of the natural world

d. an explanation of a phenomenon based on natural processes

ANS: D DIF: Easy REF: 2.1
OBJ: 2.1.b. Define "hypothesis" and explain why hypothesis testing is critical in the development of new scientific theories. MSC: Remembering

6. Even if philosophers accept and study the importance of biological change, a full theory of evolution by natural selection cannot exist without
   a. understanding the sorts of changes that have taken place.
   b. recognizing the significance of testing one's hypotheses.
   c. an understanding of the vast expanses of time over which some changes take place.
   d. realizing that some species go extinct.

   ANS: C DIF: Easy REF: 2.2
   OBJ: 2.2.a. Explain how perceptions of the geologic age of Earth changed and why this was critical to Darwin's theory of evolution. MSC: Remembering

7. In an early attempt to apply mathematical principles, Archbishop James Ussher calculated the age of Earth based on the Old Testament from the Christian Bible. He estimated that the creation of the world took place
   a. on exactly October 23, 4004 B.C.
   b. within a century of 3900 B.C.
   c. between 75,000 and 2–3 million years ago
   d. an inconceivably long time ago.

   ANS: A DIF: Easy REF: 2.2
   OBJ: 2.2.a. Explain how perceptions of the geologic age of Earth changed and why this was critical to Darwin's theory of evolution. MSC: Remembering

8. James Hutton, a Scottish geologist and naturalist, argued that the alignment of rock strata, the geological processes of erosion and sedimentation, and fossil data suggested that the world was created
   a. on exactly October 23, 4004 B.C.
   b. in 3998 B.C.
   c. an inconceivably long time ago.
   d. between 75,000 and 2–3 million years ago.

   ANS: C DIF: Easy REF: 2.2
   OBJ: 2.2.a. Explain how perceptions of the geologic age of Earth changed and why this was critical to Darwin's theory of evolution. MSC: Remembering

9. Building on the ideas first proposed by James Hutton, Charles Lyell aimed to explain Earth's geological features using an approach known as uniformitarianism, which hypothesized that
   a. large-scale geological events abruptly shaped the surface of Earth.
   b. all geological processes operate in a sporadic manner and vary in their rate of change.
   c. observable geological processes rapidly change Earth's surface, greatly impacting organisms living in the region of change.
   d. the same geological processes currently observable operate over very long periods of time in a slow and gradual manner.

   ANS: D DIF: Easy REF: 2.2
   OBJ: 2.2.b. Compare and contrast uniformitarianism and catastrophism.
   MSC: Understanding

10. As opposed to uniformitarianism, the approach known as catastrophism explains that Earth's geological features are a result of

a. sudden, cataclysmic, and large-scale geological events.
b. processes that were slow and gradual, but vastly different from what is currently observable.
c. the same geological processes currently observable, which operate over very long periods of time in a slow and gradual manner.
d. a combination of unknown processes, possibly as a result of supernatural forces, and known forces that have been measured and quantified.

ANS: A DIF: Easy REF: 2.2
OBJ: 2.2.b. Compare and contrast uniformitarianism and catastrophism.
MSC: Understanding

11. How did Charles Lyell explain Earth's geological features?

a. Lyell said Earth's features were a result of supernatural forces creating Earth in the same shape and form he observed and that it had not changed over time.
b. Lyell said Earth's features were a result of cataclysmic events, like volcano eruptions and earthquakes, which resulted in rapid reshaping of Earth's features.
c. Lyell said Earth's features were a result of the same processes currently observable, which have occurred over very long periods of time in a slow, gradual manner.
d. Lyell said Earth's features were a result of the same processes currently observable, which have occurred over relatively short periods of time punctuated by periods of rapid change.

ANS: C DIF: Moderate REF: 2.2
OBJ: 2.2.c. Describe how Lyell's work was a crucial influence on Darwin as he developed his theory of evolution by natural selection.. Describe how Lyell's work was a crucial influence on Darwin as he developed his theory of evolution by natural selection. MSC: Understanding

12. Greek philosophers, including Aristotle, developed a keen appreciation for the study of natural history. Which of the following contributions did Aristotle make that marked the birth of the field of natural history?
a. distinguishing among 500 species of birds, mammals, and fishes
b. proposing a taxonomy of nature—a classification system of life
c. his books, *Physics* and *Natural History of Animals*
d. an evolutionary theory of biology that recognized change over time

ANS: C DIF: Easy REF: 2.3
OBJ: 2.1.a. Explain the importance of the early Greeks' shift away from super natural explanations of natural phenomena. MSC: Remembering

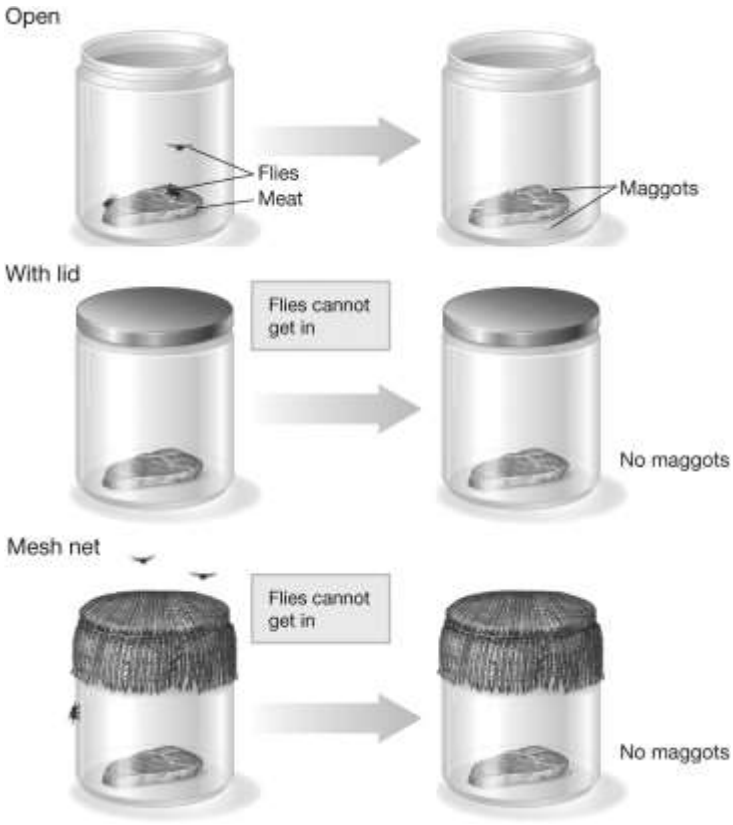
13. Which of the following examples best illustrates the concept of spontaneous generation?
    a. Some sea anemones spontaneously bud newly developed young from their outer skin.
    b. During flooding, frogs spontaneously arise from mud.
    c. When a dried bean is moistened and kept moist, it spontaneously transforms into a bean sprout.
    d. Maggots spontaneously transform in to flies.

    ANS: B DIF: Moderate REF: 2.3
    OBJ: 2.3.a. Define "spontaneous generation" and understand why Redi's experiment provided evidence that this does not occur. MSC: Applying

14. Which of the following concepts was a commonality of early Greek theories on how life started and how diverse living forms arose?
    a. divine creation
    b. spontaneous generation
    c. uniformitarianism
    d. inheritance of acquired characteristics

    ANS: B DIF: Easy REF: 2.3
    OBJ: 2.3.a. Define "spontaneous generation" and understand why Redi's experiment provided evidence that this does not occur. MSC: Remembering

15. Francesco Redi's experiment, illustrated in the figure below, addressed the question of whether flies spontaneously generated from meat carcasses. Which of the following statements regarding this experiment is true?



    a. Meat in jars covered with mesh and meat in open jars both developed maggots.
    b. Meat in neither open nor lidded jars developed maggots.
    c. Meat in jars with an open lid developed maggots, while meat in lidded and mesh-covered

jars did not develop maggots.
d. Maggots developed in all the meat tested, regardless of whether the jar was covered.

ANS: C DIF: Moderate REF: 2.3
OBJ: 2.3.a. Define "spontaneous generation" and understand why Redi's experiment provided evidence that this does not occur. MSC: Applying

16. Charles Darwin's grandfather Erasmus Darwin, an English physician and philosopher, was one of the first to propose an idea of evolutionary change. What did he propose?
    a. He proposed that all life developed from what he called a single living filament, which was modified in endless ways over millions of years.
    b. He proposed that diversity was a result of modification and that traits acquired during the lifetime of an organism were passed down to its progeny resulting in increased diversity.
    c. He proposed that life arose multiple times through spontaneous formation and that diversity arose from the influence of the different environments where formation occurred.
    d. He proposed that each branch of life, or kingdom, resulted from accumulation of change, originating with different filaments for each kingdom.

    ANS: A DIF: Moderate REF: 2.3
    OBJ: 2.3.b. Describe the struggle for existence. MSC: Understanding

17. Despite his insights, Erasmus Darwin came up short of a full-blown theory of evolution by natural selection because he
    a. failed to understand the scope of geologic time.
    b. rejected the work of Mendel, which quantified the genetic inheritance of traits from parents to offspring.
    c. failed to connect the struggle for existence to the evolutionary changes that would result from such a struggle.
    d. rejected Lamarck's theory of inheritance, which correctly explained how traits are passed on to offspring and contribute to increasing diversity.

    ANS: C DIF: Moderate REF: 2.3
    OBJ: 2.3.b. Describe the struggle for existence. MSC: Understanding

18. Robert Chambers, a Scottish geologist and author of *Vestiges of the Natural History of Creation*, is often overlooked for recognizing which critical aspect of evolutionary biology?
    a. the theory of the inheritance of acquired characteristics
    b. the enormous influence of the environment on evolutionary change
    c. thinking of evolution in terms of populations and not individuals
    d. a theory for why new species came into being

    ANS: B DIF: Moderate REF: 2.3
    OBJ: 2.3.b. Describe the struggle for existence. MSC: Understanding

19. Aristotle's *scala naturae* was a linear classification system that influenced Western thinkers for thousands of years (some would argue it still does). In this classification system, each species occupied a link in a chain that became increasingly complex. *Scala naturae* did not recognize the shared degrees of complexity among organisms or the ability of species and taxa to change. Which of the following is an example demonstrating that organisms have shared degrees of complexity?
    a. A population of fish become separated by a new dam structure; after 20 years the fish living in the shallower, warmer water at the base of the dam can no longer mate with the fish living in the deeper, colder water behind the dam.
    b. A virus infects a population of black-footed ferrets and kills 60% of the animals. The remaining 20% are immune to the disease; the offspring of this group are 90% immune to the virus.

c. Due to earlier spring warming resulting from climate change, temperate woodland wildflowers bloom an average of nine days earlier.
d. *Nostoc* (a cyanobacterium) and *Helianthus* (sunflowers, a vascular plant) have chloroplasts and conduct photosynthesis.

ANS: D DIF: Difficult REF: 2.3
OBJ: 2.3.c. Explain why Aristotle's scala naturae did not encompass shared degrees of complexity and the potential to change. MSC: Applying

20. Jean-Baptiste Lamarck hypothesized that changes acquired during the lifetime of an individual organism, as a result of adapting to its environment, are passed on to progeny. Why was this incorrect but still important?
a. Acquired traits are heritable, but not part of the genetic makeup of the organisms. Lamarck's idea was important because he was the first to propose a process for evolutionary change.
b. Acquired traits are not heritable, but Lamarck's idea was important because he verified Darwin's process of natural selection.
c. Acquired traits are not heritable, but Lamarck's idea was important because he was the first to propose a process for evolutionary change.
d. Acquired traits are heritable, and Lamarck's idea was important because he proved Darwin's idea of variational evolution was incorrect.

ANS: C DIF: Moderate REF: 2.4
OBJ: 2.4.b. Explain Lamarck's theory on inheritance of acquired characteristics and understand why acquired characteristics are not inherited. MSC: Understanding

21. What were Charles Darwin's two fundamental insights about the process of evolution?
a. The environment selects on variation in the traits of individual organisms, and all species have descended from one or a few common ancestors.
b. All species have descended from one or a few common ancestors, and populations, not individuals, evolve over time.
c. The environment selects on variation in the traits of individual organisms, and organisms are in a constant struggle for existence.
d. Populations, not individuals, evolve over time, and evolutionary change is connected to environmental fit.

ANS: A DIF: Moderate REF: 2.5
OBJ: 2.5.a. Describe the two fundamental insights of Darwin's theory presented in On the Origin of Species. MSC: Remembering

22. To explain how varieties were on the path to becoming new species, Charles Darwin introduced the concept of
a. descent with modification.
b. transformational change.
c. variational change
d. spontaneous change.

ANS: A DIF: Moderate REF: 2.5
OBJ: 2.5.a. Describe the two fundamental insights of Darwin's theory presented in On the Origin of Species. MSC: Understanding

23. What was one of the ideas that separated Charles Darwin's *On the Origin of Species* as a complete, scientific explanation for evolution when compared to all other previous attempts?
a. Darwin provided copious evidence that each species was completely unique.
b. Darwin recognized that species can occasionally spontaneously arise.
c. Darwin articulated a mechanistic explanation for change in species over time and the match between organisms and the environment.

d. Darwin explained that each domain of living organisms has independent ancestry that diversified over much longer periods of time than previously recognized.

ANS: C DIF: Moderate REF: 2.5
OBJ: 2.5.b. Explain why On the Origin of Species is considered to be the first "complete" theory of evolution by natural selection. MSC: Understanding

24. Which scientist of those listed below was a contemporary of Charles Darwin and also developed a complete theory of evolution by natural selection?
a. Jean-Baptiste Lamarck
b. Alfred Russel Wallace
c. Aristotle
d. William Paley

ANS: B DIF: Easy REF: 2.5
OBJ: 2.5.c. Describe the role of Alfred Russel Wallace in Darwin's decision to finally publish On the Origin of Species. MSC: Remembering

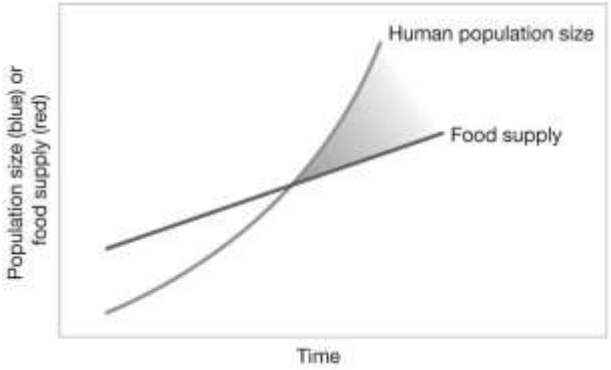
25. The primary difference(s) between the processes of natural selection and artificial selection is/are
a. the mechanism for descent and modification.
b. that artificial selection focuses on nonheritable traits while natural selection focuses on heritable traits.
c. the selective agent and the period of time over which change occurs.
d. that artificial selection focuses on creating varieties while natural selection only produces species.

ANS: C DIF: Difficult REF: 2.5
OBJ: 2.5.d. Distinguish between artificial and natural selection.
MSC: Understanding

26. A local horticulturalist works with her city to design and plant flower gardens in a targeted effort to provide habitat for bees that are experiencing severe population declines. While making observations on a particular plant species she is considering for these plantings, she observes that the deep purple flowers are visited much more frequently by bees than the light pink flowers (this particular species produces flowers with shades of color varying from deep purple to light pink). She decides to collect seeds from the deep purple plants and then germinates and grows the deep purple flowered plants in her greenhouse before transplanting them to some of the city gardens. The different colors of flowers indicate different _____ of plants and the horticulturalists is demonstrating _____ selection.
a. varieties; natural
b. species; artificial
c. species; natural
d. varieties; artificial

ANS: D DIF: Moderate REF: 2.6
OBJ: 2.6.b. Understand how Darwin applied Malthus' theories on geometrical growth in human populations to plant and animal populations. MSC: Applying

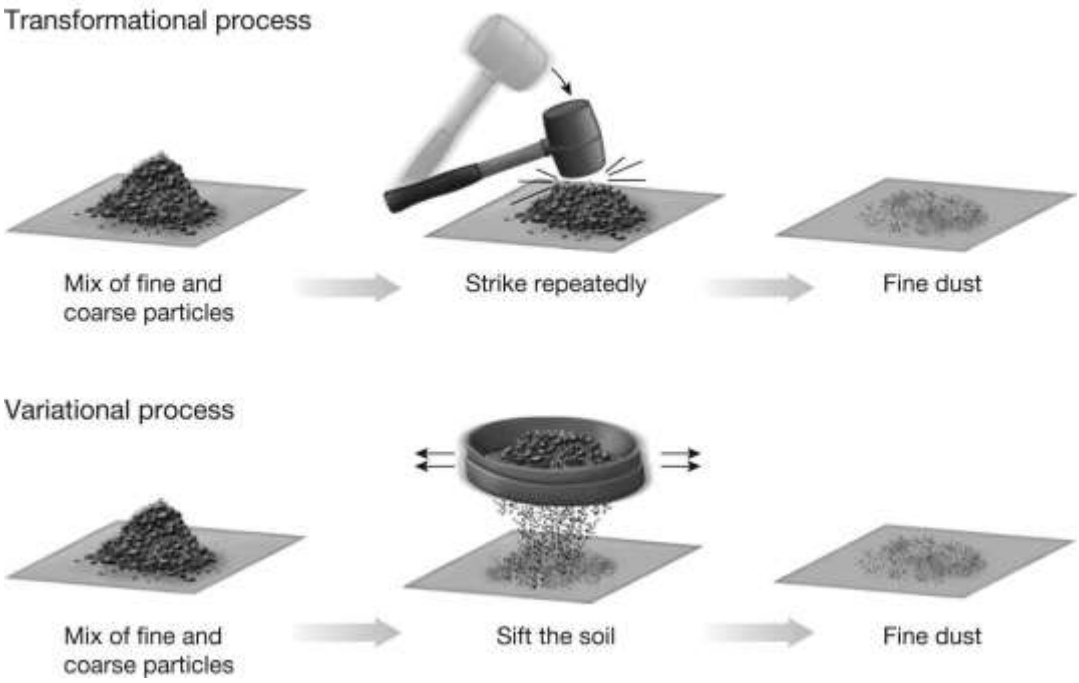
27. Thomas Malthus, a political economist, showed that the human population would outstrip available resources unless kept in check by other factors such as famine, war, and disease. How did Charles Darwin apply this principle to his theory of evolution by natural selection?



a. Darwin used this as a contrast to plant and animal populations, which live in balance with their available resources.
b. Darwin used this to illustrate that because food supply remains relatively the same, plant and animal populations show little variation in size.
c. Darwin realized this also applied to plant and animal populations, and this struggle for existence was the opportunity for natural selection to act on differences within populations.
d. Darwin used this to illustrate that as food supplies increase, populations increase.

ANS: C DIF: Difficult REF: 2.6
OBJ: 2.6.b. Understand how Darwin applied Malthus' theories on geometrical growth in human populations to plant and animal populations. MSC: Applying

28. What was one of the two primary distinctions between a "transformational" process of evolution, as described Jean-Baptiste Lamarck, and the "variational" process of evolution, as described by Charles Darwin?



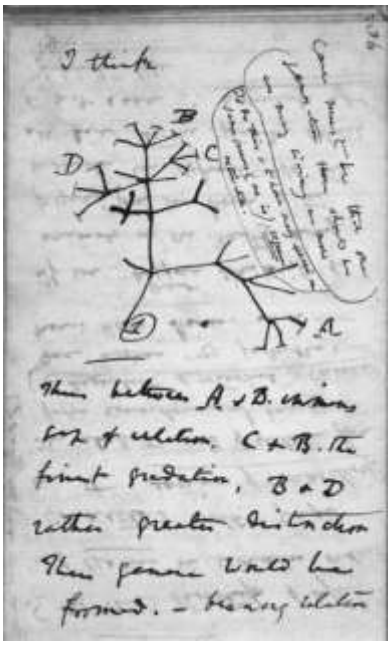
a. Darwin thought change was a result of differences acquired by members of a group and that the changes were acquired during the lifetime of the individuals and passed down to their offspring. Lamarck thought these differences already existed and were not acquired during the lifetime of the members of the group.
b. Lamarck thought change was a result of a supernatural process acting on differences

already existing in a group and those processes sorted on that existing variation.

c. Lamarck thought change was a result of differences acquired by members of a group and that the changes were acquired during the lifetime of the individual and passed down to their offspring. Darwin thought those differences already existed and were not acquired during the lifetime of the members of the group.
d. Darwin thought change was a result of a supernatural process acting on differences already existing in a group and those processes sorted on that variation.

ANS: C DIF: Moderate REF: 2.6
OBJ: 2.6.c. Compare and contrast a transformational process of evolutionary change and a variational process of evolutionary change. MSC: Understanding

29.



Charles Darwin's tree of life metaphor was used to describe

a. how a common ancestral species has diverged into many species, with the various branches illustrating the relationships among species and groups of species.
b. how each kingdom can be represented by a tree that branches as it grows, with each branch representing new lineages and species within the kingdom.
c. diversity among living organisms as multiple, independent branches unrelated to each other.
d. genetic variation within populations that led to diversification and, ultimately, speciation.

ANS: A DIF: Difficult REF: 2.7
OBJ: 2.7.a. Understand and explain what Darwin meant by the "tree of life" metaphor.
MSC: Understanding

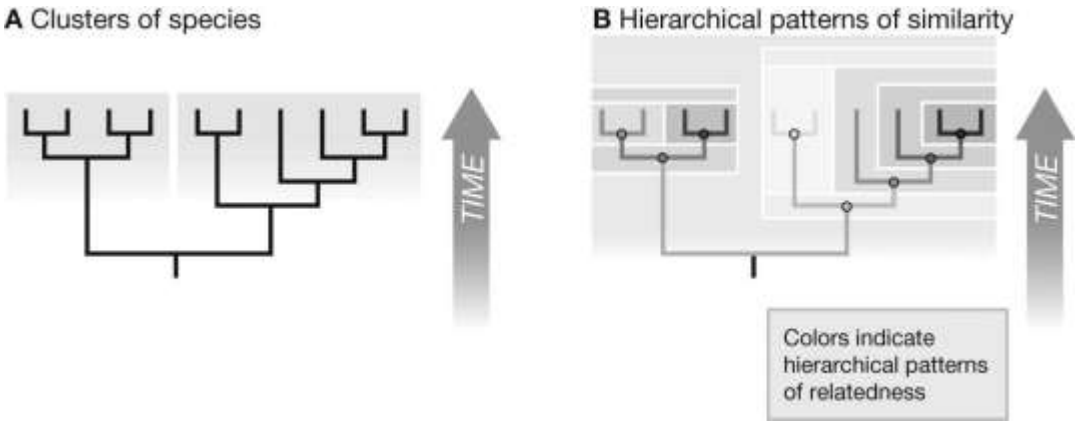
30. What was the primary difference in how Jean-Baptiste Lamarck and Charles Darwin explained the evolution of new species and the relationship among species?

a. Lamarck viewed all species as interrelated due to common ancestry and believed that species sharing a more recent common ancestor more closely resemble each other; Darwin viewed relationships among species as linear chains, with groups independent of the other.
b. Lamarck viewed lineages of species as not arising independently, but with each group related to the other; Darwin viewed all species as interrelated due to common ancestry and believed that species sharing a more recent common ancestor more closely resemble each other.

c. Lamarck viewed relationships among species as linear chains, with each group independent of the other; Darwin viewed all species as interrelated due to common ancestry and believed that species sharing a more recent common ancestor more closely resemble each other.
d. Lamarck and Darwin both viewed all species as having common ancestry, but Lamarck viewed each group as evolving independently while Darwin viewed groups as interrelated and having evolved from a single common ancestor.

ANS: C DIF: Difficult REF: 2.7
OBJ: 2.7.b. Understand how the hypothesis of common ancestry with branching descent explains the hierarchical patterns of similarity in nature. MSC: Understanding

31. In the figure, the hierarchically arrayed groups indicated by the shaded gray boxes are called _____ by modern evolutionary systematists.



a. nodes
b. species
c. genera
d. clades

ANS: D DIF: Easy REF: 2.7
OBJ: 2.7.b. Understand how the hypothesis of common ancestry with branching descent explains the hierarchical patterns of similarity in nature. MSC: Remembering

32. Both Alfred Russel Wallace and Charles Darwin traveled extensively and were struck by the strong patterns they observed in the geographic distribution of nature's diversity. Which of the following observations did Wallace make?
a. Similar species tended to be widely separated geographically and occupied widely different times in geologic history.
b. Geographic features seem to play an important role in the clustering of dissimilar, nonrelated species; these dissimilar species clustered together in time and space.
c. Geographic features seem to play an important role in the clustering of similar, closely related species, and these similar species clustered together in time and space.
d. Wallace observed that geographic distribution of species appeared to be random, correlating with the random nature of genetic mutation.

ANS: C DIF: Moderate REF: 2.7
OBJ: 2.7.c. Describe how geographic correlations support the theory that each species arises only in a single time in a single place, by descent with modification. MSC: Understanding

33. While various religious leaders challenged almost all of Charles Darwin's major conclusions, how did the British scientific community react to his work?
a. All early experimental evolutionists agreed with Darwin's theory of evolution and the mechanism for evolutionary change by natural selection.

b. They almost universally accepted natural selection but rejected his theory of evolution.
c. The majority rejected his theory of evolution.
d. They almost universally accepted Darwin's theory of common ancestry but rejected his theory of natural selection.

ANS: D DIF: Moderate REF: 2.9
OBJ: 2.9.a. Explain how the scientific community reacted to Darwin's presentation of On the Origin of Species. MSC: Understanding

34. In the 1880s, experimental work by August Weisman demonstrated that traits acquired during a lifetime could not be inherited. This dealt a deathblow to previous theories of Lamarckian inheritance and left scientists with which possible scientific processes of evolution?
a. saltationism and slow-acting natural selection
b. creationism and spontaneous generation
c. creationism and saltationism
d. spontaneous generation and slow-acting natural selection

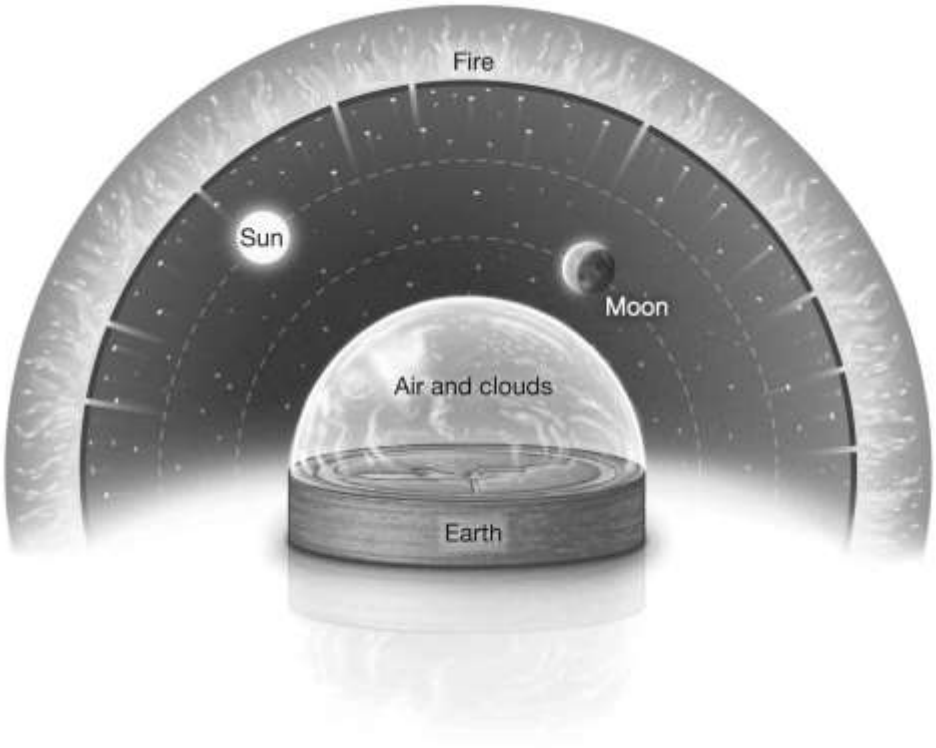
ANS: A DIF: Moderate REF: 2.9
OBJ: 2.9.b. Describe how the work of Weismann and Mendel contributed to the end of Lamarckian inheritance. MSC: Understanding

35. After the rediscovery in 1900 of Gregor Mendel's now-famous experiments from the 1850s and 1860s, evolutionary biologists viewed variation in two ways. What were these views and how were the differences eventually resolved?
a. Mendelians viewed inheritance as continuous while biometricians viewed inheritance as discrete. Scientists eventually learned inheritance operates in both ways, leading to the modern, evolutionary synthesis.
b. Mendelians viewed inheritance as discrete while biometricians viewed inheritance as continuous. Scientists eventually verified that inheritance acts in a discrete manner only, leading to the rejection of the blending theory.
c. Mendelians viewed inheritance as discrete while biometricians viewed inheritance as continuous. Scientists eventually learned inheritance operates in both ways, leading to the modern, evolutionary synthesis.
d. Mendelians viewed inheritance as continuous while biometricians viewed inheritance as discrete. Scientists eventually learned that inheritance is only continuous, verifying Darwin's theory of natural selection.

ANS: C DIF: Moderate REF: 2.9
OBJ: 2.9.c. Describe the role of genetics in the modern synthesis of the theory of evolution.
MSC: Applying

SHORT ANSWER

1. The Greek philosopher Anaximander (ca. 610–546 B.C.) provided a mechanistic rather than divine explanation of the celestial bodies, as illustrated in the figure. We now know the details were wrong. Explain why, given the state of knowledge during his lifetime, this was a conception of the universe that made sense and was a breakthrough.



ANS:
Answers will vary but should include the following: the mechanism works to explain the perceived motion of heavenly bodies around Earth, and the explanation is important because it is based on natural rather than supernatural phenomena.

DIF: Moderate REF: 2.1
OBJ: 2.1.a. Explain the importance of the early Greeks' shift away from super natural explanations of natural phenomena. MSC: Analyzing

2. The Greek philosopher Empedocles recognized that plant life preceded animal life. Xenophanes (570–470 B.C.) studied fossils in sedimentary rock and concluded that the rocks must have been under water at one time. Explain why these were important shifts in logical thinking.

ANS:
Answers will vary but should include the following: these ideas implied that the world had changed in significant ways over time, which is necessary for significant breakthroughs in the development of evolutionary thinking.

DIF: Difficult REF: 2.2
OBJ: 2.2.a. Explain how perceptions of the geologic age of Earth changed and why this was critical to Darwin's theory of evolution. MSC: Understanding

3. Explain and relate the two geological features shown in the figure, employing the principle of uniformitarianism put forth by Charles Lyell in 1830.

ANS:
Answers will vary but should indicate that uniformitarianism is the assumption that the processes that operate now are the same as those that have operated in the past; this can explain how massive canyons (right) form as the result of slow processes of erosion that occurred over millennia, which are equivalent to those illustrated in the left panel.

DIF: Moderate REF: 2.2
OBJ: 2.2.c. Describe how Lyell's work was a crucial influence on Darwin as he developed his theory of evolution by natural selection.. Describe how Lyell's work was a crucial influence on Darwin as he developed his theory of evolution by natural selection. MSC: Understanding

4. Charles Darwin read Charles Lyell's book, *Principles of Geology*, while serving as ship's naturalist on the *HMS Beagle.* Describe how Lyell's work influenced Darwin.

ANS:
Answers will vary but should include that prior to publishing *On the Origin of Species*, Darwin published three books on geology; Darwin's ideas on the gradual changes associated with evolution are biological interpretations of Lyell's uniformitarian ideas. By explaining Earth's dramatic geological features through uniformitarianism, Lyell conceived the world as changing across enormous expanses of time. This change in the perception of time was critical to understanding Darwin's theory of biological change over a scale of time much, much longer than previously understood.

DIF: Moderate REF: 2.2
OBJ: 2.2.c. Describe how Lyell's work was a crucial influence on Darwin as he developed his theory of evolution by natural selection.. Describe how Lyell's work was a crucial influence on Darwin as he developed his theory of evolution by natural selection. MSC: Understanding

5. Explain why the linear hierarchy of Aristotle's *scala naturae* is incompatible with Darwin's phylogenetic view of biological diversity.

ANS:
Answers will vary but should include the following: according to Aristotle's classification system, each species occupies a link in a chain of being, which lacks two critical concepts that were necessary for the development of evolutionary thinking—shared degrees of complexity and the potential to change or evolve.

DIF: Moderate REF: 2.3
OBJ: 2.3.c. Explain why Aristotle's scala naturae did not encompass shared degrees of complexity and the potential to change. MSC: Analyzing

6. The text presents several examples of the belief in spontaneous generation. Why do you think this theory persisted for thousands of years, until Charles Darwin's time, even after the experiments of Francesco Redi?

   ANS:
   Answers will vary but should include the difficulty in observing a clear parental source.

   DIF: Difficult REF: 2.3
   OBJ: 2.3.a. Define "spontaneous generation" and understand why Redi's experiment provided evidence that this does not occur. MSC: Evaluating

7. Describe the three important evolutionary ideas outlined by Patrick Matthew in his work *On Naval Timber and Arborculture*. How did Charles Darwin's work differ from Matthew's? Why has Matthew not received as much attention for his theories?

   ANS:
   Answers will vary but should include that Matthew said that resources are limited and only so many offspring can survive to the age of reproduction; individuals will differ in terms of traits that allow them to garner resources, and over time this will lead to organisms that are well adapted to their environments. Darwin presented a unified theory, while Matthew did not; Darwin discussed both natural selection and how it results in evolution, while Matthew only discussed natural selection. In addition, Matthew presented very little evidence, while Darwin presented voluminous evidence supporting his theory. Matthew's work was published in a book that was not read by scientists interested in biodiversity and most of his ideas on the subject were hidden in his notes and appendix.

   DIF: Difficult REF: 2.4
   OBJ: 2.4.c. Describe the three important evolutionary ideas outlined in Matthew's "circumstance-adaptive law." MSC: Evaluating

8. Identify the five major developments that led to the development of Charles Darwin's *On the Origin of Species*.

   ANS:
   Moving from supernatural explanations to methodological naturalism; from catastrophism to uniformitarianism; from logic to pure reason to observations, testing, and refutation; from an unchanging world to a world in flux; and moving away from the idea of spontaneous generation to the idea that species come from other, closely related species.

   DIF: Moderate REF: 2.4
   OBJ: 2.4.d. Summarize the five major developments that progressively led the way for Darwin's On the Origin of Species. MSC: Remembering

9. Write a short counter to William Paley's argument that as it is virtually impossible for a fully working watch to come into being simply by chance, it is just as impossible for even more complex living creatures to come into being without a fully conscious creator.

   ANS:

Answers will vary but should include that gradual changes occur over long periods of time; those changes can accumulate if they confer increases in fitness and organisms are naturally selected in terms of a good fit to their environment; thus, it is not "by chance" but rather by selection that complexity increases.

DIF: Difficult REF: 2.4
OBJ: 2.4.a. Understand why the metaphor of God as watchmaker was used to explain the fit of diverse species to their environment. MSC: Evaluating

10. In 1858 Charles Darwin received a manuscript from Alfred Russel Wallace in which Wallace proposed a theory very similar to his own. Darwin first presented his ideas in a joint paper with Wallace, which was read to the Linnaean Society, also in 1858. Why do you think history primarily associates Darwin's, not Wallace's, name with the theory of evolution?

ANS:
Answers will vary but should include that Wallace generously agreed that Darwin deserved primary credit considering the evidence he had gathered. There also is the possibility that a student has read outside of the text and may mention class and opportunity differences.

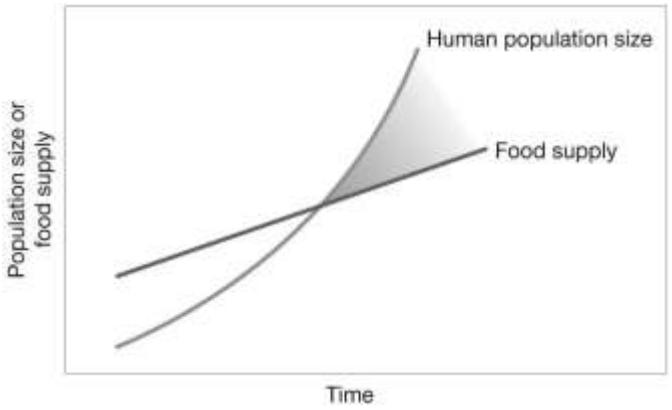
DIF: Moderate REF: 2.5
OBJ: 2.5.c. Describe the role of Alfred Russel Wallace in Darwin's decision to finally publish On the Origin of Species. MSC: Understanding

11. Why was it such a brilliant strategy for Charles Darwin to open *On the Origin of Species* with a discussion of artificial selection?

ANS:
Answers will vary but should include that most people in the 1850s were familiar with dog and pigeon breeding, which helped his readers to relate to the book and made his theory of change over time more believable and approachable to the average reader.

DIF: Moderate REF: 2.5
OBJ: 2.5.d. Distinguish between artificial and natural selection.
MSC: Applying

12. Give an explanation of the English economist Thomas Robert Malthus' argument, presented in the figure.

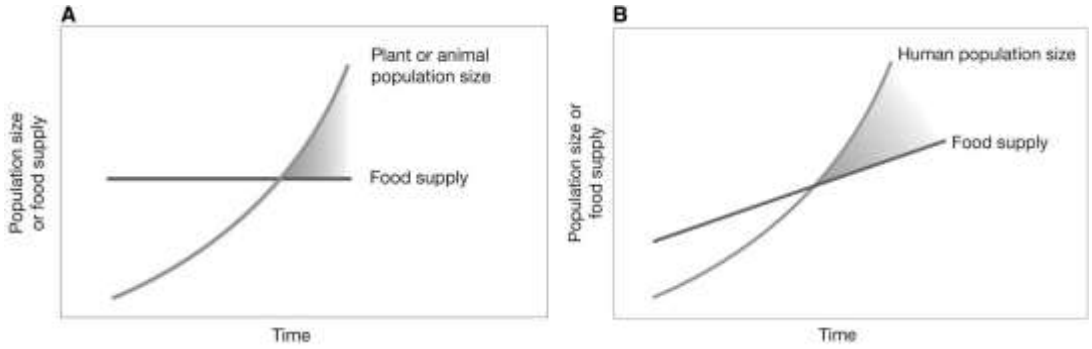


ANS:

Answers will vary but should include that Malthus brought attention to the fact that the human population grows geometrically in time, unless it is kept in check (war, famine, disease, etc.). He believed food supply, on the other hand, could only increase arithmetically. When human population growth outstrips food supply, famine or other checks on the population will result. Darwin believed this also applied to natural populations, where unchecked reproduction would rapidly outstrip available resources.

DIF: Moderate REF: 2.6
OBJ: 2.6.b. Understand how Darwin applied Malthus' theories on geometrical growth in human populations to plant and animal populations. MSC: Understanding

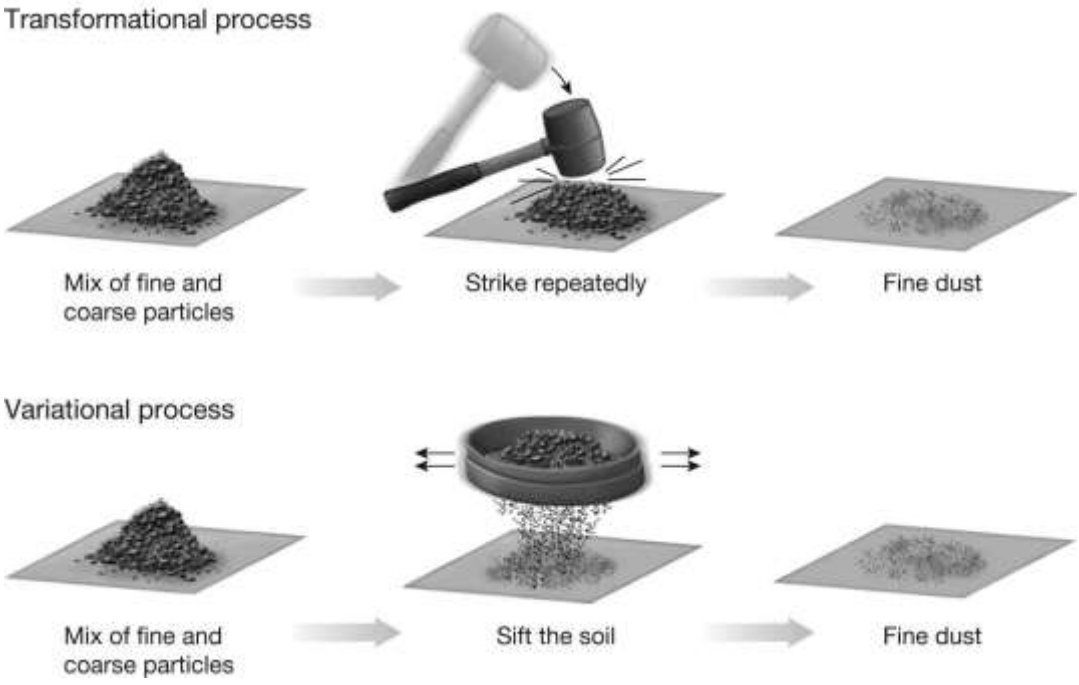
13. Compare Charles Darwin's adaptation of Thomas Malthus' argument to plants and animals in nature (Graph A) with the figure representing Malthus' original argument (Graph B).



ANS:
Answers will vary but should include the following: the food supply curve is flatter in Graph A than in Graph B, and in Graph B, the food supply curve also increases, illustrating the result of human innovation in food production.

DIF: Moderate REF: 2.6
OBJ: 2.6.b. Understand how Darwin applied Malthus' theories on geometrical growth in human populations to plant and animal populations. MSC: Analyzing

14. Before Charles Darwin, scientists such as Jean-Baptiste Lamarck envisioned evolutionary change as transformational—properties of an ensemble change because every member of the ensemble changes. Darwin's theory of evolutionary change was, by contrast, a variational one—the properties of an ensemble change because of the action of some sorting process acting on preexisting variation within the ensemble. Referring to the figure, describe the kind of sorting process that takes place (a) when we use artificial selection to change the characteristics of a breed of animals or plants and (b) when natural selection operates on a population.



ANS:
Answers will vary but should include the following: (a) For artificial selection, the sorting process is determined by the breeder, who makes choices about which individuals will breed. (b) For natural selection, the sorting process is determined by which variants survive and reproduce most successfully.

DIF: Difficult REF: 2.6
OBJ: 2.6.c. Compare and contrast a transformational process of evolutionary change and a variational process of evolutionary change. MSC: Applying

15. One of the challenges with which Charles Darwin was confronted about his theory was the fact that he could not explain how variation persisted in a population when his theory of natural selection appeared to continually reduce variation because only certain individuals survive and reproduce in a given environment. Why could he not explain it?

ANS:
At the time of publication of *On the Origin of Species*, biologists did not understand the basic principles of heredity. Even though Gregor Mendel had formulated his laws that paved the way for our modern understanding of genetics, his work was still largely unknown at this point in history. Without this information, Darwin could not explain why variation was not continually lost through blending inheritance.

DIF: Moderate REF: 2.8
OBJ: 2.8.a. Describe the three major challenges to Darwin's theory.
MSC: Understanding