Answer Key

SECTION 10.1. EARLY IDEAS ABOUT EVOLUTION
1. developed a classification system to group organisms by their similarities, that also reflects evolutionary relationships
2. suggested that species shared ancestors
3. contended that all living things were descended from a common ancestor and that more-complex forms of life arose from less-complex forms.
4. proposed that changes in physical characteristics could be inherited and were driven by environmental changes over time
5. they must be able to reproduce and have fertile offspring
6. Lamarck thought that greater use or disuse of a structure or organ would cause changes that could then be passed on to offspring.
7. different species could be produced with hybridization, showing that species can change
8. Catastrophism: the theory that natural disasters such as floods and volcanic eruptions have happened often during Earth’s long history. These events have shaped landforms and caused species to become extinct.
   Gradualism: the principle that changes observed in landforms resulted from slow changes over a long period of time.
   Uniformitarianism: the theory that the geologic processes that shape Earth are uniform through time.
9. fossils
10. evolution
11. catastrophism
12. uniformitarianism
13. Erasmus Darwin
14. Lamarck
15. Linnaeus
16. Buffon

SECTION 10.2. DARWIN’S OBSERVATIONS
1. interspecific variation
2. intraspecific variation
3. Galápagos Islands
4. that species may somehow be able to adapt to their surroundings
5. He thought modern animals might have some relationship to fossil forms
6. It would take much longer than 6000 years for the changes to occur between the fossil organisms he saw and their modern-day relatives.
7. Darwin saw that in geologic processes, great changes can occur slowly, over a long period of time. He extended this insight to the evolution of organisms.
8. There are differences in shell shape, the edges of the shells, the lengths of the tortoises necks, the lengths of their legs.
9. variation
10. adaptation
11. adaptation
12. variation
   Be Creative: First sketch should depict a bird with a strong, thick beak. Second sketch should depict a bird with a delicate-looking beak.
SECTION 10.3. THEORY OF NATURAL SELECTION
1. Darwin noticed breeders could produce a great amount of diversity in species.
2. If a trait is not heritable, it won’t be passed down to offspring.
3. The traits are selected only if they give advantages to individuals in their present environment.
4. Human populations would grow geometrically if resources were unlimited. Instead, disease and a limited food supply kept the population smaller.
5. overproduction
6. variation
7. adaptation
8. descent with modification
9. sketch should reflect variation in a population
10. sketch should reflect overproduction
11. sketch should reflect an adaptation
12. sketch should reflect descent with modification over generations
13. increase
14. decrease
15. artificial selection
16. natural selection
17. fitness
18. heritability
19. population

SECTION 10.4. EVIDENCE OF EVOLUTION
1. Fossils: More primitive fossil organisms are in older layers, with more complex forms found in upper layers.
2. Geography: Different ecosystems favor different traits and can establish separate populations that have a common ancestor.
3. Embryology: Embryos of very different organisms that develop similarly provide evidence of a common ancestor.
4. Anatomy: Homologous structures are features that are similar in structure but appear in different organisms and have different functions. They are evidence of a common ancestor.
5. These homologies provide evidence of descent from a common ancestor.
6. the tiny pelvic bones and hind limbs in many snakes, the wings of ostriches, and the human appendix
7. The ancestor of whales lived on land.
8. homologous structure
9. analogous structure
10. analogous structure
11. vestigial structure
12. homologous structure
13. analogous structure
14. vestigial structure

Sketch it Out: Students should match homologous structures directly between the two forelimbs.
SECTION 10. 5. EVOLUTIONARY BIOLOGY TODAY
1. most living things do not form into fossils after they die, and fossils have not been looked for in many areas of the world
2. Basilosaurus isis
3. They demonstrate the evolution of traits within groups as well as the common ancestors between groups.
4. The more related two organisms are, the more similar their DNA will be. Because there are thousands of genes in even simple organisms, DNA contains a huge amount of information on evolutionary history.
5. Pseudogenes no longer function but can change as they are carried along with functional DNA through generations. Similarities between pseudogenes must come from a common ancestor.
6. Homeobox genes control the development of specific structures. Similar homeobox gene clusters are evidence of a common ancestor.
7. Similarities of proteins across organisms can be revealed by molecular fingerprinting, and are evidence of a common ancestor.
8. The theory of natural selection combined with genetics
9. Comparisons of milk protein genes confirm the fossil evidence that modern-day whales descended from land mammals
10. The basic principles of evolution are used in all the fields of biology
11. The study of fossils can provide new information and support current hypotheses about how evolution occurs.

Sketch It Out: Answers should reflect knowledge that Pakicetus lived on land and Durodon lived in water.

SECTION 11.1. GENETIC VARIATION WITHIN POPULATIONS
1. genetic variation
2. A wide range of phenotypes increases the likelihood that some individuals will have traits that allow them to survive in new environmental conditions.
3. gene pool
4. the combined alleles of all individuals in a population
5. allele frequency
6. dividing the number of times an allele occurs by the total number of alleles
7. Can produce new alleles. Mutations in reproductive cells can be passed on to offspring.
8. Forms new genetic combinations that are passed on to offspring.
9. New genetic information can be introduced into populations when species mate with other closely-related species.
10. it contains all of the genes/alleles of all the individuals in a population
11. how common a certain allele is in a gene pool

SECTION 11. 2. NATURAL SELECTION IN POPULATIONS
1. graph that shows the frequency of each phenotype for a trait in a population
2. how common each phenotype is in the population; whether or not the population is undergoing natural selection for that trait
3. a normal distribution or a bell-shaped curve

Phenotypic Distribution: Graph should resemble a bell-shaped curve. X-axis should be labeled “range” or “range of phenotypes”; y-axis should be labeled “frequency.” Mean phenotype should be labeled in the center of the curve, which is also the peak of the curve.
4. Favors phenotypes at one extreme of a trait’s range; graph should show a normal distribution shifted either to the right or left.
5. Favors intermediate phenotypes/selects against phenotypes at both extremes; graph should show distribution with sharp peak in center at the mean.
6. Favors phenotypes at both extremes of a trait’s range/selects against intermediate phenotypes; graph should show distribution with one peak at each extreme.
7. allele frequencies
8. stabilizing
9. disruptive
10. directional

SECTION 11.3. OTHER MECHANISMS OF EVOLUTION
1. emigrates
2. immigrates
3. gene pools
4. Changes in allele frequencies through genetic drift are due to chance alone, while changes in allele frequencies through natural selection are the result of specific environmental pressures.
   **Y Diagram:** Bottleneck effect—results from drastic reduction in population size; Founder effect—results from a small number of individuals colonizing a new area; Both—involve genetic drift in a small population, resulting in a decrease in genetic variation over time
5. Smaller populations are more likely to be affected by chance events, since there are not as many alleles to “balance out” random changes in allele frequencies.
6. The loss of genetic diversity decreases the chance that some individuals will be able to survive new environmental conditions, and genetically harmful alleles can build up in the population due to chance alone.
7. Males produce many sperm continuously and females are much more limited in the number offspring they can produce in each reproductive cycle.
8. Certain male traits increase mating success based on the choosiness of females for potential mates.
9. Introsexual, intersexual
   **Vocabulary Check:** Gene flow—could show two “populations” of shapes with arrows going back and forth in between them; Bottleneck effect—could show bottle being held upside-down with only a few of pieces of its contents spilling out; Founder effect—could show a few shapes that have founded a small “population” next to the original, larger population

SECTION 11.4. HARDY-WEINBERG EQUILIBRIUM
1. allele frequencies
2. very large population (so genetic drift does not occur); no emigration or immigration (so there is no gene flow); no mutations (so no new alleles are introduced into gene pool); random mating (so there is no sexual selection); no natural selection.
3. biologists can (1) study the degree in which real populations are evolving and (2) better understand the five factors that can lead to evolution
4. \[ p^2 + 2pq + q^2 = 1 \]
5. \[ p^2, \text{ frequency of dominant homozygous genotype}; 2pq, \text{ frequency of heterozygous genotype}; q^2, \text{ frequency of recessive homozygous genotype}; p, \text{ frequency of dominant allele}; q, \text{ frequency of recessive allele} \]
6. single-gene traits in simple, dominant-recessive systems
7. the phenotype and allele frequencies; specifically the phenotype frequency of the recessive homozygotes \( (q^2) \), from which the frequency of the recessive allele \( (q) \) can be calculated
8. the population is not in H-W equilibrium for the trait, which means one or more of the conditions are not met, which means the population is evolving

9. Genetic drift: in small populations, allele frequencies can change due to chance alone.
   - Gene flow: migration of individuals results in the movement of alleles among populations, which changes allele frequencies.
   - Mutation: new alleles can form due to mutation, which changes allele frequencies.
   - Sexual selection: alleles associated with traits that increase mating success can increase in frequency.
   - Natural selection: alleles associated with traits that increase survival and reproductive success can increase in frequency.

10. allele frequencies

SECTION 11.5. SPECIATION THROUGH ISOLATION

1. gene flow
2. gene pools
3. environments, genetic drift
4. mate
5. speciation, species
6. mutation
7. behavioral, geographic, and temporal barriers
8. Behavioral isolation: changes in behavior between two populations can act as barriers that prevent mating.
   - Examples: Fruit flies in the ds2 experiment which evolved different pheromones, firefly species with different flash patterns.
   - Geographic isolation: physical barriers can divide populations. Example: Isthmus of Panama divides populations of marine species in the Atlantic and Pacific Oceans.
   - Temporal isolation: differences in mating periods or times of day when individuals are active can prevent mating between populations. Example: Plant species that shed pollen during different times of the year.
9. the rise of two or more species from one existing species
10. temporal
11. behavioral
12. geographic

SECTION 11.6. PATTERNS IN EVOLUTION

1. Main Idea: Evolution through natural selection is not random.
2. Natural selection has direction: Environmental pressures can “push” a population’s traits in a certain direction.
3. Its effects are cumulative: The effects of natural selection add up over time, and the alleles associated with advantageous traits add up over many generations in the gene pool.
4. Convergent evolution: Distantly-related species can evolve similar traits while adapting to similar environments.
5. Divergent evolution: Closely-related species can evolve different traits while adapting to different environments.
6. Beneficial relationship: Two or more species evolve in a cooperative way, each evolving characteristics that are beneficial to the other; Example: stinging ants and bull-thorn acacia
7. Evolutionary arms race: Two or more species evolve in a competitive way, each evolving characteristics that put some type of evolutionary pressure on the other; Example: crabs and murex snails.
8. Background extinction: caused by local changes in the environment, such as changes in food supply; outcome is that a few species may go extinct in localized area
9. Mass extinction: Caused by catastrophic events on a global level, such as an ice age; outcome is that many species go extinct around the world in a relatively short period of time

10. speciation, change
11. descendent
12. environments or opportunities
13. Convergent evolution is two unrelated species “coming together” by becoming increasingly similar; divergent evolution is two related species “branching out” by becoming increasingly different.
14. Species evolve together, in response to changes in one another.
15. The equilibrium between speciation and extinction is “periodically interrupted” by episodes of rapid speciation.

SECTION 12.3. ORIGIN OF LIFE
1. Earth is billions of years old, and the conditions of the early planet and its atmosphere were very different from those of today.
2. Heat released by: Impacts from space debris
3. Heat released by: radioactive decay of elements within Earth
4. Atmosphere made of: Ammonia, water vapor, methane, carbon dioxide
5. Absent in Atmosphere: oxygen
6. Eon name: Hadeon
7. Energy provided by: solar radiation
8. Energy provided by: lightning
9. Miller-Urey
10. more than 90 amino acids have been identified from this meteorite
11. Hypothesized that nucleotides may have formed inside spaces within ice crystals.
12. Clay adsorption hypothesis
13. Iron-sulfide bubbles hypothesis
14. spontaneously form in nature and could have formed the first true cell membranes
15. Coacervate hypothesis
16. When cooled in water, proteinoids formed bilayers similar to the structure of cell membranes.
17. nebula
18. ribozyme

SECTION 12.4. EARLY SINGLE-CELLED ORGANISMS
1. By depositing minerals and by giving oxygen off as a by-product of photosynthesis.
2. Cyanobacteria existed as long as 3.5 billion years ago, which also suggests that oxygen was present on Earth at that time.
3. eukaryotes
4. nucleus
5. aerobic
6. cell
7. Simple infectious prokaryotic cells were taken up by larger prokaryotes.
8. Over generations, bacteria evolved as mitochondria or chloroplasts.
9. In the theory of endosymbiosis, chloroplasts are considered the descendants of cyanobacteria. An early infectious cyanobacteria may have entered a larger prokaryote, and after many generations evolved as a chloroplast in an early eukaryote.

10. Producing many offspring quickly.

11. Genetic variation allows a population to adapt quickly to new conditions.

12. cyanobacteria

13. endosymbiosis

14. Answers will vary. Examples include endotherm, endoplasmic reticulum, endorphin, endorse, endospore.

15. Cyanobacteria live in aquatic systems and can photosynthesize.

SECTION 5. RADIATION OF MULTICELLULAR LIFE

1. four-legged vertebrates such as amphibians became common
2. 70 percent of land animal species at the time became extinct by the period’s end
3. dinosaurs roamed Earth
4. earliest crocodiles arose
5. ichthyosaurs, marine reptiles, dominated the oceans
6. Mammals radiated during the Cenozoic era.
7. placental mammals evolved and diversified
8. monotremes, mammals that lay eggs, evolved and diversified
9. earliest ancestors of modern humans evolved
10. Mesozoic
11. Paleozoic
12. Cambrian explosion
13. Cenozoic
14. Cambrian explosion
15. Mesozoic
16. Cenozoic
17. Paleozoic
18. Paleozoic
19. Mesozoic
20. Cenozoic