Review the Concepts

Work through the following exercises to review the concepts in this chapter. For additional review, refer to the activities at www.mybiology.com. The website offers a pre-test that will help you plan your studies.

Exercise 1 (Modules 13.1–13.3)

Charles Darwin was not the first person to ponder the origin of species, and biologists continue to study and document evolutionary change. Match each of the following with their place in unraveling the history of life. Don't focus on names and dates, but rather on how ideas about the origin and history of life have continued to . . . evolve.

_____ 1. Greek philosopher who believed species to be perfect and permanent
_____ 2. Stated that all species were designed by a supreme creator
_____ 3. Research on Galapagos finches documents natural selection
_____ 4. Proposed that acquired characteristics may be inherited
_____ 5. His book about gradual geological change influenced Darwin.
_____ 6. Asserted that populations grow faster than resources
_____ 7. Wrote *The Origin of Species*, explaining "descent with modification"
_____ 8. Conceived a theory of evolution almost identical to Darwin's

A. Charles Darwin
B. Charles Lyell
C. Alfred Russell Wallace
D. Book of Genesis
E. Aristotle
F. Jean Baptiste Lamarck
G. Peter and Rosemary Grant
H. Thomas Malthus

Exercise 2 (Modules 13.1–13.3)

Darwin's key insight was the mechanism of evolution—natural selection. Review Darwin's theory by filling in the blanks in this story.

If you think that the more you mow your lawn, the meaner the weeds get, you may be right. Researchers have found that in lawns that are mown regularly, the dandelions fight back! Dandelions in a regularly mown lawn are shorter and reproduce faster than their ancestors in more "natural" environments. This allows them to produce seeds in between mowings. But how does it happen? What causes the dandelions to change?

[1]_____, the English scientist who first devised the theory of [2]_____, would have explained it this way: Not all dandelions are alike; they [3]_____ in color, size, and rate of maturation. Many of these characteristics are [4]_____, or passed on to offspring. Some dandelions grow slowly and are taller when they mature and produce seeds. Others are faster-growing and shorter when they reach maturity. Apparently height and growth rate are inherited.

Every dandelion flower is capable of producing hundreds, perhaps thousands, of white-tufted seeds in a season. This constitutes an overproduction of offspring, because the [5]_____ can only support so many; only a fraction of offspring will mature and leave offspring of their own. But which offspring will make it? Darwin speculated that those individuals whose inherited characteristics suited them best to their environment would be more likely to [6]_____ and [7]_____ than other, less-suited individuals. This would cause [8]_____ traits to accumulate

over generations. When a lawn is mown often, the taller slower-growing dandelions get lopped off. The shorter, faster-growing ones survive to reproduce. Over time, the dandelions get shorter, and they grow faster. Darwin called this unequal reproduction [9]_____. He likened it to the process by which humans pick out and breed individuals with [10]_____ traits, a process called artificial selection.

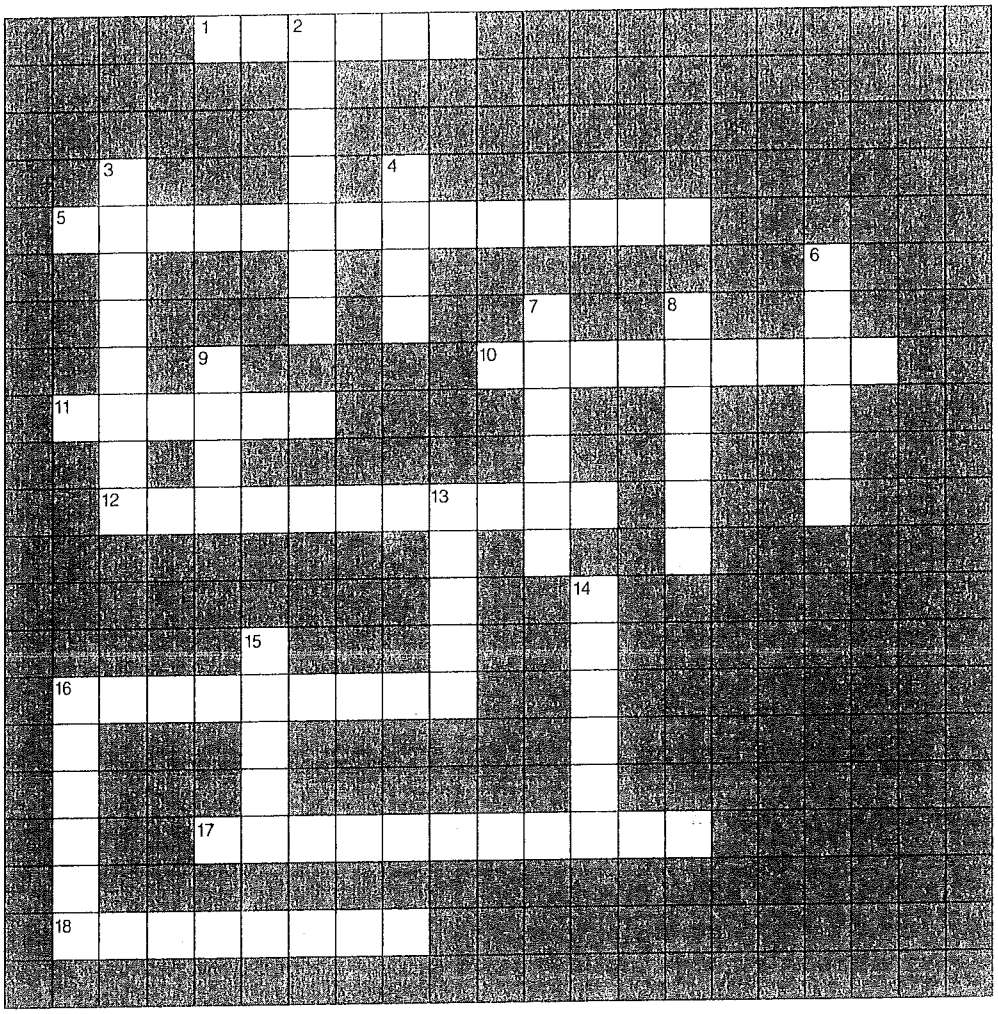
Many examples of natural selection are known. In a long-term study of Galapagos ground finches, Peter and Rosemary Grant found that individuals with bigger, stronger [11]_____ become more numerous during dry years, when small seeds are in short supply and the birds eat more large seeds. Another example, similar to the dandelion scenario, is the evolution of [12]_____ resistance in insects. The poison might kill most members of an insect [13]_____, but individuals with alleles that protect them best from being poisoned survive and reproduce, passing those alleles onto their descendents. Resistant insects are seen in greater and greater numbers in succeeding generations. Less resistant individuals die out.

Natural selection does not *create* the [14]_____ for dandelion height or pesticide resistance or beak size. It just selects for individuals in the population that already have those alleles. Also, natural selection favors those characteristics that fit the local [15]_____. In a crowded, unmowed field, the situation might be reversed, and taller, slower-growing dandelions might have the advantage. Organisms do not *try* to evolve; evolution is not [16]_____ -directed. It does not lead to the perfect dandelion, insect or finch.

Finally, note that natural selection involves differences among individuals, but *individual* dandelions do not evolve. An individual does not change its growth rate. But because there is heritable variation in the survival and reproduction of individuals with different alleles for different traits, the [17]_____ of dandelions changes. Over time, the dandelions in your yard evolve; they [18]_____ to their environment.

Exercise 3 (Modules 13-4)

Review fossils by completing this crossword puzzle.



Across

1. Most fossils are the hard parts of animals, such as bones, teeth, and ____.
5. A ____ is a scientist who studies fossils.
10. Fossils trace the evolution of mammals from a ____ ancestor.
11. Rock layers are called ____.
12. Biologists rely mainly on fossils preserved in ____ rock.
16. An entire organism may be preserved if bacteria and fungi do not ____ the corpse.
17. The oldest fossils are ____ from 3.5 billion years ago.
18. The ____ ages of fossils can be deduced from the layers in which they are found.

Down

2. Many fossil species no longer exist; they are ____.
3. Scientists have studied whole ____ frozen in ice.
4. A fossil seashell might be an empty ____ filled with sediments.
6. Fossils show that ____ evolved from four-legged land mammals.
7. The fossil ____ is the sequence of fossils within layers of rock.
8. Ankle bones show that whales are related to pigs, ____, cows, camels, and deer.
9. Sedimentary rocks form from layers of mud or ____.
13. Footprints, burrows, and tracks are called ____ fossils.
14. Fossils found in the deepest strata are generally the ____.
15. Entire insects can be perfectly preserved in ____.
16. Fossils demonstrate that past organisms ____ from existing ones.

Exercise 4 (Modules 13.3–13.4)

In addition to fossils, examples of natural selection, and examples of artificial selection, there are other kinds of evidence for evolution: biogeography, comparative anatomy, and molecular biology. Each of the examples below illustrates which of these kinds of evidence?

Category	*Example*
_____	1. Fertilized eggs of earthworms, insects, and snails all go through the same pattern of cell division.
_____	2. The same gene seems to be involved in the formation of eyes in many animals.
_____	3. The genes of humans and chimpanzees are about 96% identical.
_____	4. Remains of upright-walking but small-brained apes have been found in Africa.
_____	5. All animals with backbones have 12 pairs of nerves extending from the brain.
_____	6. Bacteria quickly become resistant to antibiotics.
_____	7. The American Kennel Club recognizes more than 150 dog breeds.
_____	8. Many unique marsupial mammals live in Australia.
_____	9. A protein called albumin is very similar in dogs and wolves, less similar in dogs and cats.
_____	10. The farther an island is from the mainland, the more unique its plants and animals.
_____	11. The limbs of all land vertebrates have one upper "leg" bone and two lower "leg" bones.
_____	12. Humans have small tail bones, and occasionally a baby is born with a short tail.
_____	13. Animals called trilobites were common in the oceans 300 million years ago, but they have been extinct for millions of years.
_____	14. In all living things, AUG is the mRNA "start" codon.
_____	15. Some whales possess vestigial hind leg and foot bones.
_____	16. Cabbage, cauliflower, and broccoli were all bred from a wild mustard.

Exercise 5 (Modules 13.5–13.6)

A human arm and a bat wing are homologous structures—features that may have different functions but are structurally similar because of common ancestry. Such homologies, whether anatomical or molecular, are important clues to evolutionary relationships. Check off each of the examples in Exercise 4 (above) that illustrate homologous structures.

Exercise 9 (Modules 11.1–11.3)

These modules introduce evolution of populations. After reading the modules, circle the word that best matches each statement.

1. A group of individuals of the same species: *gene pool, population*
2. What natural selection acts on: *individual, population*
3. What actually evolves: *individual, population*
4. All the alleles in all the individuals in the population: *genome, gene pool*
5. Change in relative frequencies of alleles in the gene pool: *microevolution, macroevolution*
6. Causes of variation (circle all that apply): *mutation, natural selection, sexual reproduction*
7. Portion of variation relevant to natural selection: *acquired, genetic*
8. Produces new alleles: *mutation, sexual reproduction*
9. Where most mutations occur: *body (somatic) cells, gametes*
10. Mutations that affect population's variability: *somatic mutations, mutations in gametes*
11. Most mutations: *harmful, helpful*
12. Important source of helpful variation: *deletion mutation, duplication mutation*
13. Organisms in which mutation alone generate most variation: *eukaryotes, prokaryotes*
14. Mutation rate in most plants and animals: *1/100,000, 1/1000*
15. Generates most new gene combinations in animals and plants: *mutation, sexual reproduction*
16. Sexual processes that generate variation: (circle all that apply) *crossing over, independent assortment, random fertilization*

Exercise 10 (Modules 11.2–11.8)

Returning one last time to the wildflowers discussed in Exercises 7 and 8, complete the following scenario regarding fitness and natural selection.

An early writer on evolution described natural selection as "nature red in tooth and claw." This may be true for cheetahs and antelope on the Serengeti, but natural selection is usually more subtle. All living things are engaged in what Charles Darwin called a [1]_____ for existence." Natural selection may be "survival of the [2]_____," but fitness is more than simply brute strength. Biologists define [3]_____ as the relative contribution that an individual makes to the gene pool of the next generation. It has more to do with reproduction than strength or cunning

For the wildflowers in our previous example, the struggle for existence involves physical traits such as color and shape of leaves and metabolic characteristics such as efficiency in capturing sunlight and resistance to cold. The [4]_____ of the plant is a composite of all its characteristics. Only the [5]_____, not the [6]_____, is exposed to the environment. A red flower may be protected from predation, while a yellow flower is eaten. Genes for red color increase fitness, and these genes are more likely to be passed on to the next generation. The frequency of red alleles in the [7]_____ increases, as does the frequency of red individuals in the [8]_____.

If the red flowers have an advantage, how is it that we still see yellow individuals? Why has the yellow [9]_____ not been eliminated from the gene pool? One reason is that the flowers are [10]_____—each individual has two sets of chromosomes and two genes for each character. In heterozygous red flowers, yellow alleles are hidden, or protected, from natural selection. These hidden alleles constitute a "reserve" of genetic [11]_____, keeping the gene pool from becoming too uniform. The yellow alleles might become useful if the [12]_____ changes.

It is also possible for natural selection to maintain both alleles in the gene pool—a phenomenon called [13]_____ selection. For example, the heterozygous red flowers could have some advantage over both the homozygous red or yellow forms—improved disease resistance, for example. This is called [14]_____ advantage, and would maintain the yellow allele in the gene pool. Another type of balancing selection is [15]_____-dependent selection, which maintains two different phenotypic forms in a population by selecting against either form if it becomes too common. An herbivore might develop a "search image" and eat the common red flowers, while ignoring the yellow ones. As the red flowers disappear, the herbivore then might notice the yellow ones. Finally, much of the genetic variation in population probably has little or no impact reproductive success and is considered [16]_____ variation.

Most flowers contain both male and female parts, but because males and females are distinct in most animal species, natural selection often shapes differences in appearance, such as antlers or bright plumage. Such difference is called sexual [17]_____. Among some species, these [18]_____ sexual characteristics might be used in fighting over females. This is called [19]_____ selection. A more common form of sexual selection, called [20]_____ selection, involves [21]_____ choice. Usually males display their bright "plumage" and females do the choosing. According to the "good [22]_____" hypothesis, bright plumage, a long tail, or a loud mating call might reflect overall male health.

There are three different ways in which natural selection can act on the variation in a population. Many characteristics are not simple "either/or" alternatives like red and yellow flower color. Characteristics such as height vary continuously and can be described by a [23]_____-shaped curve. There may be a few very short plants in the population, a majority of plants of medium height, and a few very tall plants. Imagine our wildflowers growing in a cold, windy environment. Very tall plants might freeze before their seeds mature. Shorter plants would stay warmer, but very short plants might have trouble dispersing their seeds to favorable environments. In this kind of situation, [24]_____ selection favors the intermediate variants, not too tall and not too short. Next imagine a situation where the environment is gradually becoming

drier. In this case, [25]_____ selection might favor those individuals genetically programmed to grow the deepest roots. This kind of natural selection is most common during periods of environmental [26]_____. Finally, [27]_____ selection occurs when two different sets of environmental conditions favor the extreme phenotypes and act against [28]_____ types. For example, plants with shallow, spreading roots might be at an advantage in dry rocky soil, where water tends to penetrate quickly. At the same time, a deep taproot system might be favored in richer soil that holds water longer. Intermediate root systems would be at a disadvantage in both environments.

Will natural selection ever shape a perfect flower? Probably not. [29]_____ can only act on existing variations, which depend on history and chance. And because a plant must do many different things, adaptations are often [30]_____.

Test Your Knowledge

Multiple Choice

1. During his voyage around the world, Charles Darwin was inspired to think about evolution by
   a. books that he read.
   b. fossils he collected.
   c. studying adaptations of organisms to their environments.
   d. unique organisms he saw in the Galápagos Islands.
   e. all of the above.

2. _____ and _____ generate variation, while _____ results in adaptation to the environment.
   a. genetic drift . . . natural selection . . . mutation
   b. mutation . . . sexual reproduction . . . natural selection
   c. overproduction of offspring . . . mutation . . . sexual reproduction
   d. natural selection . . . mutation . . . sexual reproduction
   e. sexual reproduction . . . natural selection . . . mutation

3. Breeding of plants and animals by humans is called
   a. natural selection.
   b. balancing selection.
   c. founder effect.
   d. artificial selection.
   e. intersexual selection.

4. Microorganisms can adapt to changes in the environment by means of mutation alone because
   a. they are so small in size.
   b. their populations are very isolated from one another.
   c. most of their mutations are helpful, rather than harmful.
   d. they multiply so rapidly.
   e. their populations are so large.

5. The smallest unit that can evolve is a
   a. species.
   b. genotype.
   c. population.
   d. gene.
   e. individual.

6. "Differential reproduction" is just another way of saying
   a. natural selection.
   b. mutation.
   c. variation.
   d. recombination.
   e. genetic drift.

7. Which of the following changes in the gene pool results in adaptive evolution?
   a. nonrandom mating
   b. genetic drift
   c. natural selection
   d. gene flow
   e. mutation

8. The ultimate source of all genetic variation is
   a. natural selection.
   b. genetic drift.
   c. sexual recombination.
   d. the environment.
   e. mutation.

9. In evolutionary terms, an organism's fitness is measured by its
   a. health.
   b. contribution to the gene pool of the next generation.
   c. mutation rate.
   d. genetic variability.
   e. stability in the face of environmental change.
10. Organisms that possess homologous structures probably
   a. are headed for extinction.
   b. evolved from the same ancestor.
   c. have increased genetic diversity.
   d. by chance had similar mutations in the past.
   e. are not related.
11. Recombination of alleles occurs when chromosomes are shuffled in _____ and fertilization.
   a. mitosis
   b. genetic drift
   c. natural selection
   d. mutation
   e. meiosis
12. Darwin
   a. was the first person to conceive that organisms could change over time.
   b. believed that organisms could pass on acquired changes to offspring.
   c. was the first biologist to win the Nobel Prize.
   d. worked out the mechanism of evolution—natural selection.
   e. was the first to realize that fossils are remains of ancient organisms.
13. Endangered species are often subject to _____ which _____ genetic diversity.
   a. balancing selection . . . reduces
   b. the bottleneck effect . . . reduces
   c. disruptive selection . . . increases
   d. neutral variation . . . reduces
   e. genetic drift . . . increases

Essay

1. Explain how heritable variations, overproduction of offspring, and limited natural resources cause a species to adapt to its environment.
2. Briefly describe five categories of evidence for evolution.
3. What is the difference between a population and a species?
4. What are homologous structures? Give some examples. Why are homologous structures considered important evidence for evolution?
5. Horses look a lot like zebras. How would Darwin have explained this?
6. Sometimes a harmful allele may be present in the gene pool at a relatively high frequency. How might this be explained in terms of genetic drift? How might it relate to the fact that most organisms are diploid? What might it have to do with heterozygote advantage?
7. Describe how each of the following might alter the gene pool: genetic drift, nonrandom mating, gene flow, mutation, and natural selection.

Apply the Concepts

Multiple Choice

1. In a population of black bears, which would be considered the fittest?
   a. the biggest bear
   b. the bear having the most mutations
   c. the healthiest bear
   d. the strongest, fiercest bear
   e. the bear that leaves the most descendants
2. A geneticist mixed together many different kinds of fruit flies—some with long wings, some with short wings, some with red eyes, some with brown eyes, and so on. He allowed the flies to feed, mate randomly, and reproduce by the thousands. After many generations, most of the flies in the population had medium wings and red eyes, and most of the extreme types had disappeared. This experiment appears to demonstrate
   a. stabilizing selection.
   b. neutral variation.
   c. diversifying selection.
   d. genetic drift.
   e. fitness.
3. Because of global climate change, researchers have discovered that Arctic wildflowers are blooming weeks earlier than they did a few decades ago. The earlier blooming time seems to be genetic. This appears to be an example of
   a. directional selection.
   b. diversifying selection.
   c. bottleneck effect.
   d. sexual dimorphism.
   e. genetic drift.