

ecology focus

Overexploitation of Asian Turtles

Conservation Alert

Collection and trade of terrestrial tortoises and freshwater turtles for human consumption and other uses has surged in Asia over the past two decades and is now spreading to areas around the globe (Fig. 47A). With 40 to 60% of all types of turtles already endangered, these practices have virtually wiped out many tortoise and freshwater turtle populations from wide areas of Asia and have brought others to the brink of extinction in a matter of years. The wild-collection trade started in Bangladesh in order to supply consumption demands in South China and then it quickly spread across tropical Asia as one area after another became depleted. Currently, the practice has spread to the United States.

Tortoises and turtles mature late (at the order of 10–20+ years), experience great longevity (measured in decades), and have low annual reproductive rates. Traders prefer to collect larger size, and therefore breeding age, individuals. This means that wild populations are not likely to recover after they have been plundered. Presently, the stocking of thousands of new turtle farms (ranging from backyard to industrial scale operations) is also causing a further run on the last remain-

ing wild stocks of many endangered species. Then, too, there is a very active illegal pet trade in rare tortoises and freshwater turtles for wealthy patrons. This illegal pet trade in rare tortoise and freshwater turtle species is now vexing enforcement authorities in Asia, Europe, and the United States.

Major Challenges Today and in the Future

Basic scientific knowledge about the range, natural history, and conservation needs of individual species of tortoises and turtles is lacking. In fact, some traded species are so poorly known, and so endangered, that specimens have sometimes only been found by researchers in wildlife markets. Wildlife inspectors and enforcement officials are often unaware of conservation concerns and unable to identify turtle species and to associate them with pertinent regulations. Because the wild-collection trade is now worldwide, it is essential that all nations and states with (remaining) wild turtle populations ensure that their domestic legislation is adequate to secure the



FIGURE 47B Aquaculture farms.

Red-eared slider turtles (*Trachemys scripta elegans*) are now raised in aquaculture farms. Although this takes pressure off wild turtle populations, such turtles reinforce the habit of turtle consumption and can become invasive species when they escape into the wild.

future of their turtle populations. Too often, trade starts up and occurs faster than regulatory measures can be put in place to prevent local populations from being decimated.

Another issue that needs attention is the threat of invasive species and the spread of diseases from aquaculture facilities to wild populations. It is known that Chinese soft-shell turtles and red-eared slider turtles have an extreme ability to adapt to new environments (Fig. 47B). Reports abound from around the globe that turtles have either escaped or have been deliberately released from aquaculture facilities. Ecologists can only speculate about how they will impact wild populations when they become competitors, predators, hybridizers, and disease vectors. Impact studies are desirable, as is a regulatory framework governing the transport and handling of non-local turtles.

The public needs to become aware and concerned about the plight of tortoises and freshwater turtle populations because serious conservation research and legislative action is immediately required in order to save local populations from extinction.

Written by Peter Paul van Dijk with the assistance of Bruce J. Weissgold.



FIGURE 47A Turtles for sale.

Since the 1990s, great numbers of wild-caught tortoises and freshwater turtles can be seen offered for sale at markets in East Asia. Shown here are steppe tortoises (*Testudo horsfieldii*) (back) and elongated tortoises (*Indotestudo elongata*) (front).

Overexploitation

Overexploitation occurs when the number of individuals taken from a wild population is so great that the population becomes severely reduced in numbers. A positive feedback cycle explains overexploitation: The smaller the population, the more valuable its members, and the greater the incentive to capture the few remaining organisms. Poachers are very active in the collecting and sale of endangered and threatened species because it has become so lucrative. The overall international value of trading wildlife species is \$20 billion, of which \$8 billion is attributed to the illegal sale of rare species.

Markets for rare plants and exotic pets support both legal and illegal trade in wild species. Rustlers dig up rare cacti, such as the crested saguaros, and sell them to gardeners for as much as \$15,000 each. Parrots are among birds taken from the wild for sale to pet owners. For every bird delivered alive, many more have died in the process. The same holds true for tropical fish, which often come from the coral reefs of Indonesia and the Philippines. Divers dynamite reefs or use plastic squeeze-bottles of cyanide to stun them; in the process, many fish and valuable corals die.

The Convention of International Trade of Endangered Species (CITES) was an agreement established in 1973 to ensure that international trade of species does not threaten their survival. Today, over 30,000 species of plants and animals receive some level of protection from over 172 countries worldwide.

Poachers still hunt for hides, claws, tusks, horns, or bones of many endangered mammals. Because of its rarity, a single Siberian tiger is now worth more than \$500,000—its bones are pulverized and used as a medicinal powder. The horns of rhinoceroses become ornate carved daggers, and their bones are ground up to sell as a medicine. The ivory of an elephant's tusk is used to make art objects, jewelry, or piano keys. The fur of a Bengal tiger sells for as much as \$100,000 in Tokyo.

The U.N. Food and Agricultural organization tells us that we have now overexploited 11 of 15 major oceanic fishing areas. Fish are a renewable resource if harvesting does not exceed the ability of the fish to reproduce. Our society uses larger and more efficient fishing fleets to decimate fishing stocks. Pelagic species such as tuna are captured by purse-seine fishing, in which a very large net surrounds a school of fish, and then the net is closed in the same manner as a draw-string purse. Up to thousands of dolphins that swim above schools of tuna are often captured and then killed in this type of net. However, many tuna suppliers advertise their product as “dolphin safe.” Other fishing boats drag huge trawling nets, large enough to accommodate 12 jumbo jets, along the seafloor to capture bottom-dwelling fish (Fig. 47.8a). Only large fish are kept; undesirable small fish and sea turtles are discarded, dying, back into the ocean. Trawling has been called the marine equivalent of clear-cutting trees because after the net goes by, the sea bottom is devastated (Fig. 47.8b). Today's fishing practices don't allow fisheries to recover. Cod and haddock, once the most abundant bottom-dwelling fish along the northeast coast of the United States, are now often outnumbered by dogfish and skate.



a. Fishing by use of a drag net



b. Result of drag net fishing

FIGURE 47.8 Trawling.

- a. These Alaskan pollock were caught by dragging a net along the seafloor.
b. Appearance of the seafloor after the net passed.

A marine ecosystem can be disrupted by overfishing, as exemplified on the U.S. west coast. When sea otters began to decline in numbers, investigators found that they were being eaten by orcas (killer whales). Usually orcas prefer seals and sea lions to sea otters, but they began eating sea otters when few seals and sea lions could be found. What caused a decline in seals and sea lions? Their preferred food sources—perch and herring—were no longer plentiful due to overfishing. Ordinarily, sea otters keep the population of sea urchins, which feed on kelp, under control. But with fewer sea otters around, the sea urchin population exploded and decimated the kelp beds. Thus, overfishing set in motion a chain of events that detrimentally altered the food web of an ecosystem.

Check Your Progress

47.3

1. What are the five main causes of extinction?
2. Explain why the introduction of exotic species can be detrimental to biodiversity with reference to Figures 47.6 and 47B.

47.4 Conservation Techniques

Despite the value of biodiversity to our very survival, human activities are causing the extinction of thousands of species a year. Clearly, we need to reverse this trend and preserve as many species as possible. Habitat preservation and restoration are important in preserving biodiversity.

Habitat Preservation

Preservation of a species' habitat is of primary concern, but first we must prioritize which species to preserve. As mentioned previously, the biosphere contains biodiversity hotspots, relatively small areas having a concentration of endemic (native) species not found anywhere else. In the tropical rain forests of Madagascar, 93% of the primate species, 99% of the frog species, and over 80% of the plant species are endemic to Madagascar. Preserving these forests and other hotspots will save a wide variety of organisms.

Keystone species are species that influence the viability of a community, although their numbers may not be excessively high. The extinction of a keystone species can lead to other extinctions and a loss of biodiversity. For example, bats are designated a keystone species in tropical forests of the Old World. They are pollinators that also disperse the seeds of trees. When bats are killed off and their roosts destroyed, the trees fail to reproduce. The grizzly bear is a keystone species in the northwestern United States and Canada (Fig. 47.9a). Bears disperse the seeds of berries; as many as 7,000 seeds may be in one dung pile. Grizzly bears kill the young of many hoofed animals and thereby keep their populations under control. Grizzly bears are also a principal mover of soil when they dig up roots and prey upon hibernating ground squirrels and marmots. Other keystone species are beavers in wetlands, bison in grasslands, alligators in swamps, and elephants in grasslands and forests.

Keystone species should not be confused with **flagship species**, which evoke a strong emotional response in humans. Flagship species are considered charismatic and are treasured for their beauty, cuteness, and regal nature. These species can motivate the public to preserve biodiversity. Flagship species include lions, tigers, dolphins, and the giant panda.

Metapopulations

The grizzly bear population is actually a **metapopulation** [Gk. *meta*, between; L. *populus*, people], a population subdivided into several small, isolated populations due to habitat fragmentation. Originally there were probably 50,000–100,000 grizzly bears south of Canada, but this number has been reduced because human housing communities have encroached on their home range and bears are killed by frightened homeowners. Now there are six virtually isolated subpopulations totaling about 1,000 individuals. The Yellowstone National Park population numbers 200, but the others are even smaller.

Saving metapopulations sometimes requires determining which of the populations is a source and which are sinks. A **source population** is one that most likely lives in a



a. Grizzly bear, *Ursus arctos horribilis*



b. Old-growth forest; northern spotted owl, *Strix occidentalis caurina* (inset)

FIGURE 47.9

Habitat preservation.

When particular species are protected, other wildlife benefits. **a.** The Greater Yellowstone Ecosystem has been delineated in an effort to save grizzly bears, which need a very large habitat. **b.** Currently, the remaining portions of old-growth forests in the Pacific Northwest are not being logged in order to save the northern spotted owl (inset).

favorable area, and its birthrate is most likely higher than its death rate. Individuals from source populations move into **sink populations**, where the environment is not as favorable and where the birthrate equals the death rate at best. When trying to save the northern spotted owl, conservationists determined that it was best to avoid having owls move into sink habitats. The northern spotted owl reproduces successfully in old-growth rain forests of the Pacific Northwest (Fig. 47.9b) but not in nearby immature forests that are in the process of recovering from logging. Distinct boundaries that hindered the movement of owls into these sink habitats proved to be beneficial in maintaining source populations.

Landscape Preservation

Grizzly bears inhabit a number of different types of ecosystems, including plains, mountains, and rivers. Saving any one of these types of ecosystems alone would not be sufficient to preserve the grizzly bears. Instead, it is necessary to save diverse ecosystems that are at least connected. You will recall that a landscape encompasses different types of ecosystems. An area called the Greater Yellowstone Ecosystem, where bears are free to roam, has now been defined. It contains millions of acres in Yellowstone National Park; state lands in Montana, Idaho, and Wyoming; five different national forests; various wildlife refuges; and even private lands.

Landscape protection for one species is often beneficial for other wildlife that share the same space. The last of the contiguous 48 states' harlequin ducks, bull trout, westslope cutthroat trout, lynx, pine martens, wolverines, mountain caribou, and great gray owls are found in areas occupied by grizzly bears. Gray wolves have also recently returned to this territory. Then, too, grizzly bear range overlaps with 40% of Montana's vascular plants of special conservation concern.

The Edge Effect. When preserving landscapes, it is necessary to consider the **edge effect**. An edge reduces the amount of habitat typical of an ecosystem because the edges around a patch have a habitat slightly different from the interior of the patch. For example, forest edges are brighter, warmer, drier, and windier, with more vines, shrubs, and weeds than the forest interior. Also, Figure 47.10a shows that a small and a large patch of habitat have the same amount of edge; therefore, the effective habitat shrinks as a patch gets smaller.

Many popular game animals, such as turkeys and white-tailed deer, are more plentiful in the edge region of a particular area. However, today it is known that creating edges can be detrimental to wildlife because of habitat fragmentation.

The edge effect can also have a serious impact on population size. Songbird populations west of the Mississippi have been declining of late, and ornithologists have noticed

that the nesting success of songbirds is quite low at the edge of a forest. The cause turns out to be the brown-headed cowbird, a social parasite of songbirds. Adult cowbirds prefer to feed in open agricultural areas, and they only briefly enter the forest when searching for a host nest in which to lay their eggs (Fig. 47.10b). Cowbirds are therefore benefited, while songbirds are disadvantaged, by the edge effect.

Habitat Restoration

Restoration ecology is a new subdiscipline of conservation biology that seeks scientific ways to return ecosystems to their state prior to habitat degradation. Three principles have so far emerged. First, it is best to begin as soon as possible before remaining fragments of the original habitat are lost. These fragments are sources of wildlife and seeds from which to restock the restored habitat. Second, once the natural histories of the species in the habitat are understood, it is best to use biological techniques that mimic natural processes to bring about restoration. This might take the form of using controlled burns to bring back grassland habitats, biological pest controls to rid the area of exotic species, or bioremediation techniques to clean up pollutants. Third, the goal is **sustainable development**, the ability of an ecosystem to maintain itself while providing services to human beings. The Everglades ecosystem is used here to illustrate these principles. Although habitat restoration is good, there is some concern that the restored areas may not be functionally equivalent to the natural regions.

The Everglades

Originally, the Everglades encompassed the whole of southern Florida from Lake Okeechobee down to Florida Bay (Fig. 47.11a). This ecosystem is a vast sawgrass prairie, interrupted occasionally by a cypress dome or hardwood tree island. Within these islands, both temperate and tropical evergreen trees grow amongst dense and tangled vegetation. Mangroves are found along sloughs (creeks) and at the shoreline. The

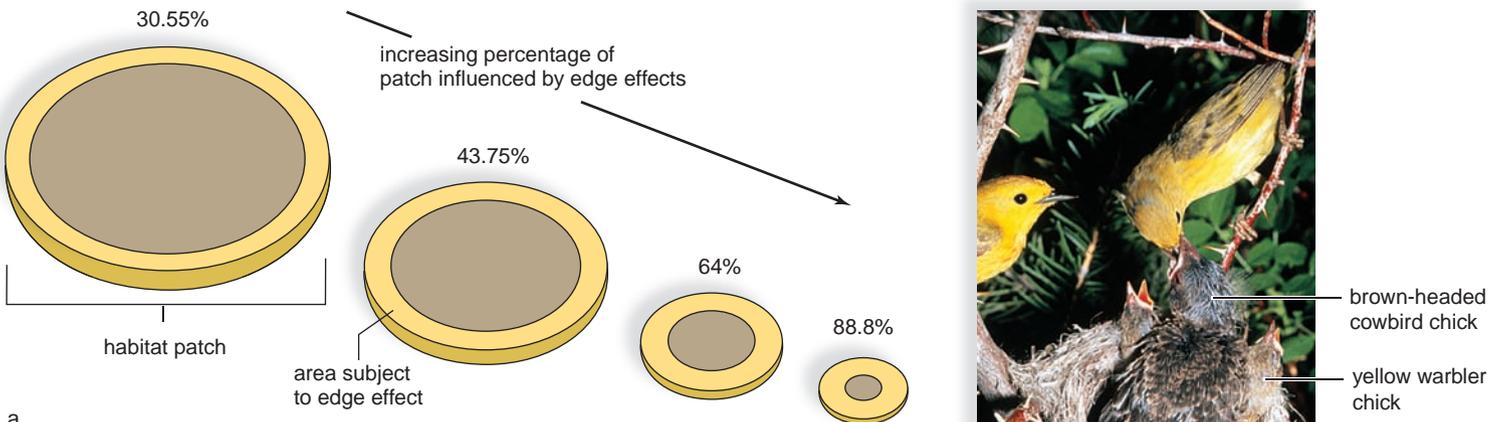


FIGURE 47.10 Edge effect.

a. The smaller the patch, the greater the proportion that is subject to the edge effect. **b.** Cowbirds lay their eggs in the nests of songbirds (yellow warblers). A cowbird is bigger than a warbler nestling and will be able to acquire most of the food brought by the warbler parent.

b.



a. Location of Everglades National Park (purple)

prop roots of red mangroves protect over 40 different types of juvenile fishes as they grow to maturity. During a wet season, from May to November, animals disperse throughout the region, but in the dry season, from December to April, they congregate wherever pools of water are found. Alligators are famous for making “gator holes,” where water collects and fishes, shrimp, crabs, birds, and a host of living things survive until the rains come again. The Everglades once supported millions of large and colorful birds, including herons, egrets, the white ibis, and the roseate spoonbill (Fig. 47.11b).

At the turn of the century, settlers began to drain the land just south of Lake Okeechobee to grow crops in the newly established Everglades Agricultural Area (EAA). A large dike now rings Lake Okeechobee and prevents water from overflowing its banks and moving slowly southward. To provide flood protection for urban development, water is shunted through the St. Lucie Canal to the Atlantic Ocean or through the canalized Caloosahatchee River to the Gulf of Mexico. In times of drought, water is contained not only in the lake but also in three conservation areas established to the south of the lake. Water must be conserved to irrigate the farmland and to recharge the Biscayne aquifer (underground river), which supplies drinking water for the cities on the east coast of Florida. The Central and Southern Florida Flood Control Project (C&SF) included the construction of over 2,250 km of canals, 125 water control stations, and 18 large pumping stations. Now the Everglades National Park receives water only when it is discharged artificially from a conservation area, and the discharge



Florida panther, *Puma concolor coryi*



American alligator, *Alligator mississippiensis*



White ibis, *Eudocimus albus*



Roseate spoonbill, *Ajaia ajaja*



Wood stork, *Mycteria americana*

b. Wildlife in Everglades

FIGURE 47.11 Restoration of the Everglades.

a. Restoration plans call for adding curves and habitat back to the Kissimmee River (A); creating large marshes and making the Shark River Slough free-flowing again (B); creating a buffer zone of wetlands between urban development along Florida’s eastern coast (C); and reducing salinity by letting fresh water flow into and through Taylor Slough (D). b. Wildlife of the Florida Everglades.

is according to the convenience of the C&SF rather than according to the natural wet/dry season of southern Florida. Largely because of this, the Everglades are now dying, as witnessed by declining bird populations. The birds, which used to number in the millions, now number in the thousands.

Restoration Plan. A restoration plan has been developed that will sustain the Everglades ecosystem while maintaining the services society requires. The U.S. Army Corps of Engineers is to redesign the C&SF so that the Everglades receive a more natural flow of water from Lake Okeechobee. This will require flooding the EAA and growing only crops such as sugarcane and rice that can tolerate these wetter conditions. This has the benefit of stopping the loss of topsoil and preventing possible residential development in the area. There will also be an extended buffer zone between an expanded Everglades and the urban areas on Florida's east coast. The buffer zone will contain a contiguous system of interconnected marsh areas, detention reservoirs, seepage

barriers, and water treatment areas. This plan is expected to stop the decline of the Everglades and its biodiversity, while still allowing agriculture to continue and providing water and flood control to the eastern coast. Sustainable development will maintain the ecosystem indefinitely and still meet human needs.

Check Your Progress

47.4

1. Why is landscape preservation, rather than ecosystem preservation, of primary importance?
2. What are the three principles of habitat restoration?

Connecting the Concepts

Our industrial societies are overusing the environment to the point of exhaustion. Forests throughout tropical, temperate, and subarctic regions are being harvested and cut for timber at unsustainable rates. Urban sprawl is completely replacing natural ecosystems in highly populated regions. Fresh waters are being diverted for agricultural and urban uses to the extent that riverbeds and lake beds are becoming dry in places. Dams are being constructed for hydropower and irrigation with little consideration for their impact on aquatic life. Exotic species of plants, animals, and microbes are being released into new environments with little or no restraint. Marine fisheries are being exploited by major fishing nations at unsustainable levels.

All these actions, and others, are reducing biodiversity, which we now realize is a resource of enormous economic value. If properly managed, sustainable yields of food and fiber can be obtained from many natural lands and waters. Modern genetic engineer-

ing technologies make the genes of millions of wild species available for use in breeding improved crops, domestic animals, and biological control agents. Enjoyment of nature appears to be an innate requirement of a healthy human life.

As natural forests, grasslands, streams, lakes, and seas are degraded, human society must expend greater amounts of nonrenewable energy and materials to substitute for benefits that biodiversity provides at no cost. Lost species, and ultimately, lost ecosystems, cannot be replaced. Biodiversity is therefore a nonrenewable resource. The goal of conservation biology is to protect, restore, and use this resource wisely. To that end, the vision of conservation biology is:

A world where leaders are committed to long-term environmental protection and to international leadership and cooperation in addressing the world's environmental problems.

A world with an environmentally literate citizenry that has the knowledge, skills, and ethical values needed to achieve sustainable development.

A world in which market prices and economic indicators reflect the full environmental and social costs of human activities.

A world in which a new generation of technologies contributes to the conservation of resources and the protection of the environment.

A world landscape that sustains natural systems, maximizes biological diversity, and uplifts the human spirit.

A world in which human numbers are stabilized, all people enjoy a decent standard of living through sustainable development, and the global environment is protected for future generations.

Modified from The Report of the National Commission on the Environment, 1993.

summary

47.1 Conservation Biology and Biodiversity

Conservation biology is the scientific study of biodiversity and its management for sustainable human welfare. The unequaled present rate of extinctions has drawn together scientists and environmentalists in basic and applied fields to address the problem.

Biodiversity is the variety of life on Earth; the exact number of species is not known, but there are assuredly many species yet to be discovered and recognized. Biodiversity must also be preserved at the genetic, community (ecosystem), and landscape levels of organization.

Conservationists have discovered that biodiversity is not evenly distributed in the biosphere, and therefore saving particular areas may protect more species than saving other areas.

47.2 Value of Biodiversity

The direct value of biodiversity is seen in the observable services of individual wild species. Wild species are our best source of new medicines to treat human ills, and they help meet other medical needs. For example, the bacterium that causes leprosy grows naturally in armadillos, and horseshoe crab blood contains a bacteria-fighting substance.

Wild species have agricultural value. Domesticated plants and animals are derived from wild species, and they use wild species as a source of genes for the improvement of their phenotypes. Instead of

pesticides, wild species can be used as biological controls, and most flowering plants benefit from animal pollinators. Much of our food, particularly fish and shellfish, is still caught in the wild. Hardwood trees from natural forests supply us with lumber for various purposes, such as making furniture.

The indirect services provided by ecosystems are largely unseen and difficult to quantify but absolutely necessary to our well-being. These services include the workings of biogeochemical cycles, waste disposal, provision of fresh water, prevention of soil erosion, and regulation of climate. Many people enjoy vacationing in natural settings. Various studies show that more diverse ecosystems function better than less diverse systems.

47.3 Causes of Extinction

Researchers have identified the major causes of extinction. Habitat loss is the most frequent cause, followed by introduction of exotic species, pollution, overexploitation, and disease. (Pollution often leads to disease, so these were discussed at the same time.) Habitat loss has occurred in all parts of the biosphere, but concern has now centered on tropical rain forests and coral reefs, where biodiversity is especially high. Exotic species have been introduced into foreign ecosystems through colonization, horticulture and agriculture, and accidental transport. Various causes of pollution include fertilizer runoff, industrial emissions, and improper disposal of wastes, among others. Overexploitation is exemplified by commercial fishing, which is so efficient that fisheries of the world are collapsing.

47.4 Conservation Techniques

To preserve species, it is necessary to preserve their habitat. Some emphasize the need to preserve biodiversity hotspots because of their richness. Often today it is necessary to save metapopulations because of past habitat fragmentation. If so, it is best to determine the source populations and save those instead of the sink populations. A keystone species such as the grizzly bear requires the preservation of a landscape consisting of several types of ecosystems over millions of acres of territory. Obviously, in the process, many other species will also be preserved.

Conservation today is assisted by two types of computer analysis. A gap analysis tries for a fit between biodiversity concentrations and land still available to be preserved. A population viability analysis indicates the minimum size of a population needed to prevent extinction from happening.

Since many ecosystems have been degraded, habitat restoration may be necessary before sustainable development is possible. Three principles of restoration are (1) start before sources of wildlife and seeds are lost; (2) use simple biological techniques that mimic natural processes; and (3) aim for sustainable development so that the ecosystem fulfills the needs of humans.

understanding the terms

biodiversity	890	keystone species	901
biodiversity hotspot	891	landscape	891
bioinformatics	890	landscape diversity	891
conservation biology	890	metapopulation	901
ecosystem diversity	891	overexploitation	900
edge effect	902	pollution	897
endangered species	890	restoration ecology	902
exotic species	897	sink population	901
flagship species	901	source population	901
genetic diversity	891	sustainable development	902
global warming	898	threatened species	890

Match the terms to these definitions:

- _____ A rather small area with an unusually large concentration of species.
- _____ A subdivided population in isolated patches of habitat.
- _____ A population that has a positive growth rate and net emigration rate to other locations.
- _____ Species that are likely to become endangered in the foreseeable future.

reviewing this chapter

1. Explain these attributes of conservation biology: (a) both academic and applied; (b) supports ethical principles; and (c) is responding to a biodiversity crisis. 890
2. Discuss the conservation of biodiversity at the species, genetic, community, and landscape levels. 890–91
3. Describe the uneven distribution of diversity in the biosphere. What is the implication of uneven distribution for conservation biologists? 891
4. List various ways in which individual wild species provide us with valuable services. 892–93
5. List various ways in which ecosystems provide us with indispensable services. 894–95
6. List and discuss the five major causes of extinction, starting with the most frequent cause. 896–900
7. Introduction of exotic species is usually due to what events? 897
8. List and discuss five major types of pollution that particularly affect biodiversity. 897–98
9. Use the positive feedback cycle to explain why overexploitation occurs. 900
10. Using the grizzly bear population as an example, explain keystone species, metapopulations, and landscape preservation. 901–2
11. Explain the three principles of habitat restoration with reference to the Everglades. 902–4

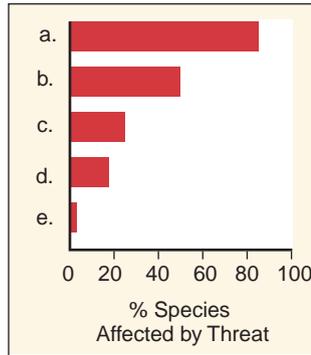
testing yourself

Choose the best answer for each question.

1. Which of these would not be within the realm of conservation biology?
 - a. helping to manage a national park
 - b. a government board charged with restoring an ecosystem
 - c. writing textbooks and/or popular books on the value of biodiversity
 - d. introducing endangered species back into the wild
 - e. All of these are concerns of conservation biology.
2. Which of these pairs does not show a contrast in the number of species?
 - a. temperate zone—tropical zone
 - b. hotspots—cold spots
 - c. rain forest canopy—rain forest floor
 - d. pelagic zone—abyssal plain
3. The value of wild pollinators to the U.S. agricultural economy has been calculated to be \$4.1–\$6.7 billion a year. What is the implication?
 - a. Society could easily replace wild pollinators by domesticating various types of pollinators.

- b. Pollinators may be valuable, but that doesn't mean any other species also provide us with valuable services.
- c. If we did away with all natural ecosystems, we wouldn't be dependent on wild pollinators.
- d. Society doesn't always appreciate the services that wild species provide naturally and without any fanfare.
- e. All of these statements are correct.
4. The services provided to us by ecosystems are unseen. This means
- a. they are not valuable.
- b. they are noticed particularly when the service is disrupted.
- c. biodiversity is not needed for ecosystems to keep functioning as before.
- d. we should be knowledgeable about them and protect them.
- e. Both b and d are correct.
5. Which of these is a true statement?
- a. Habitat loss is the most frequent cause of extinctions today.
- b. Exotic species are often introduced into ecosystems by accidental transport.
- c. Climate change may cause many extinctions but also expand the ranges of other species.
- d. Overexploitation of fisheries could very well lead to a complete collapse of the fishing industry.
- e. All of these statements are true.
6. Which of these is expected if the average global temperature increases?
- a. the inability of some species to migrate to cooler climates as environmental temperatures rise
- b. the possible drowning of coral reefs
- c. an increase in the number of parasites in the temperate zone
- d. some species will experience a population decline and others will experience an increase.
- e. All of these are expected.
7. Why is a grizzly bear a keystone species existing as a metapopulation?
- a. Grizzly bears require many thousands of miles of preserved land because they are large animals.
- b. Grizzly bears have functions that increase biodiversity, but presently the population is subdivided into isolated subpopulations.
- c. When grizzly bears are present, so are many other types of species within a diverse landscape.
- d. Grizzly bears are a source population for many other types of organisms across several population types.
- e. All of these statements are correct.
8. Sustainable development of the Everglades will mean that
- a. the various populations that make up the Everglades will continue to exist indefinitely.
- b. human needs will also be met while successfully managing the ecosystem.
- c. the means used to maintain the Everglades will mimic the processes that naturally maintain the Everglades.
- d. the restoration plan is a workable plan.
- e. All of these statements are correct.
9. Which statement accepted by conservation biologists best shows that they support ethical principles?
- a. Biodiversity is the variety of life observed at various levels of biological organization.
- b. Wild species directly provide us with all sorts of goods and services.
- c. New technologies can help determine conservation plans.
- d. There are three principles of restoration biology that need to be adhered to in order to restore ecosystems.
- e. Biodiversity is desirable and has value in and of itself, regardless of any practical benefit.
10. A population in an unfavorable area with a high infant mortality rate would be
- a. a metapopulation.
- b. a source population.
- c. a sink population.
- d. a new population.
11. What is the edge effect?
- a. More species live near the edge of an ecosystem, where more resources are available to them.
- b. New species originate at the edge of ecosystems due to interactions with other species.
- c. The edge of an ecosystem is not a typical habitat and may be an area where survival is more difficult.
- d. More species are found at the edge of a rain forest due to deforestation of the forest interior.
12. Eagles and bears feed on spawning salmon. If shrimp are introduced that compete with salmon for food,
- a. the salmon population will decline.
- b. the eagle and bear populations will decline.
- c. only the shrimp population will decline.
- d. all populations will increase in size.
- e. Both a and b are correct.
13. Biodiversity hotspots
- a. have few populations because the temperature is too hot.
- b. contain about 20% of the Earth's species even though their area is small.
- c. are always found in tropical rain forests and coral reefs.
- d. are sources of species for the ecosystems of the world.
- e. All except a are correct.
14. Consumptive use value
- a. means we should think of conservation in terms of the long run.
- b. means we are placing too much emphasis on living things that are useful to us.
- c. means some organisms, other than crops and farm animals, are valuable as products.
- d. is a type of direct value.
- e. Both c and d are correct.
15. Which of these is not an indirect value of species?
- a. participates in biogeochemical cycles
- b. participates in waste disposal
- c. helps provide fresh water
- d. prevents soil erosion
- e. All of these are indirect values.
16. Most likely, ecosystem performance improves
- a. the more diverse the ecosystem.
- b. as long as selected species are maintained.
- c. as long as species have both direct and indirect value.
- d. if extinctions are diverse.
- e. Both a and b are correct.
17. Efforts made to preserve species include all except
- a. catching tuna in dolphin-safe nets.
- b. international regulation of the trade of endangered species.
- c. captive breeding of popular plants and animals.
- d. fragmenting habitats, producing metapopulations.
- e. All of these are examples of conservation efforts.

18. Sea urchins feed on kelp beds, and sea otters feed on sea urchins. If sea otters are killed off, which of these statement(s) is true? Choose more than one answer if correct.
- Kelp beds will increase.
 - Kelp beds will decrease.
 - Sea urchins will increase.
 - Sea urchins will decrease.
19. Complete the following graph by labeling each bar (a–e) with a cause of extinction, from the most influential to the least influential.



thinking scientifically

- The scale at which conservation biologists work often makes direct experimentation difficult. But computer models can assist in predicting the future of populations or ecosystems. Some scientists feel that these models are inadequate because they cannot reproduce all the variables found in the real world. If you were trying to predict the impact on songbirds of clear-cutting a portion of a forest, what information would you need to develop a good model?
- Bioprospecting is the search for medically useful molecules derived from living things. The desire for monetary and medicinal gains from such discoveries deters the preservation of endangered habitats. However, bioprospecting does protect ecosystems and, in this way, saves many species rather than individual species. What types of living things would bioprospectors be most interested in?

bioethical issue

Protecting Bighorn Sheep

To protect the state's declining bighorn sheep populations, the New Mexico Game Commission approved a plan that calls for killing scores of mountain lions over several years. The commission pointed out that the lions have killed 36 of 43 radio-collared bighorn sheep released into the wild since 1996 and have increasingly turned to killing sheep as the state's deer herd has declined.

Mountain lions and bighorns have long coexisted as part of a common ecosystem. Rather than killing mountain lions to increase the bighorn sheep population, it would be better to consider a restoration management plan that would improve the ecosystem. The state recently engaged the Hornocker Wildlife Institute of Idaho to study the situation. The institute's report concluded that the number of lions does not necessarily affect the size of the sheep population. Rather, diseases from domestic livestock grazing in the area are responsible for more than 50% of the deaths in some bighorn sheep populations.

Opposition to the restoration plan claims that the plan to kill mountain lions was solidly based in science. The report said that killing lions in selected areas will give the sheep population a chance to rebound because there are 2,000 lions and only 760 bighorn sheep in two separate populations. Do you approve of taking steps to protect bighorn sheep from mountain lions? Why or why not? If you do approve, how would you proceed?

Biology website

The companion website for *Biology* provides a wealth of information organized and integrated by chapter. You will find practice tests, animations, videos, and much more that will complement your learning and understanding of general biology.

<http://www.mhhe.com/maderbiology10>

APPENDIX A

Answer Key

CHAPTER 1

Figure 2.6: Because carbon has only 6 electrons, while phosphorus has 15 and sulfur has 16.

Check Your Progress

1.1: 1. Acquisition and use of energy, responding to the environment, reproduction, and adaptation. 2. Viruses are not “alive” because they do not meet all the criteria for a living thing. 3. Cacti possess adaptations, such as a thick cuticle, that help prevent it from drying out from transpiration, and have deep root systems designed to tap water deep underground. **1.2:** 1. Domain, Kingdom, Phylum, Class, Order, Family, Genus, Species. 2. Protists are generally unicellular organisms; fungi are multicellular filamentous organisms that absorb food; plants are multicellular organisms that are usually photosynthetic; animals are multicellular organisms that must ingest and process their food. 3. Members of a population that have new adaptive traits are selected to reproduce more than other members and pass on these traits to the next generation. **1.3:** 1. Individuals of a community interact with members of the same species, with other populations, and with the physical environment. 2. Human activities may destroy ecosystems by altering the physical environment, much like agricultural runoff may fill in streams, ponds, and lakes; 3. They are more vulnerable, because high biodiversity ecosystems often depend on species with very specific roles that are more vulnerable to changes in the environment. **1.4:** 1. A control experiment provides a comparison for the investigator to use in determining whether or not manipulation of the independent variable in the experiment affects the outcome. 2. A model may simplify a complex living organism, so there may be other factors in the living organism that would affect the experiment that are not accounted for in the model. Sometimes lax peer review

occurs, but in other cases new and novel ideas may be hindered.

Understanding the Terms

a. metabolism; **b.** evolution; **c.** experimental variable; **d.** photosynthesis; **e.** control

Testing Yourself

1. c; 2. Brain thinks but nerve cells do not think; 3. b; 4. b; 5. b; 6. d; 7. b; 8. b; 9. b; 10. a; 11. c; 12. e; 13. b; 14. b; 15. Energy is brought into an ecosystem for the first time through photosynthesis. The sun provides energy for photosynthesis. 16. Excess carbon dioxide emitted may alter the amount of it available from its reservoirs, such as from the atmosphere. This excess carbon dioxide is more readily available to photosynthetic plants and protists, possibly causing them to overpopulate. 17. Not necessarily, if the new organism does not serve as prey for one species, allowing them to overpopulate, nor prey on or compete with existing species in the ecosystem.

Thinking Scientifically

1. **a.** After dye is spilled on culture plate, bacteria live despite exposure to sunlight; **b.** Dye protects bacteria against death by UV light; **c.** Expose two sets of plates to UV light: one set of plates contains bacteria and dye, and the other set contains only bacteria. The bacteria in both sets die; **d.** Rejects hypothesis because dye does not protect bacteria against death by UV light. 2. Treat both groups the same, except one group receives name-brand fertilizer and another group receives the generic brand. At the end of the growing season, weigh the fruit that you harvest from each plot and compare the total weight of the name-brand treatment with that of the generic treatment. 3. Experimental variable is the drug; one group of patients receives the drug and one doesn't. Responding variable is the results of the experiment.

CHAPTER 2

Check Your Progress

2.1: 1. Atomic mass is approximately the sum of the protons and neutrons in an atom. Atomic number is the number of protons in an atom. 2. a. In Group 3 (the third vertical column in the table), the atoms all have three electrons in the outer shell but the number of shells increases by one; b. In a period, such as Period III, the number of shells remains the same but the number of electrons in the outer shell sequentially increase by one. 3. Uses include imaging body parts (e.g., PET scans, thyroid imaging), sterilization of medical equipment, cancer therapy, and increased storage life of produce.

2.2: 1. An ionic bond is created when one atom gives up electron(s) and another gains electron(s) so that both atoms have outer shells filled. A covalent bond is formed when two atoms share electrons to fill their outer shells. 2. Calcium gives away its two outer electrons in order to have a complete outer shell. This will give calcium two more protons than electrons. 3. By sharing with four hydrogen atoms, carbon acquires the four electrons it needs to fill its outer shell. Hydrogen has only one shell, which is complete with two electrons; therefore, each of four hydrogens can acquire a needed electron by sharing with carbon.

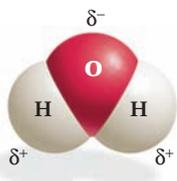
2.3: 1. When water changes to a gas, it takes much energy to break hydrogen bonds. 2. Body heat is being used to evaporate water. 3. Water freezes from the top down because ice is less dense than water. It's less dense because hydrogen bonds become more open when water freezes. **2.4:** 1. An acid dissociates in water to release hydrogen ions. A base either takes up hydrogen ions or releases hydroxide ions. 2. Both trees and fish die when their environment becomes too acid. 3. The more H^+ , the lower the pH; the fewer H^+ , the higher pH.

Understanding the Terms

a. polar covalent bond; **b.** ion; **c.** acid; **d.** molecule; **e.** buffer

Testing Yourself

1. d; 2. e; 3. c; 4. d; 5. a; 6. d; 7. e; 8. d; 9. b; 10. c; 11.



12. c; 13. b; 14. a; 15. a; 16. 7p and 7n in nucleus; two electrons in first shell, and five electrons in outer shell. This means that nitrogen needs three more electrons in the outer shell to be stable; because each hydrogen contributes one electron, the formula for ammonia in NH_3 ; 17. d; 18. e; 19. e; 20. b; 21. c; 22. d; 23. a; 24. c; 25. b

Thinking Scientifically

1. Na^+Cl^- interrupts hydrogen bonding enough to prevent the formation of the ice lattice that forms during freezing.
2. Chemical behavior is dependent on the number of electrons in the outer shell, not the number of neutrons in the nucleus.

CHAPTER 3

Check Your Progress

3.1: 1. The carbon atom bonds with up to four different elements. Carbon-to-carbon bonds are stable, so long chains can be built, chains can have branching patterns, and chains can form rings. Isomers are possible. 2. a. Same because both are made of pearls; different because the pearls can vary in color and source (e.g., fresh water, marine). b. Same because both are composed of amino acids; different because particular types of amino acids can be used. 3.2: 1. Humans have no digestive juices capable of breaking the bonds in cellulose. 2. The monomer in cellulose is glucose; in chitin, an amino group is attached to each glucose. Cellulose is found in plant cell walls, while chitin is in the exoskeleton of some animals. 3.3: 1. a. A saturated fatty acid contains no double bonds between carbon atoms, while an unsaturated fatty acid contains one or more double bonds; b. Unsaturated because it is not associated with high blood pressure, as is saturated. 2. In a bilayer, phospholipids arrange themselves so that their hydrophilic heads are adjacent to water, while the hydrophobic tails point inward

toward each other. 3.4: 1. Metabolism, transport (protein carrier and channels in plasma membrane), regulation (hormones). 2. The protein's sequence of amino acids is its primary structure. 3. a. The peptide bond includes a partially negative oxygen and a partially negative hydrogen. Therefore, hydrogen bonding between peptide bonds accounts for a protein's secondary structure; b. Covalent bonding between R groups, such as disulfide linkages. 3.5: 1. Phosphate, 5-carbon sugar, and nitrogen-containing base. 2. Between the two strands of DNA, the base A is hydrogen bonded to the base T, and the base C is bonded to the base G. Between a strand of DNA and RNA, the base A is hydrogen bonded to the base U, and the base C is bonded to the base G. 3. When ATP breaks down to $\text{ADP} + \text{P}$, energy is released.

Understanding the Terms

a. carbohydrate; b. lipid; c. polymer; d. isomer; e. peptide

Testing Yourself

1. c; 2. a; 3. e; 4. b; 5. c; 6. b; 7. c; 8. c; 9. d; 10. c; 11. e; 12. c; 13. a. monomer; b. monomer; c. dehydration reaction; d. H_2O ; e. monomer; f. monomer; g. polymer; 14. c; 15. d; 16. c; 17. d; 18. a; 19. a; 20. d; 21. a; 22. c; 23. b; 24. c; 25. b; 26. d; 27. a; 28. c; 29. b; 30. a; 31. d; 32. b; 33. d; 34. b; 35. c; 36. a; 37. e; 38. d

Thinking Scientifically

1. a. Subject the seeds of temperate and tropical plants, for which you know the amount and kind of fatty acid, to a range of temperatures from above freezing to below freezing for an extended length of time. Plant the seeds and compare the percentage of survivals per type of plant. b. The presence of unsaturated fatty acids in temperate plant seeds may be an adaptation to the environment.
2. Possible hypothesis: (1) The abnormal enzyme will not produce as much product per unit time as the normal enzyme. (2) The abnormal enzyme will have a different shape from the normal enzyme due to altered levels of organization.

CHAPTER 4

Check Your Progress

4.1: 1. A cell needs a relatively large surface area for absorption of nutrients

and secretion of wastes. 4.2: 1. A prokaryotic cell lacks a membrane-bounded nucleus, while a eukaryotic cell has one. 2. Cell envelope: mesosome, plasma membrane, cell wall, glycocalyx; cytoplasm: inclusion bodies, nucleoid, ribosomes; appendages: conjugation pilus, fimbriae, flagellum. 4.3: 1. Separates various metabolic processes; localizes enzymes, substrates, and products; and allows cells to become specialized. 2. Mitochondria are derived from aerobic bacteria, and chloroplasts are derived from photosynthetic bacteria that were taken into a eukaryotic cell. 4.4: 1. nuclear envelope—defines the nucleus; nuclear pore—allows substances to move into and out of nucleus; nucleolus—formation of ribosomal RNA (rRNA); chromatin—becomes chromosomes and contains DNA. 2. Ribosomes are found attached to the ER and in the cytoplasm. In the cytoplasm, they occur either singly or as polyribosomes. Ribosomes carry out protein synthesis. 4.5: 1. Rough ER contains ribosomes, while smooth ER does not. Rough ER synthesizes proteins and modifies them, while smooth ER synthesizes lipids, among other activities. 2. Transport vesicles from the ER proceed to the Golgi apparatus. The Golgi apparatus modified their contents and repackages them in new vesicles, some of which carry out secretion, and some of which are lysosomes. 4.6: 1. Both peroxisomes and lysosomes enclose enzymes; a peroxisome is a metabolic assistant to other organelles; a lysosome digests molecules and can break down cell parts and their component molecules. 2. Both the plant central vacuole and the lysosome break down cell parts but vacuoles also store molecules. 4.7: 1. Structure: The two main parts of a chloroplast are the thylakoids and the stroma; the two main parts of a mitochondrion are the cristae and the matrix. Function: Chloroplasts are larger than mitochondria and capture energy from the sun to build carbohydrates. Mitochondria break down carbohydrates to release energy for ATP production. 4.8: 1. Microtubules, intermediate filaments, and actin filaments. 2. Cilia and flagella are both composed of microtubules arranged in a particular pattern and enclosed by the plasma membrane. Cilia are shorter than flagella. 3. Cells lining the respiratory tract have cilia that sweep mucus and debris back up into the throat where it can be

swallowed or ejected; sperm have flagella that allow them to swim to the egg.

Understanding the Terms

a. Golgi apparatus; b. peroxisome;
c. nucleolus; d. cytoskeleton; e. fimbria

Testing Yourself

1. c; 2. c; 3. d; 4. a; 5. c; 6. c; 7. a; 8. d;
9. a. rough ER—produces proteins; b. chromatin—DNA specifies the order of amino acids in proteins; c. nucleolus—forms ribosomal RNA, which participates in protein synthesis; d. is not involved in protein synthesis; e. Golgi apparatus—processes and packages proteins for distribution; 10. b; 11. c; 12. e; 13. c; 14. a; 15. a. example;
b. Mitochondria and chloroplasts are a pair because they are both membranous structures involved in energy metabolism; c. Centrioles and flagella are a pair because they both contain microtubules; centrioles give rise to the basal bodies of flagella; d. ER and ribosomes are a pair because together they are rough ER, which produces proteins.

Thinking Scientifically

1. The plastid must be derived from an independent prokaryote that was taken up by a protist sometime in the past.
2. Uracil is a base found in RNA; therefore, you expect to find it in the nucleus and at the ribosomes.

CHAPTER 5

Check Your Progress

5.1: 1. The plasma membrane is a phospholipid bilayer with many embedded proteins. The polar heads are exposed and the fatty acid tail of phospholipids point inward. 2. Channel, transport, cell recognition, receptor, enzymatic, and junction proteins.
5.2: 1. A hypotonic solution has less solute and more solvent than the cell. A hypertonic solution has more solute and less solvent than the cell. 2. Both move molecules from high to low concentration. Diffusion does not require a membrane or transport proteins, while facilitated transport does. 5.3: 1. Both require a carrier protein, but active transport also requires energy. 2. Both use vesicles to transport materials across the plasma membrane. Molecules are transported out by exocytosis and in by

endocytosis. 5.4: 1. The extracellular matrix is composed of polysaccharides and proteins. In addition, the matrix in bone contains mineral salts. 2. Adhesion junctions: Intercellular filaments run between the two cells. Tight junctions: Plasma membranes are joined, and the result is an impermeable barrier. Gap junctions: Membrane channels allow molecules and ions to pass from one cell to the other. 3. A primary wall is composed of cellulose and other molecules, such as pectin. Secondary cell walls contain cellulose fibrils at right angles and also lignin that adds rigidity and strength.

Understanding the Terms

a. differentially permeable; b. osmosis;
c. hypertonic solution; d. glycoprotein;
e. phagocytosis

Testing Yourself

1. a. hypertonic—cell shrinks due to loss of water; b. hypotonic—central vacuole expands due to gain of water; 2. b; 3. b; 4. b; 5. c; 6. c; 7. e; 8. e; 9. b; 10. b; 11. See Figure 5.1, page 86; 12. b; 13. e; 14. d; 15. a; 16. e

Thinking Scientifically

1. Cl^- moves across the plasma membrane from the cytoplasm of cells into the bronchial tube. This creates a hypertonic solution that causes water to follow. In cystic fibrosis, the channels that allow Cl^- movement do not function, and the result is debilitating lung infections. 2. Fluidity of the plasma membrane is inversely correlated with the percent of saturated fatty acids in the phospholipids. Decreasing saturation of the fatty acid portion of the phospholipids would keep the membrane fluid enough to allow substances to enter and exit cells, even in colder weather.

CHAPTER 6

Check Your Progress

6.1: 1. Potential energy is stored energy, while kinetic energy is energy of motion. 2. The second energy law tells us that every energy transformation increases disorder. Entropy is the tendency toward disorder. 6.2: 1. ATP holds energy but easily gives it up because the last phosphate group can be removed, releasing energy. 2. ATP can donate a

phosphate to energize a compound for a reaction. Alternatively, it causes a molecule to change its shape and in that way bring about a change. 6.3: 1. They bring reactants together at their active site or position a substrate so it is ready to react. 2. Optimum amount of substrate and enzyme. Also, optimum pH and temperature. 6.4: 1. a. glucose; b. It gets broken down to carbon dioxide and water. 2. a. reduced; b. oxidized.

Understanding the Terms

a. metabolism; b. potential energy;
c. vitamin; d. entropy; e. coenzyme;
f. oxidation

Testing Yourself

1. e; 2. e; 3. e; 4. e; 5. d; 6. d; 7. b;
8. a. active site; b. substrates; c. product;
d. enzyme; e. enzyme-substrate complex;
f. enzyme. The shape of an enzyme is important to its activity because it allows an enzyme-substrate complex to form. 9. a; 10. a; 11. c; 12. b; 13. c; 14. c; 15. c; 16. d; 17. a; 18. c; 19. a; 20. b; 21. d; 22. d; 23. e; 24. c; 25. e; 26. c; 27. e; 28. See Figure 6.13, page 113.

Thinking Scientifically

1. Sugar breakdown releases a lot more energy per molecule than does breaking down ATP. Further, in converting sugar to ATP, energy has already been lost, and therefore, is metabolically wasteful to break down ATP. 2. Flower relies on enzymes, which lower the energy of activation, to break down glucose.

CHAPTER 7

Check Your Progress

7.1: 1. Plants, algae, and cyanobacteria. 2. Thylakoid membrane absorbs solar energy, and carbohydrate forms in stroma. 7.2: 1. O_2 is reduced to CH_2O and when the oxygen in water gives its H_2 ($2\text{H}^+ + 2\text{e}^-$), it is oxidized. 2. Light reactions use solar energy to split water and produce ATP and NADPH; Calvin cycle reactions use ATP and NADPH to reduce CO_2 to a carbohydrate. 7.3: 1. Visible light, specifically blue and red light. 2. ATP and NADPH. 7.4: 1. Carbon dioxide fixation, carbon dioxide reduction, and regeneration of RuBP. 2. Glucose, sucrose, starch, cellulose, fatty acids, glycerol, and amino acids. 7.5: 1. C_4 plants include many grasses, sugarcane, and corn; CAM

plants include cacti, stonecrops, orchids, and bromeliads. 2. C_4 plants prevent oxygen from competing with carbon dioxide for an active site on the enzyme rubisco.

Understanding the Terms

a. light reaction; b. photosystem; c. photosynthesis; d. Calvin cycle

Testing Yourself

1. e; 2. d; 3. a; 4. a, b; 5. c; 6. a, b, c; 7. b; 8. d; 9. T; 10. F; 11. F; 12. e; 13. e; 14. c; 15. See Figure 7. 4, page 121; f. thylakoid membranes; g. stroma; 16. a; 17. a. water; b. oxygen; c. carbon dioxide; d. carbohydrate; e. $ADP + P$; f. ATP; g. $NADP^+$; h. NADPH; 18. e; 19. e; 20. c; 21. c; 22. e

Thinking Scientifically

1. The bacteria were clustered where solar energy was being absorbed, and photosynthesis was occurring because it produces oxygen needed by the bacteria. 2. It is possible to extract the pigments from a leaf and test for which ones are present because each type pigment has its own absorption spectrum. Test for the pigments in both summer leaves and fall leaves to tell if the pigments were there all season or appear only in the fall.

CHAPTER 8

Check Your Progress

8.1: 1. Step by step breakdown allows much of the released energy to be captured and utilized by the cell. 2. Glycolysis, the preparatory reaction, the citric acid cycle, and the electron transport chain. The prep reaction and the citric acid cycle release CO_2 , ETC produces H_2O . 8.2: 1. During the energy-investment steps, ATP breakdown provides the phosphate groups to activate substrates. During the energy-harvesting steps, NADH and ATP are produced. 2. Fermentation occurs when oxygen is not available. Pyruvate enters the mitochondria for further breakdown when oxygen is available. 8.3: 1. Drawbacks: Most of the energy in a glucose molecule is unused and it results in a toxic end product. Benefits: The 2 ATP gained can be used as a burst of energy. 8.4: 1. The C_2 acetyl group comes from the prep reaction. 2. Per glucose molecule, the citric acid cycle produces 4 CO_2 , 6 NADH, 2 $FADH_2$, 2 ATP. 3. A dam

holds back water, just as the inner membrane holds back hydrogen ions. As water flows over a dam, electricity is produced. As hydrogen ions flow down their concentration gradient through an ATP synthase complex, ATP is produced. 8.5: 1. a. Hydrolytic reactions are catabolic. Dehydration reactions are anabolic. b. ATP breakdown is catabolic. 2. Both have an inner membrane (in chloroplasts, results in thylakoids; in mitochondria, results in cristae) where complexes form an ETC and ATP is produced by chemiosmosis. Both have a fluid-filled interior (in stroma of chloroplasts, NADPH help reduce CO_2 to a carbohydrate, and in matrix of mitochondria, NAD helps oxidize glucose products with the release of CO_2).

Understanding the Terms

a. glycolysis; b. oxygen debt; c. catabolism; d. metabolic pool; e. chemiosmosis

Testing Yourself

1. b; 2. c; 3. a; 4. c; 5. c; 6. c; 7. a; 8. b; 9. e; 10. c; 11. a; 12. c; 13. b; 14. b; 15. c; 16. d; 17. d; 18. c; 19. a; 20. b; 21. b; 22. b; 23. d; 24. a, c, d; 25. b, d; 26. a, b, d; 27. d; 28. a. cristae, contains electron transport chain and ATP synthase complex; b. matrix, location of prep reaction and citric acid cycle; c. outer membrane, defines the boundary of the mitochondrion; d. intermembrane space, accumulation of H^+ ; e. inner membrane, partitions the mitochondrion into the intermembrane space and the matrix.

Thinking Scientifically

1. Acid, because for ATP to be produced, H^+ must flow through the ATP synthase complex. 2. The two radioactive carbons were taken up by a component of the cycle and later released as CO_2 .

CHAPTER 9

Check Your Progress

9.1: 1. G₁, S, G₂, and M stage. DNA is replicated during S stage, and cell division occurs during M stage. 2. DNA damage, failure to properly replicate the DNA, and failure of chromosomes to attach properly to spindle. 9.2: 1. During prophase, the nuclear membrane fragments, the nucleus disappears, the chromosomes condense, and the spindle begins to form. Without these events, mitosis could not occur. 2.

Animal cells furrow and plant cells have a cell plate. Because plant cells have rigid cell walls, they cannot furrow. 9.3: 1. Cancer cells lack differentiation, have abnormal nuclei, fail to undergo apoptosis, may form tumors, undergo angiogenesis, and may also metastasize throughout the body. 2. Accumulating mutations allow the tumor to escape the capsule containing it, to attract new blood vessels, and ultimately allow tumor cells to enter circulation and lodge in other tissues of the body. 3. a. Cell commits to cell division even in the absence of proper stimuli. b. Cell fails to stop dividing because the proper stimuli to stop are absent. 9.4: 1. Binary fission involves inward growth of plasma membrane and cell wall concomitant with the separation of the duplicated chromosome attached to the plasma membrane. Mitosis always involves a mitotic spindle to distribute the daughter chromosomes. 2. Prokaryotes usually have a single, small circular chromosome with a few genes and only a few associated proteins. Eukaryotes have many long, linear chromosomes, which contain many thousands of genes and many more proteins.

Understanding the Terms

a. centrosome; b. centromere; c. spindle; d. sister chromatid; e. apoptosis

Testing Yourself

1. b; 2. e; 3. c; 4. a; 5. b; 6. b; 7. b; 8. e; 9. b; 10. c; 11. e; 12. b; 13. c; 14. c; 15. b; 16. d; 17. a; 18. c; 19. d; 20. e; 21. a. chromatid of chromosome; b. centriole; c. spindle fiber or aster; d. nuclear envelope (fragment); Early prophase.

Thinking Scientifically

1. Since histones are only needed during S stage, one would expect to see high amounts made then, and no synthesis at all during G₁ and G₂. 2. The radiation caused mutations to occur that can lead to cancer. The number of mutations required varies according to the type of cancer. Cancers that occurred earlier required fewer mutations than those that occurred later.

CHAPTER 10

Check Your Progress

10.1: 1. Homologous chromosomes are two copies of the same kind of chromosome, judged by length and

location of the centromere. Also, they contain genes for the same traits in the same order. 2. Homologous chromosomes pair during synapsis and then separate so each daughter cell receives one from each pair. During mitosis sister chromatids separate becoming daughter chromosomes so each daughter cell receives the same number and kinds of chromosomes as the parent cell. **10.2:** 1. Independent assortment of chromosomes creates an increased number of possible combinations of chromosomes in each gamete. Crossing-over shuffles the alleles between homologous chromosomes to create even more variation. 2. 2^4 or 16. 3. Genetic variability ensures that at least some individuals have traits that will allow a species to survive adverse conditions. **10.3:** 1. Two daughter cells that share the same parent cell from meiosis I are identical unless crossing-over occurred. 2. Interkinesis is the intervening cell cycle between meiotic divisions. It differs from interphase in that the stages of the cell cycle do not occur. The chromosomes are already duplicated. **10.4:** 1. In metaphase I of meiosis, homologous chromosomes are paired at the metaphase plate with each homologue facing opposite spindle poles. In metaphase II and mitotic metaphase, homologous chromosomes are not paired, and sister chromatids are attached to spindle fibers from opposite spindle poles. 2. Meiosis II resembles mitosis because sister chromatids are separated during both processes. Meiosis II differs from mitosis because the cells are haploid and not diploid. **10.5:** 1. In males, the primary spermatocytes located within the testes; in females, the primary oocytes located within the ovaries. 2. The bulk of the cytoplasm and other cellular contents are in the one cell that will undergo embryonic development. **10.6:** 1. Nondisjunction in meiosis may cause aneuploidy, an extra or missing chromosome. 2. Sex chromosome aneuploidy is more common because only one of the X chromosomes is active. Any extra X chromosomes become Barr bodies. 3. An inversion involves the reversal of a piece of a chromosome from within, and normally does not cause symptoms. A translocation is swapping of two chromosome fragments from one to the other, and while not usually troublesome, may cause severe problems in offspring if the two chromosomes go into separate cells.

Understanding the Terms

a. spermatogenesis; b. bivalent; c. polar body; d. secondary oocyte; e. homologue

Testing Yourself

1. b; 2. d; 3. e; 4. b; 5. a; 6. d; 7. c; 8. a; 9. c; 10. d; 11. b; 12. d; 13. 24, 12; 14. spermatogenesis, oogenesis; 15. fertilization; 16. gametes, spore; 17. diploid, haploid; 18. e; 19. b; 20. b; 21. c; 22. d; 23. a; 24. a

Thinking Scientifically

1. The homologous chromosomes separate during anaphase I. 2. It is possible because this checkpoint functions to ensure that DNA is not damaged before the second meiotic division occurs. One way that this could possibly be tested experimentally would be to induce DNA damage with radiation in cells that have completed meiosis I, and then examine the cells to see if meiosis II still occurs. 3. There is a 50% chance that the man will pass his abnormal copy of chromosome 2 to his children; likewise, the chance he will pass the abnormal copy of chromosome 6 to his children is 50%. To calculate the chance of passing both abnormal chromosomes to his child (maintaining the balanced translocation), multiply the odds of both events together (as described in Chapter 11). Thus, the chance he will pass the balanced translocation to his child is 0.25, or 25%.

CHAPTER 11

Check Your Progress

Figure 11.8: This person is heterozygous because she has a child that is affected.

Figure 11.9: This person is heterozygous because he has a child that is unaffected.

11.1: 1. Mendel was successful because he chose a good subject, always followed the same well-planned procedure, kept careful records, and used mathematical analysis to analyze his data. 2. The garden pea was a good choice because it has many easily observed traits, a relatively short generation time, each plant produces many offspring (peas), and cross pollination is only possible by hand. **11.2A:** 1.a. all W ; b. $\frac{1}{2} W$, $\frac{1}{2} w$; c. $\frac{1}{2} T$, $\frac{1}{2} t$; d. all T . 2. bb . 3. 3:1, 40. **11.2B:** 1. LG , Lg , lG , lg . 2. 9:3:3:1. **11.2C:** 1. 75% yellow; 25% green. 2. 75%. 3. a. 9:3:3:1; b. freckles, short fingers; freckles, long fingers; no freckles, short fingers; no

freckles, long fingers; c. 1/16. **11.2D:** 1. 25%. 2. $LlGg \times llgg$; $LlGg \times LlGg$. 3. $Tt \times tt$, t . **11.2E:** 1. cc , Cc . 2. 25%. 3. woman: Hh ; husband: hh . 4. 50%. **11.3A:** 1. A_1A_2 . 2. child: ii ; mother: $I^A i$; father: $I^A i$, $I^B i$, or i . 3. See Figure 11.15. **11.3B:** 3. Mother $X^B X^b$; father, $X^B Y$; female offspring are $X^B X^b$, and males are $X^b Y$. 1. $X^R X^R$ and $X^R Y$. 2. a. 100%; b. none; c. 100%.

Understanding the Terms

a. recessive allele; b. allele; c. dominant allele; d. testcross; e. genotype

Testing Yourself

1. b; 2. a; 3. c; 4. d; 5. c; 6. d; 7. a; 8. b; 9. b; 10. b; 11. a; 12. d; 13. d; 14. c; 15. c; 16. b; 17. a; 18. c; 19. autosomal dominant

Additional Genetic Problems

1. 100% chance for widow's peak and 0% chance for straight hairline; 2. 25%; 3. $Bb \times bb$; 4. 210 gray bodies and 70 black bodies; 140 = heterozygous; 5. 50%; 6. 9/16; 7. $I^A I^B$; yes, mother could be AB , A , B , O ; 8. No, because the son does not inherit alleles on the X from his father; 9. mother, $X^H X^h$, $X^H Y$, $X^h Y$.

Thinking Scientifically

1. Cross it now with a fly that lacks the characteristic. Most likely, the fly is heterozygous and only a single autosomal mutation has occurred. Therefore, the cross will be $Aa \times aa$ with 1:1 results. If the characteristic disappears in males, cross two F_1 flies to see if it reappears; it could be X-linked. 2. Give plants with a particular leaf pattern different amounts of fertilizer from none (your control) to over-enriched, and observe the results. Keep other conditions, such as amount of water, the same for all.

CHAPTER 12

Check Your Progress

12.1: 1. DNA must be able store information about the development of an organism, must be stable enough so that it can be replicated accurately, and must be able to undergo changes that provide genetic variability within a population. 2. DNA is a right-handed double helix with two strands that run in opposite directions. The backbone is composed of alternating sugar-phosphate groups, and the molecule is held together in the center by hydrogen bonds between

interacting bases. A always hydrogen bonds to T, and G to C. **12.2:** 1. (1) The DNA strands are separated by DNA helicase, (2) new nucleotides are positioned by complementary base pairing, and (3) the new nucleotides are joined together by DNA polymerase to form a new DNA strand. 2. When a DNA molecule is replicated, each copy contains one pre-existing strand and one newly made strand. 3. Prokaryotic DNA replication begins at a single origin of replication and usually proceeds in both directions towards a termination region on the opposite side of the chromosome. Eukaryotic DNA replication begins at multiple origins of replication and continues until the replication forks meet. **12.3:** 1. mRNA carries information from DNA to direct the synthesis of a protein. rRNA makes up part of the ribosomes that are used to translate messenger RNAs. tRNA transfers amino acids to the ribosome during protein synthesis. 2. Several different codons may specify the same amino acid. **12.4:** 1. Transcription proceeds along the template strand in the 3' to 5' direction. The RNA molecule is therefore built in the 5' to 3' direction. 3. The introns are spliced out and the exons joined together, and a 5' guanosine cap and a 3' poly-A tail are added as the mRNA is processed. **12.5:** 1. Transfer RNA delivers amino acids to the ribosome by binding to the appropriate codon on the mRNA being translated. 2. A ribosome consists of a small and large subunit. Each subunit is composed of a mixture of protein and ribosomal RNA. 3. Initiation of all components of the translational complex, including the first tRNA carrying methionine, are assembled. Elongation: Amino acids are delivered one by one as tRNA molecules pair with the codons on the mRNA. Termination: A stop codon is reached, a release factor binds to it, and the completed protein is cleaved from the last tRNA as the ribosomal subunits dissociate. **12.6:** 1. Euchromatin consists of the 30 nm zigzag structure that is folded into radial loops, whereas heterchromatin is further compacted by further association with scaffold proteins.

Understanding the Terms

a. intron; b. DNA polymerase; c. interspersed repeats; d. translation

Testing Yourself

1. c; 2. a; 3. e; 4. c; 5. b; 6. d; 7. e; 8. e; 9. b; 10. a. GGA GGA CUU ACG UUU; b. CCU CCU GAA UGC AAA; c. glycine-glycine-leucine-threonine-phenylalanine; 11. d; 12. a; 13. a; 14. a; 15. b, d; 16. a; 17. a; 18. c; 19. d; 20. d; 21. e; 22. e

Thinking Scientifically

1. Sequence the gene and determine if a transposon sequence is present in the sequence. 2. Isolate a plant cell and insert into the cell the gene that codes for green fluorescent protein (GFP). Allow the cell to develop into a mature plant.

CHAPTER 13

Check Your Progress

13.1: 1. An operon is a group of genes that are regulated in a coordinated manner. 2. A gene under positive control is transcribed when it is regulated by a protein that is an activator and not a repressor, whereas one under negative control is not transcribed when it is regulated by a protein that is a repressor. **13.2:** 1. Chromatin, transcriptional, posttranscriptional, translational, and after posttranslational. 2. Packing genes into heterochromatin inactivates a gene, while it is genetically active when held in loosely packed euchromatin. 3. Alternative processing of mRNA allows organisms to produce multiple types of mRNAs, and thus proteins, from a single gene, allowing cells to fine tune gene activity. **13.3:** 1. Errors in DNA replication and natural chemical changes in the bases in DNA may lead to spontaneous mutations; organic chemicals and physical mutagens like x-rays and UV radiation may cause induced mutations. 2. A frameshift mutation may shift the reading frame of a gene so that all following codons encode different amino acids, rendering the protein nonfunctional.

Understanding the Terms

a. posttranscriptional control; b. operon; c. Barr body; d. induced mutation; e. carcinogen

Testing Yourself

1. a; 2. e; 3. a; 4. b; 5. d; 6. e; 7. b; 8. b; 9. b; 10. b; 11. b; 12. e; 13. e; 14. e; 15. a. DNA; b. regulator gene; c. promoter;

d. operator; e. active repressor; 16. c; 17. d; 18. d; 19. d

Thinking Scientifically

1. Translocation may cause portions of two genes to become one gene. If so, the resulting protein could have a new activity with respect to cell cycle regulation. Alternatively, the regulatory sequences of one gene could be controlling the other gene leading to higher or lower levels of expression. Either way, the normal regulation of the cell cycle could be lost. 2. A mutation outside a gene may alter its expression if it, for example, (1) disrupts an enhancer or silencer that regulates a nearby gene or (2) affects the chromatin structure so that it changes from euchromatin to heterochromatin or the reverse in the vicinity of the gene.

CHAPTER 14

Check Your Progress

14.1: 1. To create an rDNA molecule, a piece of foreign DNA is cut with with restriction enzymes and mixed with a plasmid vector cut with the same restriction enzyme. The DNAs are mixed together and DNA ligase is added to seal the molecule. Then, it can be given to bacteria. 2. DNA molecules amplified by PCR can be used to create fingerprints, enabling paternity testing and forensic DNA analysis, among other applications. **14.2:** 1. Animals are multicellular, requiring that the genes be introduced into a fertilized egg, whereas bacteria are unicellular. 2. A transgenic animal contains recombinant DNA molecules in addition to its genome, while a cloned animal is genetically identical to the one from which it was created, but does not contain rDNA. **14.3:** 1. Liposomes, nasal sprays, and adenoviruses are currently being used to deliver genes to cells for gene therapy. 2. Ex vivo gene therapy is being used to treat SCID and familial hypercholesterolemia by adding genes to isolated bone marrow stem cells and liver cells, respectively, before returning them to the patient. In vivo gene therapy is being used to treat cystic fibrosis by introducing genes to cells in the respiratory tract, and genes are being delivered to tumors to make them more susceptible to chemotherapy. **14.4a:** 1. A tandem repeat consists of repeated sequences that are one next to the other, whereas interspersed repeats may be

spread across different portions of the same or different chromosomes. 2. We now know that much of eukaryotic DNA has functions other than coding for amino acids in proteins. **14.4b:** 1. Scientists are discovering individual differences in base sequence from the human genome sequence and how some of these differences may be linked to health and disease. 2. Proteomics gives information regarding which genes are expressed as proteins in a particular cell type or tissue, and can help us to understand what makes some cells or tissues unique. 3. Comparative genomics reveals the overall similarity in base sequence from one species to another, giving a rough idea of exactly how similar the organisms are at the molecular level.

Understanding the Terms

a. restriction enzyme; b. transgenic organism; c. xenotransplantation; d. cloning; e. polymerase chain reaction (PCR)

Testing Yourself

1. c; 2. c; 3. e; 4. d; 5. e; 6. c; 7. e; 8. a; 9. c; 10. a; 11. b; 12. d; 13. e; 14. d; 15. e; 16. a; 17. d; 18. left: AATT; right: TTAA; 19. a; 20. e

Thinking Scientifically

1. If a researcher has both a genomic clone and a cDNA clone of a gene, they may compare the sequence of the two clones to determine where the introns and exons occur within the genomic clone. 2. For example, if an individual has an oncogene, intergenic DNA might contain a silencer that decreases expression of the mutant allele. But if this intergenic DNA contained an enhancer, the additional copies of the intergenic DNA could be harmful because it could increase expression of the oncogene.

CHAPTER 15

Check Your Progress

15.1: 1. Black. 2. They would be created anew because it would be impossible to get replacement species from the surrounding area. **15.2:** 1. Variations. 2. Long-fur rabbits at top of mountain and short-fur rabbits at bottom of mountain. Longer fur would keep the rabbits warmer at the top of the mountain. **15.3:** 1. Fossils are direct evidence. Dating fossils allows you to trace the history of evolution. 2. In South America, marsupials had to compete

with placental mammals, and they became extinct. 3. No, because biogeography gives evidence of evolution when unrelated species are similarly adapted to same type of environment.

Understanding the Terms

a. biogeography; b. paleontology; c. vestigial structure; d. adaptation; e. inheritance of acquired characteristics

Testing Yourself

1. d; 2. e; 3. b; 4. e; 5. e; 6. e; 7. e; 8. e; 9. e; 10. b; 11. a; 12. b, d; 13. c; 14. a; 15. d; 16. c; 17. b, d; 18. d; 19. d; 20. Life has a history, and it's possible to trace the history of individual organisms. 21. Two different continents can have similar environments, and therefore unrelated organisms that are similarly adapted. 22. All vertebrate forelimbs contain the same sets of bones organized in similar ways. 23. All vertebrates share a common ancestor, who had pharyngeal pouches during development. 24. Similarities are expected because all species share recent and distant common ancestors. Base difference through the occurrence of mutations account for the diversity of life.

Thinking Scientifically

1. Because of the frequent rate of mutations, the virus' recognition proteins would change making it less likely the virus would be detected by the immune system. 2. Yes; due to natural selection of boll weevils resistant to the insecticide.

CHAPTER 16

Check Your Progress

16.1: 1. Over time, the allele frequency differences between the two populations will tend to disappear. 2. The offspring represent only a fraction of the genetic diversity of the original gene pool. **16.2:** 1. Directional selection because the result is a shifting of traits in one direction. 2. Sexual selection increases the ability of an organism to reproduce. **16.3:** 1. Aside from noting that mutations, gene flow, and genetic drift still occur, natural selection only acts on certain types of traits; not all traits are exposed to natural selection; the environment and selective agents can be changeable; and the heterozygote can be favored so that all three genotypes are maintained. 2. The dominant allele (p) and the recessive allele (q) must be present in the

previous generation in order for the heterozygote (pq) to appear in the next generation.

Understanding the Terms

a. stabilizing selection; b. territoriality; c. genetic drift; d. gene pool; e. gene flow

Testing Yourself

1. c; 2. c; 3. c; 4. c; 5. e; 6. b; 7. c; 8. e; 9. b; 10. See Figure 16.8, page 289; 11. a; 12. d; 13. c; 14. c; 15. a; 16. e; 17. b; 18. e; 19. e; 20. c; 21. c

Additional Genetics Problems

1. 36%; 2. 99%; 3. 0.10

Thinking Scientifically

1. Some insects are naturally resistant to the pesticide. On the first farm, the dose was low enough that even some nonresistant insects could survive to reproduce. Their offspring are also sensitive and so the pesticide retains its effectiveness for several years. The second farmer attempted to kill all pests, and the naturally resistant insects were able to survive. Therefore, in just a few seasons, the pesticide lost its effectiveness. 2. Hypothesis: females prefer bright-feathered males because their plumage indicates they are in good health and are probably more fit.

CHAPTER 17

Check Your Progress

17.1: 1. No, because ligers share the ancestry of both lions and tigers. 2. a. Habitat isolation; b. F_2 fitness. **17.2:** 1. Show that each of the cats is adapted to a different environment. 2. The fossil record would have to show fossils of the different types of cats existing in the same location at the same time—before they begin to appear in various locations. **17.3:** 1. A gradualistic model because the liger could be a transitional link. 2. *Hox* genes have a powerful affect on development and offer a mechanism by which evolution could occur rapidly. 3. Ligers are bigger than lions and tigers. 4. No, evolution is not goal oriented.

Understanding the Terms

a. postzygotic isolating mechanism; b. adaptive radiation; c. speciation; d. allopatric speciation

Testing Yourself

1. c; 2. c; 3. b; 4. f; 5. a; 6. e; 7. h; 8. e; 9. c; 10. e; 11. a. species 1; b. geographic barrier; c. genetic changes; d. species 2; e. genetic changes; f. species 3; 12. b; 13. b; 14. b; 15. d; 16. d; 17. b; 18. b; 19. c; 20. b; 21. b; 22. d; 23. b; 24. c; 25. c

Thinking Scientifically

1. Both the biological species concept and DNA sequences provide a way to identify species without the need to examine them anatomically, but the DNA sequences method is faster and unequivocal. The evolutionary species concept allows you to trace the history of an organism in the fossil record, and the biological species concept allows you to determine how species are kept separate. 2. Their chromosomes are compatible, and the two species are very closely related. It's doubtful they should be considered different species.

CHAPTER 18

Check Your Progress

18.1: 1. Serve as a template for RNA/DNA synthesis. 2. Fermentation. 18.2A: 1. Chemical evolution, evolution of first cells, evolution of eukaryotic cells by endosymbiosis, and first heterotrophic protists before photosynthetic protists. 2. Evolution of multicellularity. 18.2B: 1. During the Carboniferous period, plants and animals invaded land and the plants became the fossil fuel we burn today. 18.2C: 1. Cenozoic era. 2. Cycads and dinosaurs. 18.3: 1. Perhaps not because the continents separated during the Mesozoic period. 2. Humans did not evolve until after the last mass extinction discussed.

Understanding the Terms

a. molecular clock; b. protocell; c. liposome; d. ocean ridge; e. ozone shield

Testing Yourself

1. c; 2. d; 3. a; 4. b; 5. e; 6. b; 7. c; 8. d; 9. b; 10. b; 11. b; 12. e; 13. e; 14. c; 15. b; 16. c; 17. d; 18. a; 19. c; 20. c; 21. e; 22. c; 23. a. oldest eukaryotic fossils; b. O₂ accumulates; c. oldest known fossils; d. protists diversify; e. Ediacaran animals; f. Cambrian animals; 24. liposomes, microspheres; 25. true; 26. photosynthesizing; 27. Carboniferous; 28. Cenozoic; 29. meteorite, drift; 30. b; 31. e; 32. d

Thinking Scientifically

1. The tree shows that all life forms have a common source and how they are related, despite the occurrence of divergence, which gives rise to different groups of organisms. 2. The specialized environmental niche of these organisms is the same as it was when they first evolved.

CHAPTER 19

Check Your Progress

19.1: 1. More inclusive: class, phylum, kingdom, domain; less inclusive: family, genus, species. 2. Yes, a genus usually contains more than one species. 19.2A: 1. Determining the common ancestors indicates how many clades. Both the common ancestor and its descendants have the same derived traits. 2. The immediate common ancestor for birds is also the immediate common ancestor for certain reptiles. 19.2B: 1. See if their wings are constructed similarly. Use DNA analysis to see how closely related are insects and bats. 2. The snake and the bird have fewer differences than either has with a monkey. 19.3: 1. RNA sequence data, along with morphological data, suggested that prokaryotes were not all the same, and further, the eukarya are more closely related to archaea than they are to bacteria. 2. Molecular data (RNA/DNA sequence data) indicates that fungi are related to animals. We have no structural data for a close association.

Understanding the Terms

a. taxonomy; b. phylogenetic tree; c. taxon; d. cladistics; e. homology

Testing Yourself

1. e; 2. e; 3. d; 4. a, b, c; 5. c, d, e; 6. b, c, d, e; 7. a; 8. c; 9. a; 10. d; 11. b; 12. e; 13. b; 14. e; 15. a; 16. b; 17. e; 18. a; 19. b; 20. b; 21. c

Thinking Scientifically

1. New systems are invariably slow to spread. In the meantime, those who use the new system find it difficult to communicate with those who use the old system. On the other hand, if classification were never revised, we would still be learning Aristotle's system. 2. If you found significant differences in rRNA sequences, you might conclude that the eukaryotes belong in different domains. Most likely, the fungi, plants,

and animals would be in separate domains. Perhaps each type protist could be assigned to one of these domains since protists are ancestral to these multicellular groups.

CHAPTER 20

Check Your Progress

20.1: 1. All viruses have a nucleic acid and a capsid. 2. Viroids and prions are nonliving because, like viruses, they are noncellular and unable to reproduce without a host. 3. If a virus' host survives, many more copies of the virus will be produced and spread to other hosts than if the host dies. 20.2: 1. Prokaryotic cells lack a nucleus and membranous organelles. 2. The cell wall lies outside the plasma membrane. 3. In conjugation, the recipient prokaryotic cell acquires new DNA from the donor cell. Sexual reproduction occurs in eukaryotes and results in a new individual with a haploid set of chromosomes from each parent. 20.3: 1. The peptidoglycan layer is much thicker in Gram-positive cells than in Gram-negative cells. 2. Endospores permit survival when environmental conditions are harsh. 3. Cyanobacteria produce by photosynthesis much of the oxygen we breathe. 20.4: 1. Archaea and bacteria differ in rRNA base sequences, and their plasma membranes and cell walls are biochemically distinct. 2. Methogens, halophiles, and thermoacidophiles. 3. Archaea and eukaryotes share some of the same ribosomal proteins, initiate transcription in the same way, and have similar tRNA. 4. Archaea that inhabit livestock intestines generate methane, a greenhouse gas.

Understanding the Terms

a. lysogenic cycle; b. photoautotroph; c. saprotroph; d. symbiotic; e. archaea

Testing Yourself

1. a. attachment; b. penetration; c. integration; d. prophage; e. biosynthesis; f. maturation; g. release; 2. e; 3. e; 4. b; 5. a; 6. c; 7. d; 8. a; 9. c; 10. c; 11. c; 12. c; 13. a; 14. e; 15. e; 16. a; 17. a; 18. b; 19. d

Thinking Scientifically

1. For the most part, viruses use host enzymes, which can cause side effects. 2. Bacteria are very small and reproduce very rapidly, so it is possible to produce

and keep many generations in a small test tube or petri dish. Having only one set of genes means that any new mutations show immediately and can be more easily analyzed. Lastly, plasmids can be used as a highly effective vector in genetic engineering experiments.

CHAPTER 21

Check Your Progress

21.1: 1. Protists. 2. Algae photosynthesize and protozoans ingest their food.

3. a. Archaeplastids; b. Opisthokonts.

21.2A: 1. The zygote undergoes meiosis. 2. *Ulva*, *Chara*, and red algae.

21.2B: 1. Their DNA base sequences are similar, and their ancestor had a flagellum. 2. Water molds.

21.2C: 1. Dinoflagellates locomote by flagella, and ciliates locomote by cilia. Apicomplexans cannot locomote.

2. Dinoflagellates can photosynthesize.

21.2D: 1. By endosymbiosis of an algae. 2. They can locomote by flagella.

21.2E: 1. The amoebozoans and rhizaria have pseudopods. 2. The feeding cells of sponges resemble choanoflagellates, which are opisthokonts.

Understanding the Terms

a. pseudopod; b. euglenid; c. diatom; d. apicomplexan; e. plankton

Testing Yourself

1. f; 2. c; 3. c; 4. a; 5. b; 6. e; 7. b; 8. b; 9. e; 10. e; 11. b; 12. d; 13. a; 14. d; 15. b; 16. d; 17. b; 18. d; 19. c; 20. a; 21. b; 22. c; 23. c; 24. a. sexual reproduction; b. gametes pairing; c. zygote (2n); d. zygospore (2n); e. asexual reproduction; f. zoospores (n); g. nucleus with nucleolus; h. chloroplast; i. starch granule; j. pyrenoid; k. flagellum; l. eyespot; m. gamete formation. See also Figure 21.5, page 376.

Thinking Scientifically

1. The mutant might be missing a protein that is responsible for completing cell wall synthesis during cytokinesis. Without complete cell wall synthesis, perhaps daughter cells cannot separate. Alternatively, if a new, unusually sticky cell wall protein is being made in the mutant, then daughter cells may not be able to separate. Either would result in a filamentous phenotype. 2. If either the protozoan or the bacteria are killed, the termite should also die since it will be unable to digest its food. The bacteria

could be killed by treating the termite's food source with an antibiotic, or the protozoan could be killed with an antiprotozoan drug (similar to those used to treat protozoan infections of humans).

CHAPTER 22

Check Your Progress

22.1: 1. Animals are heterotrophs by ingestion, and fungi are heterotrophs by absorption. 2. Fungal cell walls contain chitin, and those of plants contain cellulose. 3. A fungal spore can grow into a new organism without fusing with another cell. **22.2:** 1. Chytrids have flagellated gametes and spores; other fungi are nonmotile at all stages of their life cycle. 2. Mycoses. Sac fungi. 3. Club fungi, sac fungi, sac fungi, and zygospore fungi. **22.3:** 1. Mutualism. 2. Asexually through fragmentation. 3. Lichens become scarce when air is highly polluted.

Understanding the Terms

a. basidium; b. mycelium; c. conidiospore; d. fruiting body; e. mycorrhizae; f. chytrids

Testing Yourself

1. d; 2. b; 3. c; 4. c; 5. b; 6. e; 7. e; 8. a; 9. c; 10. a; 11. c; 12. a; 13. d; 14. d; 15. a. spores; b. sporangium; c. sporangiophore; d. stolon; e. rhizoid; 16. a; 17. e; 18. e; 19. d; 20. b; 21. e; 22. a. meiosis; b. basidiospores; c. dikaryotic mycelium; d. button stage of the mushroom (basidiocarp); e. stalk; f. gill; g. cap; h. dikaryotic; i. diploid; j. zygote. See also Figure 22.9, page 402.

Thinking Scientifically

1. While yeast is usually available in the air, the kinds and abundance of yeast would be expected to vary with different weather and climate conditions. By reserving some of the dough of bread that rose in a preferred way, a cook could be sure of having enough yeast of the correct variety for the next loaf. By keeping the mother in a cool place between baking days, the yeast would divide slowly, and not accumulate levels of waste products that would start to kill the yeast. 2. A mutualistic relationship between a fungus and a plant might evolve when environmental conditions are harsh enough that neither can

survive well alone. During the transition period between free-living and symbiosis, it would be essential that fungus not harm the plant. Varieties that did kill plants would be less successful (leave fewer offspring) than varieties that did not. A parasitism lifestyle might have evolved if there were competition for free space on the ground. An additional requirement would be an abundance of host plants. Since the parasite often kills the host, there must be other hosts available for the fungus to survive.

CHAPTER 23

Check Your Progress

23.1: 1. Plentiful light and CO₂. 2. A cellulose cell wall produced in same way; apical cells that produce new tissue; plasmodesmata between cells; transfer of nutrients from haploid cells of previous generation to zygote of new generation. 3. The diploid sporophyte produces haploid spores by meiosis. The haploid gametophyte produces gametes. **23.2:** 1. Advantages: The sporophyte embryo is protected from drying out, and the sporophyte produces windblown spores that are resistant to drying out. Disadvantage: The sperm are flagellated and need an outside source of moisture in order to swim to the egg. **23.3:** 1. In lycophytes, the dominant sporophyte has vascular tissue, and therefore roots, stems, and leaves. 2. The walls of xylem contains lignin, a strengthening agent. **23.4:** 1. The independent gametophyte generation lacks vascular tissue, and it produces flagellated sperm. 2. In ferns, but not mosses, the sporophyte is dominant and separate from the gametophyte. **23.5A:** 1. (1) Water is not required for fertilization because pollen grains (male gametophytes) are windblown, and (2) ovules protect female gametophytes and become seeds that disperse the sporophyte, the generation that has vascular tissue. 2. Conifers, cycads, ginkgoes, gnetophytes. **23.5B:** 1. The stamen contains the anther and the filament. Pollen forms in the pollen sac of the anther. 2. The carpel contains the stigma, style, and ovary. An ovule in the ovary becomes a seed, and the ovary becomes the fruit. 3. Gymnosperms (cone-bearing, such as cycads and pine trees) and angiosperms (flowering plants, such as fruit trees and garden plants) produce seeds. 4. Presence of an

ovary leads to production of seeds enclosed by a fruit. Animals are often used as pollinators. 5. Animal-pollinated flowers are showy, and in different ways, such as color and fragrance, attract their particular pollinators.

Understanding the Terms

a. sporophyte; b. monocotyledon; c. pollen grain; d. rhizoid

Testing Yourself

1. e; 2. a; 3. b; 4. c; 5. b; 6. b; 7. e; 8. c; 9. c; 10. e; 11. d; 12. b; 13. a; 14. b; 15. b; 16. e; 17. c; 18. a. sporophyte (2n); b. meiosis; c. gametophyte (n); d. fertilization. See also Figure 23.3, page 412.

Thinking Scientifically

1. a. ferns; b. seed plants; c. naked seeds; d. needlelike leaves, Conifers; e. fan-shaped leaves, Gingkos; f. enclosed seeds; g. one embryonic leaf, Monocots; h. two embryonic leaves, Eudicots.
2. a. Lycophytes evolved from a common ancestor that had microphylls. b. Ferns, gymnosperms, and angiosperms evolved from a common ancestor that has megaphylls.

CHAPTER 24

Check Your Progress

24.1: 1. Vegetative organs are the leaves (photosynthesis), the stem (support, new growth, transport), and the root (absorb water and minerals). 2. Monocots: embryo with single cotyledon; xylem and phloem in a ring in the root; scattered vascular bundles in the stem; parallel leaf veins; flower parts in multiples of three. Eudicots: embryo with two cotyledons; phloem located between arms of xylem in the root; vascular bundles in a ring in the stem; netted leaf veins; flower parts in multiples of fours or fives.
24.2: 1. Epidermal tissue: epidermal cells; ground tissue: parenchyma, collenchyma, and sclerenchyma cells; vascular tissue: xylem (vessel elements and tracheids) and phloem (sieve-tube members). 2. Xylem transports water and minerals usually from roots to leaves. Phloem transports organic compounds throughout the plant. 24.3: 1. The root apical meristem is located at the tip of the root and is covered by the root cap. 2. Cortex: food storage; endodermis: control of mineral uptake; pericycle: formation of branch roots. 24.4: 1. A

vascular bundle contains xylem and phloem. 2. Vascular bundles are scattered in monocot stems and form a ring in eudicot stems. 3. Primary growth is growth in length and is nonwoody; secondary growth is growth in girth and is woody. 4. Bark is composed of cork, cork cambium, cortex, and phloem. 5. An annual ring is composed of one year's growth of wood—one layer of spring wood followed by one layer of summer wood. 24.5: 1. Photosynthesis, which produces organic food for a plant, occurs in the mesophyll.

Understanding the Terms

a. mesophyll; b. vascular cambium; c. cotyledon; d. stolon; e. xylem

Testing Yourself

1. c; 2. b; 3. c; 4. c; 5. b; 6. b; 7. b; 8. c; 9. c; 10. b; 11. d; 12. e; 13. d; 14. d; 15. d; 16. c; 17. c; 18. e; 19. a; 20. a. epidermis; b. cortex; c. endodermis; d. phloem; e. xylem. See also Figure 24.8, page 440; 21. a. upper epidermis; b. palisade mesophyll; c. leaf vein; d. spongy mesophyll; e. lower epidermis. See also Figure 24.20, page 450.

Thinking Scientifically

1. Use tissue autoradiography: allow plants to take up radioactive amino acids for a short time; at increasing intervals of time, prepare thin sections of stem; radiation will expose a photographic film, and microscopic examination of films allows the experimenter to follow the path of protein. 2. Grow stolons under various environmental conditions. Control group: These stolons are provided with a warm temperature, plentiful water, and sunlight. Make sure the nodes are touching the ground: it should be observed that new plants are arising from the nodes. Test groups: Deprive each test group of only one variable, either the mechanical stimuli of having the nodes touch the ground, or warm temperature, or water, or sunlight. Most likely, all these conditions are requirements for the growth of new plants from nodes.

CHAPTER 25

Check Your Progress

25.1: 1. a. Nitrogen and sulfur are needed to form protein. All plant roots take up nitrate (NO_3^-) and sulfate (SO_4^{2-}) from the

soil. b. Nitrogen and phosphate (HPO_4^{2-}) are needed to make nucleic acids. Plant roots also take up phosphate from the soil. 2. (1) Helps prevent soil erosion; (2) helps retain moisture; and (3) as the remains decompose, nutrients are returned to the soil. 3. Humus improves soil aeration, soil texture, increases water-holding capacity, decomposes to release nutrients for plant growth, and helps retain positively charged minerals and make them available for plant uptake. 25.2: 1. The nonpolar tails of phospholipid molecules make the center of the plasma membrane nonpolar. 2. The bacteria convert atmospheric nitrogen to nitrate or ammonium, which can be taken up by plant roots. 3. The fungus obtains sugars and amino acids from the plant. The plant obtains inorganic nutrients and water from the fungus. 25.3: 1. Evaporation of water from leaf surfaces causes water to be under tension in stems. 2. When water molecules are pulled upward during transpiration, their cohesiveness creates a continuous water column. Adhesion allows water molecules to cling to the sides of xylem vessels, so the column of water does not slip down. 3. Sugars enter sieve tubes at sources, creating pressure as water flows in as well. The pressure is relieved at the other end when sugars and water are removed at the sink.

Understanding the Terms

a. pressure-flow model; b. soil horizon; c. transpiration; d. Casparian strip; e. guard cell

Testing Yourself

1. d; 2. e; 3. a; 4. c; 5. d; 6. c; 7. d; 8. a; 9. b; 10. c; 11. d; 12. b; 13. a; 14. c; 15. c; 16. e; 17. a; 18. The diagram shows that air pressure pushing down on mercury in the pan can raise a column of mercury only to 76 cm. When water above the column is transpired, it pulls on the mercury and raises it higher than 76 cm. This suggests that transpiration would be able to raise water to the tops of trees. 19. e; 20. a. See Figure 25.13, page 466. b. After K^+ enters guard cells, water follows by osmosis and the stoma opens. 21. There is more solute in bulb 1 than in bulb 2, therefore water enters bulb 1. This creates a positive pressure that causes water, along with solute, to flow toward bulb 2. See also illustration on page 468.

Thinking Scientifically

1. Divide a large number of identical plants into control and experimental groups. Both groups are to receive the same treatment, including all necessary nutrients, but the experimental group will not be given any calcium. It is expected that only the experimental group will suffer any ill effects. If only the control or if both groups do poorly, some unknown variable is affecting the results. 2. The plants get most of their water from fog that rolls off the nearby ocean at night. Therefore at night, the plants open all their stomata and take in both moisture and carbon dioxide for photosynthesis. The stomata are closed during the day. The large number of stomata, in this unusual case, actually helps the plant to survive in a very dry environment.

CHAPTER 26

Check Your Progress

26.1: 1. Hormones coordinate the responses of plants to stimuli. 2. You could apply gibberellins to induce growth and cytokinins to increase the number of cells. 3. a. ABA maintains dormancy and closes stomata. b. Gibberellins have the opposite effect. **26.2A:** 1. It is adaptive for roots to grow toward water because it enhances their ability to extract water and dissolve minerals from the soil for plant tissues. 2. Rotating horizontally will prevent the statoliths from settling and triggering differential growth. Therefore, neither the root nor the shoot is expected to curve up or down. 3. These animals are nocturnal, so it would be a waste of energy to open their flowers and produce scent during the day. **26.2B:** 1. Red light converts Pr to P_{fr}; P_{fr} binds to a transcription factor; and the complex moves to the nucleus, where it binds to DNA so that genes are turned on or off. 2. The plant is responding to a short night, not to the length of the day. **26.2C:** 1. Plants have (1) physical and chemical defenses (e.g., secondary metabolites); (2) wound responses (e.g., proteinase inhibitors); (3) hypersensitive responses (e.g., sealing off of infected areas); and (4) relationships with animals (e.g., acacia and ants).

Understanding the Terms

a. circadian rhythm; b. gravitropism; c. abscission; d. gibberellin; e. photoperiodism

Testing Yourself

1. c; 2. a; 3. d; 4. b; 5. c; 6. c; 7. d; 8. e; 9. d; 10. d; 11. b; 12. e; 13. a; 14. c; 15. Place the banana in a closed container with a ripened fruit. 16. d; 17. c; 18. d; 19. e; 20. c; 21. b; 22. e; 23. a; 24. e; 25. b; 26. e; 27. b; 28. a.; 29. c; 30. d; 31. d

Thinking Scientifically

1. Use a plant that tracks the sun as your experimental material. Make tissue slides to confirm the presence of a pulvinus, as in Figure 26.14. Apply ABA to live pulvinus tissue under the microscope to test for the results described in Figure 26.14. 2. Shine a light underneath a plant growing on its side. If the stem now curves down, the phototropic response is greater than the gravitropic response and your hypothesis is not supported.

CHAPTER 27

Check Your Progress

27.1: 1. Male gametophytes are produced in the anther of the stamen. The female gametophyte is produced in an ovule within the ovary of the carpel. 2. Each microspore produces a two-celled pollen grain. The generative cell produces two sperm, and the tube cell produces a pollen tube. One of the four megaspores produces a seven-celled female gametophyte, called the embryo sac, within the ovule. 3. When one sperm fertilizes the egg, a zygote results. When the second sperm joins with two other nuclei of the embryo sac, the endosperm results. **27.2:** 1. The embryo is derived from the zygote; the stored food is derived from the endosperm; and the seed coat is derived from the ovule wall. 2. The ovule is a sporophyte structure produced by the female parent. Therefore, the wall (becomes seed coat) is 2n. The embryo inside the ovule is the product of fertilization and is, therefore, 2n. 3. Cotyledons are embryonic leaves that are present in seeds. Cotyledons store nutrients derived from endosperm (in eudicots). **27.3:** 1. Dry fruits, with a dull, thin, and dry covering derived from the ovary, are more apt to be windblown. Fleshy fruits, with a juicy covering derived from the ovary and possibly other parts of the flower, are more apt to be eaten by animals. 2. Eudicot seedlings have a hook shape, and monocot seedlings have a sheath to protect the

first true leaves. **27.4:** 1. Advantages to asexual reproduction include: (1) the newly formed plant is often supported nutritionally by the parent plant until it is established; (2) if the parent is ideally suited for the environment, the offspring will be as well; and (3) if distance between individuals make cross-pollination unlikely, asexual reproduction is a good alternative. 2. For example, stolons and rhizomes produce new shoots and roots; fruit trees produce suckers; and stem cuttings grow new roots and become a shoot system. 3. Tissue from leaves, meristem, and anthers can become whole plants in tissue culture.

Understanding the Terms

a. carpel; b. fruit; c. female gametophyte; d. seed; e. pollen grain

Testing Yourself

1. d; 2. a; 3. b; 4. a; 5. a; 6. e; 7. a; 8. e; 9. c; 10. d; 11. b; 12. e; 13. d; 14. c; 15. a; 16. b; 17. c; 18. e; 19. c; 20. a. diploid ; b. anther; c. ovule; d. ovary; e. haploid; f. megaspore; g. male; h. female; i. sperm; j. seed. See also Figure 27.1, page 496.

Thinking Scientifically

1. You could study (a) the anatomy of the wasp and flower, trying to determine if the mouth parts of the wasp are suitable for collecting nectar from this flower; (b) the appearance of the flower in sunlight/ultraviolet light to determine if the result is suitable to the vision of the wasp; and (c) the behavior of the wasp to see if it is suitable as a pollinator of this flower. 2. a. Use asexual reproduction through tissue culture (see Fig. 27.13). b. Continue to propagate in this manner only the most hardy plants.

CHAPTER 28

Check Your Progress

28.1: 1. Multicellular, usually with specialized tissues, ingest food, diploid life cycle. 2. Animals are descended from an ancestor that resembles a hollow spherical colony of flagellated cells. Individual cells became specialized for reproduction. Two tissue layers arose by invagination. 3. Multicellular; bilateral symmetry, three tissue layers, body cavity, deuterostome development. **28.2:** 1. Sponges are multicellular; no symmetry; no digestive cavity.

Cnidarians have true tissues; radial symmetry; have a gastrovascular cavity. **28.3:** 1. They all have bilateral symmetry, three tissue layers, and protostome development. They have no body plan, coelom, or any sort of nervous tissue. 2. Annelids and molluscs have a complete digestive tract, a true coelom, and a circulatory system (closed in annelids and open in molluscs). Flatworms have a gastrovascular cavity with only one opening, no coelom, and no circulatory system. 3. Flukes and tapeworms are parasitic flatworms. Their head region now contains hooks and/or suckers for attaching to the digestive tract (tapeworms) or blood vessel (fluke). Leeches (annelids) are external parasites. **28.4:** 1. Roundworms and arthropods are the molting protostomes. They both have a true coelom. 2. Crustaceans breathe by gills and have swimmerets. Insects breathe by tracheae and they have wings. 3. The first pair of appendages is the chelicerae (modified fangs), and the second pair is the pedipalps (hold, taste, chew food). **28.5:** 1. The larval stage is bilaterally symmetrical. 2. The water vascular system functions in locomotion, feeding, gas exchange, and sensory reception.

Understanding the Terms

a. gastrovascular cavity; b. true coelom; c. metamorphosis; d. water vascular

Testing Yourself

1. d; 2 e; 3. e; 4. e; 5. d; 6. b; 7. a; 8. c; 9. a; 10. a. tapeworm; b. mollusc; c. sponge; d. cnidaria; e. rotifer; f. flatworm; g. arthropod; 11. b; 12. b; 13. c; 14. a; 15. d; 16. a. all; b. annelids and arthropods; c. all; d. all; e. all; f. all; g. arthropods; h. mollusc; 17. a. earthworms; b. clams; c. clams; d. clams; e. earthworms; f. earthworms; g. clams; h. clams; i. earthworms; j. earthworms; 18. a. head; b. antenna; c. simple eye; d. compound eye; e. thorax; f. tympanum; g. abdomen; h. forewing; i. hindwing; j. ovipositor; k. spiracles; l. air sac; m. spiracle; n. tracheae; 19. b; 20. b; 21. d; 22. c; 23. a; 24. b; 25. c; 26. a; 27. d; 28. e; 29. c; 30. e; 31. e; 32. b

Thinking Scientifically

1. Animals that are sessile tend to be radially symmetrical because their food comes to them from all directions. There is

no need to have anterior and posterior body regions. Animals that move through their environment are bilaterally symmetrical, with the anterior portion containing sensory organs. This allows the animal to sense and respond to the environment as it travels through it. 2. (1) Drying out is not a danger. (2) Water facilitates metabolic reactions and moderates temperatures. (3) Diffusion in water helps distribute nutrients in cells. (4) Water supports animals.

CHAPTER 29

Check Your Progress

29.1: 1. Humans are chordates, and therefore, they have the four characteristics at some point in their life cycle. Humans have all four chordate characteristics as embryos. 2. A sea squirt larva has the four characteristics as a larva, then undergoes metamorphosis to become an adult, which has gill slits but none of the other characteristics.

29.2: 1. The vertebral column shows vertebrates are segmented because it is composed of repeating units. 2. Vertebrates evolved in the water where the environment prevents drying out. The terrestrial vertebrates practice internal fertilization and development with extraembryonic membranes. Amniotic fluid surrounds the embryo.

29.3: 1. All fishes are aquatic vertebrates and ectothermic. They all live in water, breathe by gills, and have a single circulatory loop (Fig. 29.9a).

2. Cartilaginous fish have jaws, two pairs of paired fins, gill slits, dermal denticles, and a skeleton made up of cartilage.

29.4: 1. a. Paired limbs, smooth, nonscaly skin that stays moist, lungs, a three-chambered heart with a double-loop circulatory pathway, sense organs adapted for a land environment, ectothermic, and have aquatic reproduction. b. Lobe-finned fish and amphibians both have lungs and internal nares that allow them to breathe air. The same bones are present in the front fins of the lobe-finned fish as in the forelimbs of early amphibians. 2. Usually, amphibians carry out external fertilization in the water. The embryos develop in the eggs until the tadpoles emerge. They then undergo metamorphosis, growing legs and reabsorbing the tail, and become adults.

29.5: 1. Paired limbs allow reptiles to locomote on land; a thick, dry skin

prevents water loss; they breathe air and have a double circulatory path; they lay a shelled egg that contains extraembryonic membranes. 2. Alligators live in fresh water and have a thick skin, two pairs of legs, powerful jaws, and a long muscular tail that allow them to capture and eat other animals that are in or come to the water's edge. Snakes have no limbs and have relatively thin skin. They live close to or in the ground and can escape detection. They use smell (Jacobson's organ) and vibrations to detect prey. Some use venom to subdue prey, which they eat whole because their jaws are distensible. 3. Yes, birds are reptiles: feathers are modified scales; they have clawed feet and a tail that contains vertebrae. If their common ancestor was a dinosaur, they are dinosaurs. **29.6:** 1. Mammals have hair or fur and mammary glands, endothermy, limbs under body, differentiated teeth, and an enlarged brain. 2. Three groups of mammals are monotremes (have a cloaca and lay eggs), marsupials (young are born immature and finish development in a pouch), and placental mammals (development occurs internally and the fetus is nourished by placenta). Placental mammals include bats (chiroptera) that can fly, primates that live in trees, whales and dolphins (cetaceans) that live in the sea, and elephants (proboscidea) that have a long trunk.

Understanding the Terms

a. endothermic; b. monotreme; c. reptile; d. notochord

Testing Yourself

1. e; 2. a; 3. c; 4. e; 5. a; 6. e; 7. b; 8. b; 9. e; 10. c; 11. a; 12. a; 13. a. pharyngeal pouches; b. dorsal tubular nerve cord; c. notochord; d. postanal tail; 14. d; 15. d; 16. a

Thinking Scientifically

1. Teeth in the jaw bones are much heavier than a beak. As with many of the characteristics of birds, beaks probably evolved due to selection pressures to decrease the body weight of birds, making flight possible. Being lower in weight also makes flight less energetically costly.

2. The skin in amphibians is highly vascularized (many blood vessels) because of its role in respiration. Since the skin is on the outside of the body, it would come in contact with pollutants in the soil and water, not just the air, like the lungs.

CHAPTER 30

Check Your Progress

- 30.1:** 1. prosimians: 6, anthropoid: 5, 4, 3, 2, 1, hominoids: 4, 3, 2, 1, hominines: 3, 2, 1, hominins: 2, 1; 2. Molecular data.
- 30.2:** 1. Standing on tree limbs to reach fruit overhead; traveling and foraging on ground. 2. Molecular data.
- 30.3:** 1. Gracile: slight of frame and smaller teeth. Robust: larger frame, massive jaws with large teeth. Diet because robust fed on tough plant material. 2. Eastern because their arm length is proportioned as in *Homo*.
- 30.4:** 1. Shows they are physically and intellectually competent. 2. *Homo* has the use of tools and fire. Most likely, *Homo erectus* men could hunt, which means they had to work together and perhaps even speak to each other. The woman may have gathered edible plants and plant products. **30.5A:** 1. Cro-Magnon made knife blades and combined them with wooden handles. They made spears that could be thrown from a distance. 2. Fossil evidence shows that humans evolved in Africa. Molecular data shows that there are few genetic differences between people today. 3. It represents symbolic thinking.
- 30.5B:** 1. People from any two ethnic groups produce fertile offspring. 2. Within ethnic groups.

Understanding the Terms

- a. anthropoid; b. Cro-Magnon; c. Neandertal; d. *Homo ergaster*; e. hominids

Testing Yourself

1. a; 2. b; 3. b; 4. d; 5. e; 6. d; 7. b; 8. c; 9. a; 10. c; 11. b; 12. d; 13. T; 14. T; 15. T; 16. T; 17. F; 18. anthropoids; 19. Africa; 20. erect, small; 21. Cro-Magnon; 22. thousands; 23. d; 24. a. modern humans; b. archaic humans; c. *Homo erectus*; d. *Homo erectus*. See also Figure 30.10, page 570.

Thinking Scientifically

- The fact that the trait has survived is usually taken as definition that the trait is more advantageous than not, even though there are "trade-offs."
- Sequence the Neandertal genome using DNA from Neandertal bones, and compare the sequence to the human genome of today. Look for sequences present in both genomes.

CHAPTER 31

Check Your Progress

- 31.1:** 1. Squamous epithelium: flat cells that line the blood vessels and air sacs of lungs; cuboidal epithelium: cube-shaped cells that line the kidney tubules and various glands; columnar epithelium: rectangular cells that line the digestive tract. 2. Fibrous connective tissue has collagen and elastic fibers in a jellylike matrix between fibroblasts; supportive connective tissue has protein fibers in a solid matrix between collagen or bone cells; fluid connective tissue lacks fibers and has a fluid matrix between blood cells or lymphatic cells. 3. Skeletal muscle, which is striated with multiple nuclei, causes bones to move when contracted. Smooth muscle, which is spindle-shaped with a single nucleus, causes the walls of internal organs to constrict. Cardiac muscle, which has branching, striated cells each with a single nucleus, causes the heart to beat. 4. Dendrites conduct signals toward the cell body; cell body contains most of the cytoplasm and the nucleus, it carries on the usual functions of the cell; and the axon conducts nerve impulses.
- 31.2:** 1. The epidermis is stratified squamous epithelium, and it protects and prevents water loss. The dermis is dense fibrous connective tissue, and it helps regulate body temperature and provides sensory reception. 2. Sweat glands are located in all regions of the skin. They help modify body temperature. Oil glands are associated with hair follicles and lubricate the hair within the follicle and the skin. 3. The dorsal cavity contains the cranial cavity and the vertebral cavity; the ventral cavity contains the thoracic cavity and the abdominopelvic cavity.
- 31.3:** 1. Homeostasis, the dynamic equilibrium of the internal environment, maintains body conditions within a range appropriate for cells to continue living. 2. Circulatory system brings nutrients and removes waste from tissue fluid. Respiratory system carries out gas exchange. Urinary system excretes metabolic wastes and maintains salt-water balance and pH of blood. 3. When conditions go beyond or below a set point, a correction is made to bring conditions back to normality again.

Understanding the Terms

- a. ligament; b. epidermis; c. striated; d. homeostasis; e. spongy bone

Testing Yourself

1. c; 2. b; 3. a; 4. e; 5. e; 6. e; 7. b; 8. e; 9. e; 10. c; 11. a. columnar epithelium, lining of intestine (digestive tract), protection and absorption; b. cardiac muscle, wall of heart, pumps blood; c. compact bone, skeleton, support and protection. 12. e; 13. d; 14. c; 15. c; 16. c, a, g; 17. e, d, b; 18. b, c, f; 19. b; 20. d; 21. a; 22. c

Thinking Scientifically

- Epithelial cells are the outer layer of protection of the body. Therefore, any mutagens in the environment contact epithelial cells first. A second factor is the high rate of cell division in these cells. Epithelial cells are constantly being sloughed off and replaced. This high rate of cell division means that spontaneous mutations arising from errors in DNA replication are more likely to occur here.
- The immune system responds to a wide variety of infectious agents. If the hypothalamus were to also respond it would be duplicating a function of the immune system. It is economical for the immune system to recognize infectious agents and signal the hypothalamus when the body's temperature set point needs to be changed. A potential disadvantage arises if the immune system signal is sent in error or cannot be turned off. Inappropriate or uncontrollable fevers could result.

CHAPTER 32

Check Your Progress

- 32.1:** 1. To carry nutrients and oxygen to cells and to carry away their wastes. 2. Both use a heart to pump fluid. An open system pumps hemolymph through channels and cavities. The hemolymph eventually drains back to the heart. A closed system pumps blood through vessels that carry blood both away from and back to the heart. The trachea, but not an open circulatory system, is more efficient because it takes oxygen directly to the muscles. **32.2:** 1. Arteries carry blood away from the heart, capillaries exchange their contents with tissue fluid, and veins return blood back to the heart. 2. The one-circuit pathway utilizes a heart with one atrium and one ventricle to send blood to the gill capillaries and then the systemic capillaries in a single loop. The two-circuit pathway pumps blood to both the pulmonary and systemic capillaries simultaneously. **32.3:** 1. The wall of the left ventricle is thicker than the wall of

the right ventricle, and it generates a greater pressure than the right ventricle. The right ventricle pumps blood into the pulmonary circuit, which takes blood only to the lungs for gas exchange, while the left ventricle pumps blood into the systemic circuit, which take blood to all the cells of the body. 2. From the body: venae cavae, right atrium, tricuspid valve, right ventricle, pulmonary semilunar valve, pulmonary trunk and arteries. From the lungs: pulmonary veins, left atrium, bicuspid valve, left ventricle, aortic semilunar valve, aorta. 3. First the atria contract, then the ventricles contract, and then they both rest. The *lub* sound occurs when the atrioventricular valves close, and the *dub* sound occurs when the semilunar valves close. 4. Thromboembolism, stroke, heart attack. **32.4:** 1. Blood transports substances to and from the capillaries, defends against pathogen invasion, helps regulate body temperature, and forms clots to prevent excessive blood loss. 2. Red blood cells are smaller, lack a nucleus, contain hemoglobin, and are red in color. White blood cells are larger, have a nucleus, do not contain hemoglobin, and are translucent in appearance. 3. Platelets accumulate at the site of injury and release a clotting factor that results in the synthesis of thrombin. Thrombin synthesizes fibrin threads that provide a framework for the clot. 4. A type B recipient has anti-A antibodies in the plasma, and they will react with the donor's red blood cells, causing agglutination.

Understanding the Terms

a. artery; b. platelet; c. plasma; d. venae cavae; e. hemoglobin

Testing Yourself

1. b; 2. b; 3. a; 4. d; 5. d; 6. c; 7. b; 8. b; 9. e; 10. e; 11. c; 12. e; 13. b; 14. c; 15. e; 16. F; 17. T; 18. F; 19. T; 20. a. blood pressure; b. osmotic pressure; c. blood pressure; d. osmotic pressure; 21. See Figure 32.7, page 599.

Thinking Scientifically

1. Artificial blood must be able to carry oxygen from the lungs to the tissues. Therefore it must contain a molecule like hemoglobin which binds oxygen and still releases it. The ion composition (K^+ , Ca^{2+} , and Na^+) of artificial blood should be similar to human blood. Most likely artificial blood would not contain formed

elements because they would be too difficult to replicate. Most likely it would not be possible to reproduce any part of the clotting mechanism also. 2. SA rapid heartbeat is not an electrically abnormal heartbeat. The space between the T wave and the P wave would be very short, and the amplitude of the QRS complex might be higher but the overall pattern should be similar to a normal ECG.

CHAPTER 33

Check Your Progress

33.1: 1. The lymphatic system consists of the lymphatic vessels, which have the same structure as cardiovascular veins, and the lymphatic organs: red bone marrow, lymph nodes, and spleen. 2. The lymphatic system absorbs fats, returns excess tissue fluid to the bloodstream, produces lymphocytes, and helps defend the body against pathogens. 3. Red bone marrow is a spongy, semisolid red tissue located in certain bones (e.g., ribs, clavicle, vertebral column, heads of femur, and humerus), which produces all the blood cells of the body. The thymus is a soft, bilobed gland located in the thoracic cavity between the trachea and the sternum where T lymphocytes mature. A lymph node is a small ovoid structure located along lymphatic vessels where lymph is cleansed. The spleen is an oval organ with a dull purplish color that cleanses the blood. **33.2:** 1. Barriers to entry (e.g., skin); inflammatory response; phagocytes and natural killer cells; protective proteins (e.g., complement). 2. Phagocytes (dendritic cells, macrophages, neutrophils) devour pathogens. Natural killer cells kill virus-infected cells and cancer cells by cell-to-cell contact. 3. Complement proteins complement (assist) the other nonspecific defenses by enhancing inflammation, binding to the surface of pathogens, and forming a membrane attack complex. **33.3:** 1. Specific defense requires that the immune system be able to (1) recognize, (2) respond to, and (3) remember foreign antigens. 2. Once we recover from an infection, the immune system remembers the antigen and we are immune to it. The immune system also reacts to foreign tissues and cancer cells. 3. B cells are responsible for antibody-mediated immunity, and T cells are responsible for cell mediated immunity. B cells produce antibodies; cytotoxic T cells attack viral-infected or cancer cells, and helper T cells produce

cytokines that stimulate the immune response. **33.4:** 1. Tissue rejection occurs when foreign tissues and organs are rejected by the body. Autoimmune diseases (e.g., rheumatoid arthritis) occur when cytotoxic T cells or antibodies mistakenly attack the body's own cells. Immune deficiency occurs when the immune system is deficient, as in AIDS. Allergies occur when the body responds to environmental substances such as pollen that normally do not provoke a response.

Understanding the Terms

a. vaccine; b. lymph; c. antigen; d. apoptosis; e. T lymphocyte

Testing Yourself

1. b; 2. e; 3. e; 4. a; 5. b; 6. c; 7. a; 8. b; 9. b; 10. a. antigen-binding sites; b. light chain; c. heavy chain; d. *V* stands for variable region; *C* stands for constant region; 11. d; 12. e 13. b; 14. d; 15. a; 16. b; 17. e; 18. d; 19. d; 20. d; 21. b; 22. b

Thinking Scientifically

1. Drugs such as cyclosporine inhibit IL-2, therefore suppressing the production of natural killer cells and cytotoxic T cells. However, it does not affect other components of the immune of healing systems, including the production of other types of white blood cells. 2. Your results indicate that an immune system that can mount an immediate response to a viral challenge tends to be indiscriminate in its response. It reacts against the virus and the body's own cells. Therefore, an autoimmune disease frequently occurs. Your results also suggest that a slow specific response is better than a fast specific response because the chance of a crippling autoimmune response is less.

CHAPTER 34

Check Your Progress

34.1: 1. When a digestive tract has both a mouth and anus, each part of the tract can become specialized as in the earthworm where the pharynx, crop, gizzard, and intestine have specialized functions. 2. Discontinuous feeders tend to eat large meals and often have a storage area, such as a crop or stomach, to hold their food before the start of the digestive process. Continuous feeders take in small amounts all the time and do not require a storage area. 3. Carnivores tend to have pointed

incisors and enlarged canine teeth to tear off pieces small enough to quickly swallow. The molars are jagged for efficient chewing of meat. Herbivores have reduced canines but sharp even incisors to clip grasses. The large flat molars grind and crush tough grasses.

34.2A: 1. Mouth, pharynx, esophagus, stomach, small intestine, large intestine, rectum, anus. 2. The small intestine finishes the digestion of proteins, fats, carbohydrates, and nucleic acids. Bile from the liver (emulsifies fat) and pancreatic juice assist digestion but so do the brush-border enzymes, so called because they are on the microvilli that extend from intestinal villi. The villi and microvilli greatly enhance the surface area of the intestinal wall, thereby assisting the small intestine's second function: absorption of the final products of digestion. **34.2B:** 1. The pancreas, the liver, and the gallbladder. 2. Pancreatic juice, which enters the duodenum, contains pancreatic amylase for the digestion of starch, trypsin for the digestion of protein, and lipase for the digestion of fat. The liver makes bile, which is stored in the gallbladder. Bile enters the duodenum where it emulsifies fat preparatory to its digestion by lipase. The liver has many other functions, such as the storage of glucose as glycogen.

34.3: 1. Starch digestion begins in the mouth where salivary amylase digests starch to maltose and pancreatic amylase continues this same process in the small intestine. Maltase and brush-border enzyme digests maltose to glucose, which enters a blood capillary. Protein digestion starts in the stomach where pepsin digests protein to peptides and continues in the small intestine where trypsin carries out this same process. The intestinal enzyme called peptidase digest peptides to amino acids, which enter a blood capillary.

34.4: 1. Vegetables, if properly chosen, can supply limited calories but all necessary amino acids and vitamins. Much urea results when excess amino acids from proteins are metabolized. The loss of water needed to excrete urea can result in dehydration and loss of calcium ions. 2. Eat well-balanced meals (limit saturated fats and instead consume unsaturated fats). Keep body weight within the normal range and exercise regularly.

Understanding the Terms

a. vitamins; b. lipase; c. lacteal; d. esophagus; e. gallbladder

Testing Yourself

1. a; 2. b; 3. d; 4. b; 5. d; 6. c; 7. e; 8. a; 9. c; 10. c; 11. e; 12. c; 13. d; 14. c; 15. a; 16. b; 17. Test tube 1: no digestion—no enzyme and no HCl; Test tube 2: some digestion—no HCl; Test tube 3: no digestion—no enzyme; Test tube 4: digestion—both enzyme and HCl are present.

Thinking Scientifically

1. The drug was probably modified by the liver. All the blood from the intestine goes to the liver where any actual or potentially poisonous compound is metabolized, or changed, in order to make it less toxic or easier to excrete via the kidneys. 2. The jaws of snakes that swallow whole animals unhinge to make this possible. The teeth curve backwards to retain the prey. Extrusion of the trachea allows breathing while slow swallowing occurs. The esophagus and stomach expand to allow passage and storage of the animal. The intestines are short because the food source is mostly protein and fat. Chemical digestion of a whole animal would require powerful digestive enzymes.

CHAPTER 35

Check Your Progress

35.1: 1. Air has a drying effect, and respiratory surfaces have to be moist. The body of a terrestrial animal provides this moisture. 2. Insects have many tracheae that branch into ever smaller tubes, which deliver oxygen to the cells. The two steps of respiration (breathing, external exchange) are not necessary. 3. Chronic bronchitis, emphysema, cancer, aneurysms, stroke, miscarriage, and many more. **35.2:** 1. During inspiration, the rib cage moves up and out, and the diaphragm contracts and moves down. As the thoracic cavity expands, air flows into the lungs due to decreased air pressure in the lungs. During expiration, the rib cage moves down and the diaphragm relaxes and moves up to its former position. Air flows out as a result of increased pressure in the lungs. 2. In the lungs, oxygen entering pulmonary capillaries combines with hemoglobin (Hb) in red blood cells to form oxyhemoglobin (HbO₂). In the tissues, Hb gives up O₂. CO₂ enters the blood and the red blood cells. Some combines with Hb to form carbaminohemoglobin HbCO₂. Most CO₂

combines with water to form carbonic acid, which dissociates into H⁺ and HCO₃⁻. The H⁺ is absorbed by the globin portions of hemoglobin to form reduced hemoglobin HbH⁺. This helps stabilize the pH of the blood. The HCO₃⁻ is carried in the plasma. **35.3:** 1. Infections: pneumonia, pulmonary tuberculosis. Environmental: pulmonary fibrosis, emphysema, bronchitis, lung cancer

Understanding the Terms

a. ventilation; b. diaphragm; c. vocal cord; d. gill; e. expiration

Testing Yourself

1. a. external respiration; b. CO₂; c. CO₂; d. tissue cells; e. internal respiration; f. O₂; g. O₂; 2. a; 3. b; 4. b; 5. d; 6. c; 7. b; 8. c; 9. b; 10. e; 11. b; 12. d; 13. d; 14. c; 15. b; 16. e; 17. b; 18. d; 19. a. nasal cavity; b. nostril; c. pharynx; d. epiglottis; e. glottis; f. larynx; g. trachea; h. bronchus; i. bronchiole. See also Figure 35. 6a, page 654.

Thinking Scientifically

1. A severed spinal cord prevents the medulla oblongata from communicating with the rib cage and diaphragm via the phrenic nerve and intercostal nerves. 2. Fetal hemoglobin must have a higher affinity of oxygen than maternal hemoglobin. Therefore it will bind to oxygen at a lower partial pressure and a lower pH than does maternal hemoglobin.

CHAPTER 36

Check Your Progress

36.1: 1. Urea is not as toxic as ammonia, and it does not require as much water to excrete; uric acid takes more energy to prepare than urea. 2. No, the workings of the nephridia stay the same, regardless of the thickness of the skin. 3. The blood of a shark is isotonic to seawater. 4. Most likely, the tonicity of a seagull's urine is about the same as that of a human because they rid the body of salt using a salt gland, not kidneys. **36.2:** 1. The kidneys. 2. All small molecules enter the filtrate, and the blood takes back what it needs. 3. It fine-tunes the reabsorption of sodium ions.

Understanding the Terms

a. Malpighian tubule; b. glomerular capsule; c. urea; d. aldosterone; e. uric acid

Testing Yourself

1. d; 2. a; 3. c; 4. b; 5. a; 6. e; 7. b; 8. e; 9. c; 10. b; 11. d; 12. a; 13. c; 14. d; 15. c; 16. d; 17. c; 18. a; 19. a. glomerular capsule; b. proximal convoluted tubule; c. Loop of the nephron; d. descending limb; e. ascending limb; f. distal convoluted tubule; g. collecting duct; h. renal artery; i. afferent arteriole; j. glomerulus; k. efferent arteriole; l. peritubular capillary network; m. renal vein. See also Figure 36.9, page 671.

Thinking Scientifically

1. A low-salt diet should by itself reduce blood pressure. Kidney damage, if it is not too serious, should then repair itself. If kidney damage came first, the low-salt diet may not by itself lower the blood pressure. 2. Angiotensin II is a vasoconstrictor, and in addition, it stimulates aldosterone secretion. Therefore, this treatment causes a large decrease in blood pressure.

CHAPTER 37

Check Your Progress

37.1: 1. A ganglion is a cluster of neuron (nerve cell) bodies. In animals with a CNS and a PNS, it is a cluster of neurons located outside the CNS. 2. Bilateral symmetry plus cephalization leads to paired sensory organs for sight, hearing, and smell, that are useful for obtaining information about the animal's environment. 3. The CNS (central nervous system) consists of the brain and spinal cord. The PNS (peripheral nervous system) is composed of nerves and ganglia. 37.2: 1. The nerve impulse would travel more quickly down the myelinated axon due to saltatory conduction. 2. a. Na^+ moves from the outside of the axon membrane to the inside. b. K^+ moves from the inside of the axon membrane to the outside. 3. Neurotransmitter molecules may be degraded by enzymes, or be taken up by the presynaptic cell. 37.3: 1. The spinal cord contains important pathways for communication between the brain and the spinal nerves which serve the rest of the body. 2. Output from the RAS functions keeps us awake. A malfunctioning RAS may stop signaling to the sleep centers in the hypothalamus, enabling them to temporarily take over and cause uncontrollable sleepiness. 3. We normally experience positive feelings when we recognize the familiar

faces of our loved ones. A disconnect between the amygdala and the cortex disables this emotional response, and the injured person, desperate for an explanation, adopts the "imposter" belief. 37.4: 1. Cranial nerves emerge from the brain; some are sensory, some are motor, and others are mixed. Spinal nerves emerge from the spinal cord; all are mixed. 2. a. The spinal cord; b. The brain. 3. The parasympathetic ("rest and digest") division dominates as you enjoy your meal, but your friend's "surprise" causes a sudden increase in sympathetic ("fight or flight") activity.

Understanding the Terms

a. reflex; b. neurotransmitter; c. autonomic system; d. ganglion; e. acetylcholine

Testing Yourself

1. b; 2. b; 3. c; 4. a; 5. a; 6. c; 7. d; 8. b; 9. b; 10. c; 11. d; 12. c; 13. c; 14. d; 15. b; 16. c; 17. b; 18. c; 19. a. central canal; b. gray matter; c. white matter; d. dorsal root; e. cell body of sensory neuron in dorsal root ganglion; f. spinal nerve; g. cell body of motor neuron; h. interneuron

Thinking Scientifically

1. The most direct cause of the fight-or-flight response is norepinephrine released by the sympathetic nervous system. If norepinephrine is being released inappropriately it could be that the postganglionic fibers are being triggered unnecessarily. If so, control could be attempted by blocking production of norepinephrine or interaction of norepinephrine with its receptor. However, the harm caused by disabling the sympathetic nervous system would probably outweigh the benefit of reducing the panic response. 2. The portion of the brain's somatosensory cortex originally devoted to sensation from an amputated limb gradually reorganizes itself; as a result, sensory input from different areas of the body is often perceived as pain in the missing limb. In addition, some portion of the sensory neurons serving the amputated leg will still be present. The axon portion of these neurons in the spinal cord would still be able to release neurotransmitter substances. The release of neurotransmitter by sensory neurons coming from an amputated limb is being perceived as pain by the brain.

CHAPTER 38

Check Your Progress

38.1: 1. Both are chemical senses that use chemoreceptors to detect molecules in the environment. 2. Sweet, sour, salty, bitter, and umami. 3. The olfactory cells that bind odor molecules are neurons, and they convey impulses directly to the olfactory bulbs of the brain. 38.2: 1. Rods are for peripheral vision and motion detection; they are well-suited for dim light. Cones are for color perception and fine detail, and are best-suited for bright light. Many rods may excite a single ganglion cell, but much smaller numbers of cones excite individual ganglion cells. 2. Sclera, choroid, retina. 3. Ganglion cell layer, bipolar cell layer, photoreceptor (rod and cone) layer. Light must pass through the ganglion and bipolar cell layers before it reaches the photoreceptor cells. 38.3: 1. a. middle; b. outer; c. inner; d. inner; e. inner; f. outer. 2. Auditory canal, tympanic membrane (eardrum), ossicles (malleus, incus, and stapes), oval window, cochlea. 3. Utricle and saccule. Semicircular canals.

Understanding the Terms

a. compound eye; b. retina; c. sclera; d. chemoreceptor; e. organ of Corti

Testing Yourself

1. e; 2. c; 3. c; 4. e; 5. d; 6. c; 7. c; 8. b; 9. d; 10. e; 11. a; 12. b; 13. c; 14. a; 15. d; 16. b; 17. d; 18. a. retina—contains sensory receptors; b. choroid—absorbs stray light; c. sclera—protects and supports eyeball; d. optic nerve—transmits impulses to brain; e. fovea centralis—makes acute vision possible; f. muscle in ciliary body—holds lens in place, accommodation; g. lens—refracts and focuses light rays; h. iris—regulates light entrance; i. pupil—admits light; j. cornea—refracts light rays. See also Figure 38.5, page 705.

Thinking Scientifically

1. Taste perception in the brain may be less in obese individuals with low density of taste buds. Measuring eating-associated brain activity may indicate taste perception. Hypothesis: If low density of taste buds causes obesity then brain activity associated with taste perception would be less in obese individuals compared to those who are not obese. While quantity of taste

perception may be related to obesity, many other factors may also be involved because eating must have various levels of control. **2.** Perhaps the increased air pressure upon submersion intensifies volume (loudness) leading to hearing loss. Hypothesis 1: If increased air pressure causes hearing loss, then hair cells of the organ of Corti will be damaged in individuals subjected to increased air pressure. Hypothesis 2: If increased air pressure causes the inability to hear high tones, then the organ of Corti at the base of the cochlea will show the greatest damage.

CHAPTER 39

Check Your Progress

39.1: Exoskeleton, endoskeleton, exoskeleton, exoskeleton, endoskeleton.
1. The tongue is a muscular hydrostat.
2. Because the muscle layers surrounding the coelom no longer contract, the hydrostatic skeleton cannot provide support for the body. **39.2:** **1.** Osteoblasts build bone and osteoclasts break it down. Osteocytes occupy lacunae. **2.** Axial, axial, appendicular, appendicular, axial, appendicular, axial, appendicular, axial.
39.3: **1.** Pair of muscles that work opposite to one another; for example, if one muscle flexes (bends) the joint the other extends (straightens) it.
2. Myofibrils are tubular contractile units that are divided into sarcomeres. Each sarcomere contains actin (thin filaments) and myosin (thick filaments). **3.** The movement of myosin heads, triggered by the release of ADP and P, that pulls thin filaments toward the center of the sarcomere.

Understanding the Terms

a. osteoblast; **b.** sliding filament model; **c.** actin; **d.** appendicular skeleton; **e.** pectoral girdle; **f.** hydrostatic skeleton

Testing Yourself

1. b; **2. f;** **3. c;** **4. e;** **5. e;** **6. b;** **7. e;** **8. b;** **9. b;** **10. c;** **11. b;** **12. e;** **13. a;** **14. e;** **15. a;** **16. c;** **17. b;** **18. b;** **19. a.** T tubule;
b. sarcoplasmic reticulum; **c.** myofibril;
d. Z line; **e.** sarcomere; **f.** sarcolemma of muscle fiber

Thinking Scientifically

1. Neurons that cause the contraction of many muscle fibers would produce more lifting power than neurons that cause the contraction of only a few fibers. Previous

experience may be the basis on which the brain “decides” how much lifting power is needed and appropriately innervates the correct number of muscle fibers. If the brain does not perceive the situation correctly, as when a large box is empty, the box or you could go flying.

2. Hypothesis 2 can be tested by determining if oral creatine is absorbed into the blood; if so, does absorbed creatine reach the inside of muscle fibers and result in a measurably greater amount of creatine phosphate?

Hypothesis 1 is probably more difficult to test since it is subject to a serious placebo effect: “Endurance” can be affected by a great many emotional factors. It would be difficult, if not impossible, to control these factors in an experimental investigation.

CHAPTER 40

Check Your Progress

40.1: **1.** Exocrine glands secrete their products through ducts, while endocrine glands generally secrete hormones into the bloodstream. **2.** Peptide hormones have receptors in the plasma membrane. Steroid hormones have receptors that are generally in the nucleus, sometimes in the cytoplasm. **3.** Peptide hormones.
40.2: **1.** PRL stimulates the mammary glands to produce milk, and oxytocin triggers milk letdown so that milk is released from the breasts. **2.** ADH and oxytocin are produced in the hypothalamus, and released from the posterior pituitary. **3.** TSH, ACTH, PRL, GH, FSH, LH, and MSH.
40.3: **1.** Angiotensin II causes arterioles to constrict; aldosterone causes reabsorption of Na⁺, accompanied by water, in the kidneys. **2.** Adrenal cortex, pineal gland, adrenal medulla, kidneys, adipose tissue, pancreas, heart, adrenal cortex, thyroid gland. **3.** PTH stimulates osteoclasts and calcitonin inhibits them

Understanding the Terms

a. thyroid gland; **b.** negative feedback; **c.** pineal gland; **d.** peptide hormone; **e.** pheromone; **f.** thymus; **g.** anabolic steroids; **h.** leptin

Testing Yourself

1. f; **2. b;** **3. c;** **4. a;** **5. e;** **6. c;** **7. d;** **8. b;** **9. d;** **10. a;** **11. e;** **12. a;** **13. e;** **14. b;** **15. e;** **16. e;** **17. a;** **18. a;** **19. a.** inhibits; **b.** inhibits; **c.** releasing hormone; **d.** stimulating hormone; **e.** target gland hormone; **20. d;**

21. b; **22. a;** **23. b;** **24. c;** **25. e;** **26. d;** **27. d;** **28. c;** **29. e;** **30. e**

Thinking Scientifically

1. Caffeine would have the effect of increasing the effect of epinephrine. cAMP is normally broken down quickly, but in the presence of caffeine, its slower breakdown would be equivalent to increasing the amount of epinephrine in the blood, and a longer or stronger response would result. **2.** The genes for all possible sexual characteristics must be present in both males and females. Like any other genes, one allele of each pair of genes is inherited from each parent. Which genes are expressed is dependent on the sex hormones present, which ultimately is dependent on the inheritance of sex chromosomes.

CHAPTER 41

Check Your Progress

41.1: **1.** Asexual reproduction allows organisms to reproduce rapidly and colonize favorable environments quickly. Sexual reproduction produces offspring with a new combination of genes that may be more adaptive to a changed environment. **2.** An oviparous animal lays eggs which hatch outside the body. A viviparous animal gives birth after the offspring have developed within the mother’s body. Ovoviviparous animals retain fertilized eggs within a parent’s body until they hatch; the parent then gives birth to the young. **3.** A shelled egg contains extraembryonic membranes which keep the embryo moist, carries out gas exchange, collect wastes, and provide yolk as food.
41.2: **1.** Seminiferous tubule, epididymis, vas deferens, ejaculatory duct, urethra. **2.** Seminal vesicles, prostate gland, and bulbourethral glands. **3.** LH, FSH. **41.3:** **1.** Ovary, oviduct, uterus, cervix, vagina. **2.** All four hormones are at their lowest or nearly lowest levels. **3.** FSH stimulates ovarian follicles to produce primarily estrogen. LH stimulates the corpus luteum to produce primarily progesterone. **41.4:** **1.** Male and female condom and the diaphragm prevent sperm from coming in contact with the egg. **2.** In AID, sperm are placed in the vagina or sometimes the uterus. In IVF, conception takes place in laboratory glassware and embryos are transferred to the woman’s uterus. In GIFT, eggs and sperm are brought together in laboratory glassware, and placed in the

oviducts immediately afterward. In ICSI, one sperm is injected directly into an egg. **41.5:** 1. Chlamydia, gonorrhea, syphilis, and bacterial vaginosis. 2. HIV infects helper T lymphocytes, which are important to the immune system because they stimulate B lymphocytes and cause them to produce antibodies. 3. Chlamydia and gonorrhea.

Understanding the Terms

a. ovulation; b. parthenogenesis;
c. progesterone; d. semen; e. gonad

Testing Yourself

1. a. seminal vesicle; b. ejaculatory duct; c. prostate gland; d. bulbourethral gland; e. anus; f. vas deferens; g. epididymis; h. testis; i. scrotum; j. foreskin; k. glans penis; l. penis; m. urethra; n. vas deferens; o. urinary bladder; 2. b; 3. e; 4. c; 5. e; 6. c; 7. c; 8. c; 9. c; 10. a; 11. a; 12. c; 13. c; 14. b; 15. e; 16. c; 17. a; 18. c; 19. b; 20. c

Thinking Scientifically

1. Fetuses take a high caloric toll on their mothers. In modern times food supply is usually sufficient for our needs, but earlier in human history the food supply may not have been as dependable. Mothers with low percentages of body fat might starve during pregnancy or the prolonged period of breast-feeding that early human infants presumably required, and thus would not be able to reproduce at all. By stopping the reproductive cycle when the body senses insufficient food reserves, the woman is perhaps better able to survive to a time when food is more plentiful. 2. The possibility exists that spermatogenesis is not occurring as it should. Therefore, it would be helpful to see if the number of cells undergoing spermatogenesis is normal. Data concerning the levels of various sex hormones in the blood would also be useful. A low testosterone level would be a significant find. It's also been suggested that many organic pollutants such as pesticides have hormonal effects that could be interfering with the normal stimulation of spermatogenesis by testosterone. Therefore, comparative sperm count data between men exposed to organic pollutants and men not exposed would be helpful.

CHAPTER 42

Check Your Progress

42.1: 1. The fast block is the depolarization of the egg's plasma

membrane that occurs upon initial contact with a sperm. The slow block occurs when the secretion of cortical granules converts the zona pellucida into the fertilization membrane. 2. Mesoderm, endoderm, ectoderm, ectoderm, mesoderm, mesoderm, mesoderm, endoderm. 3. Neurulation.

42.2: 1. Cytoplasmic segregation is the parceling out of maternal determinants as mitosis occurs. Induction is the influence of one embryonic tissue on the development of another. 2. A morphogen is a transcription factor that is distributed along a concentration gradient in the embryo and helps direct morphogenesis.

3. The homeobox encodes the homeodomain region of the protein product of the gene. The homeodomain is the DNA-binding region of the protein, which is a transcription factor.

42.3: 1. Allantois, yolk sac, and chorion. 2. The upper third of the oviduct. Morula. 3. The placenta provides gas exchange, nutrient delivery, and waste removal for the embryo and later the fetus.

Understanding the Terms

a. induction; b. germ layer; c. amnion;
d. homeobox; e. gastrula

Testing Yourself

1. b; 2. b; 3. a; 4. e; 5. b; 6. e; 7. e; 8. d; 9. a. chorion (contributes to forming placenta where wastes are exchanged for nutrients and oxygen); b. amnion (protects and prevents desiccation); c. embryo; d. allantois (blood vessels become umbilical blood vessels); e. yolk sac (first site of blood cell formation); f. chorionic villi (embryonic portion of placenta); g. maternal portion of placenta; h. umbilical cord (connects developing embryo to the placenta). See also Figure 42. 11, page 807. 10. c; 11. a; 12. d; 13. b; 14. e; 15. b; 16. c; 17. b

Thinking Scientifically

1. The gene is for a maternal determinant and such genes are only expressed as the egg is maturing. Individuals can have mutant genes and still develop normally because genes for maternal determinants are not expressed in the present generation; They are expressed in the next generation. The mutant female is sterile because none of her eggs contain the maternal determinant in question. 2. These findings tell us that *Ubx* is important in wing morphogenesis for both orders of insects, but as a homeotic

gene its role is that of a selector for target gene activity (not a simple controller of wing number). Since the effects of *Ubx* mutation are so different in flies versus butterflies, there must have been a shift in the target genes of *Ubx* since these two orders of insects diverged from their common ancestor.

CHAPTER 43

Check Your Progress

43.1: 1. Fisher lovebird (carry nesting material in beak) mated to Peach-faced lovebird (carry nesting material in rump feathers) result in offspring with intermediate behavior. Offspring of inland garter snakes (do not eat slugs) and coastal garter snakes (eat slugs) show an intermediate liking for slugs. 2. Gene for egg-laying hormone in *Aplysia* was isolated and its protein product controls egg-laying behavior. The gene *fosB* has been found to control maternal behavior in mice. **43.2:** 1. Associative learning. 2. Just hatched, laughing gull chicks instinctively peck at parents bill to be fed but their accuracy improves after a few days. 3. Chimpanzees pile up boxes to reach food and ravens use their beak and feet to bring up food attached to a string. **43.3:** 1. Pheromones are used to mark a territory so other animals of that species will stay away; honeybees do a waggle dance to guide other bees to a food source; vervet monkeys have calls that make other vervets run away. 2. Chemical (effective all the time, not as fast as auditory); auditory (can be modified but the recipient has to be present when message is sent); visual (need not be accompanied by chemical or auditory, needs light in order to receive); tactile (permits bonding; recipient must be close). 3. chemical: taste buds and olfactory receptors; auditory: ears; visual: eyes; tactile: touch receptors in skin. **43.4:** 1. One benefit of territoriality is to ensure a source of food. 2. Both an animal's reproductive strategy and sexual selection favors features that increase an animal's chance of leaving offspring. 3. Altruistic behavior is supposed to be selfless but when, for example, a child helps its parents raise siblings, the child is helping to increase some of its own genes in the next generation.

Understanding the Terms

a. territoriality; b. altruism;
c. communication; d. pheromone

Testing Yourself

1. c; 2. a; 3. d; 4. b; 5. c; 6. c; 7. d; 8. e; 9. c; 10. b; 11. d; 12. c; 13. c; 14. a; 15. c; 16. b; 17. d; 18. a; 19. c; 20. b; 21. a; 22. c; 23. a; 24. b

Thinking Scientifically

1. Evidence supporting the hypothesis would be that the sentries reproduce less than nonsentries, and that reproduction of others is enhanced by the activity of the sentry. 2. Infants could have been conditioned to turn their head toward their mother's voice.

CHAPTER 44

Check Your Progress

44.1: 1. A population is all the members of a one species that inhabit a particular area and a community is all the populations that interact within that area. 2. To develop models that explain and predict the distribution and abundance of organisms. 3. Abiotic means the nonliving aspects of an environment such as rainfall and temperature. **44.2:** 1. Population density is the number of individuals per unit area and population distribution is the pattern of dispersal of individuals across an area of interest. 2. In type I survivorship curve, most individuals survive well past the midpoint of the life span and death does not come until near the end of the life span. In type II, survivorship decreases at a constant rate throughout the life span. In type III, most individuals die young. 3. In a bell-shaped age pyramid, the pre-reproductive members represent the largest portion of the population. **44.3:** 1. An environment in which the weather, food supply etc. remains stable favors iteroparity. 2. Exponential growth ceases when the environment cannot support a larger population size, that is when the size of the population has reached the environment's carrying capacity. **44.4:** 1. As population density increases, competition and predation become more intense. 2. If a flash flood occurs, mice that can stay afloat will survive and reproduce whereas those that quickly sink will not survive and will not reproduce. In this way the ability to stay afloat will be more prevalent in the next generation. **44.5:** 1. K-strategist: allocate energy to their own growth and survival and to the growth and survival of their limited number of offspring. r-strategist:

allocate energy to producing a large number of offspring and little or no energy goes into parental care. **44.6:** 1. More-developed countries have a low rate of population growth while the less-developed countries have a high population growth. 2. When there are more women entering the reproductive years than those that are leaving them behind. 3. Since resources are in limited supply, consumption in the MDC will have to decrease.

Understanding the Terms

a. demographic transition; b. population; c. exponential growth; d. carrying capacity; e. biotic potential

Testing Yourself

1. d; 2. c; 3. e; 4. b; 5. b; 6. e; 7. c; 8. e; 9. c; 10. e; 11. c; 12. e; 13. b; 14. e; 15. e

Thinking Scientifically

1. If the parasites killed a significant number of moths, there would be fewer moth hosts the next year. Evolution would seem to favor a parasite that was not too efficient in killing its host, since that would ensure an adequate supply of hosts for future generations of parasites. 2. Determine the original normal flow of the river and maintain the flow as close to normal as possible.

CHAPTER 45

Check Your Progress

45.1: 1. An organism's habitat is the place where it lives and reproduces. The niche is the role it plays in its community such as whether it is a producer or consumer. 2. The two factors are (1) the predator causes the prey population to decline leading to a decline in the predator population; later when the prey population recovers so does the predator population; (2) lack of food causes the prey population to decline followed by the prey population; later when food is available to the prey population they both recover. 3. Acacias feed the ants that protect them from herbivores; Clark's nutcrackers feed on the seeds of whitebark pine trees but also disperse the seeds; pollinators take nectar from flowers and carry their pollen to other flowers of the same species. **45.2:** 1. No, ecological succession is observable (see Figure 45.14) but ecologists want to provide an explanation for succession and decide if it results in a "climax

community". **45.3:** 1. A producer of food (photosynthesizer) is at the base of an ecological pyramid. 2. Energy passes from one population to the next and at each step more is converted to heat until all of the original input is heat. Therefore energy flows through an ecosystem. Chemicals pass from one population to the next and then recycle back to the producer populations again. 3. Return of CO₂ to the atmosphere because humans burn fossil fuels and destroy forests that take up CO₂.

Understanding the Terms

a. food web; b. habitat; c. ecological succession; d. nitrogen fixation

Testing Yourself

1. c; 2. e; 3. e; 4. a; 5. c; 6. b; 7. d; 8. b; 9. c; 10. d; 11. e; 12. a. producers; b. consumers; c. inorganic nutrient pool; d. decomposers; 13. a; 14. e; 15. c; 16. d; 17. c; 18. c; 19. b; 20. c; 21. d; 22. d

Thinking Scientifically

1. Observe the birds carefully to see if they differ in habitat and food requirements, relationships with other organisms, time of day for feeding and season of year for reproduction, and effect on abiotic environment. 2. Fill a large container with water from the pond. Add phosphate slowly over several days or months, and when you see growth, calculate the amount of phosphate you need for the pond.

CHAPTER 46

Check Your Progress

46.1: 1. Because the Earth is a sphere, the sun's rays hit the equator straight on but are angled to reach the poles. 2. The windward side of the mountain receives more rainfall than the other side. Winds blowing over bodies of water collect moisture that they lose when they reach land. **46.2:** 1. A tropical rain forest has a canopy (tops of great variety of tall evergreen hardwood trees) with buttressed trunks at ground level. Long lianas (hanging vines) limb into the canopy. Epiphytes grow on the trees. The understory consists of smaller plants and the forest floor is very sparse. A temperate deciduous forest contains trees (oak, beech, sycamore, and maple) that lose their leaves in the fall. Enough light penetrates the canopy to allow a

layer of understory trees. Shrubs, mosses, and ferns grow at ground level. 2. The savanna is an expansive grassland that has a moderate climate. Therefore, the grasses keep producing throughout the year and provide plentiful food for a great variety of and number of herbivores that provide food for carnivores. The tundra is cold much of the year and has a limited growing season; therefore, its productivity is low and it supports only small populations of a few types of herbivores. **46.3:** 1. Most of the open ocean is the pelagic zone (open waters) divided into the epipelagic zone (contains phytoplankton, zooplankton, many types of fishes and also dolphins and whales). The mesopelagic zone contains only carnivores adapted to the absence of light. The bathypelagic zone is incomplete darkness that contains strange-looking fishes and invertebrates. Few vertebrates but many invertebrates (echinoderms, tube worms) exist on the abyssal plain and feed on debris that floats down from above.

Understanding the Terms

a. estuary; **b.** pelagic zone; **c.** taiga; **d.** savanna; **e.** spring turnover

Testing Yourself

1. b; 2. d; 3. c; 4. d; 5. a; 6. b; 7. e; 8. e; 9. a; 10. a; 11. b; 12. d; 13. b; 14. a; 15. c; 16. b; 17. a; 18. d; 19. c

Thinking Scientifically

1. Bacteria and fungi grow in warm, moist environments, such as tropical rain forests. 2. Wetlands act as buffers between the land and sea. They can absorb much of the water coming in from the ocean.

CHAPTER 47

Check Your Progress

47.1: 1. Conservation biology studies all aspects of biodiversity with the goal of conserving natural resources for all generations. 2. Biodiversity includes the number of species on Earth; genetic diversity (variations in a species); ecosystem diversity (interactions of species); landscape diversity (interactions of ecosystems). **47.2:** 1. Direct value is a service that is immediately recognizable such as producing a medicine, food, or commercial product. Indirect value may not be as noticeable as in assisting biogeochemical cycles waste disposal, providing fresh water, preventing soil erosion, regulating climate or providing a place to vacation. **47.3:** 1. Habitat loss,

exotic species, pollution, overexploitation, disease. 2. Exotic plants displace native plants, predators introduced to kill pests also kill native animals; escaped animals may compete with, prey on, hybridize with or introduce diseases into native populations. **47.4:** 1. A landscape involves more than one ecosystem and sometimes keystone species move between ecosystems. 2. Begin as soon as possible, mimic natural processes, strive for sustainable development while providing services to humans.

Understanding the Terms

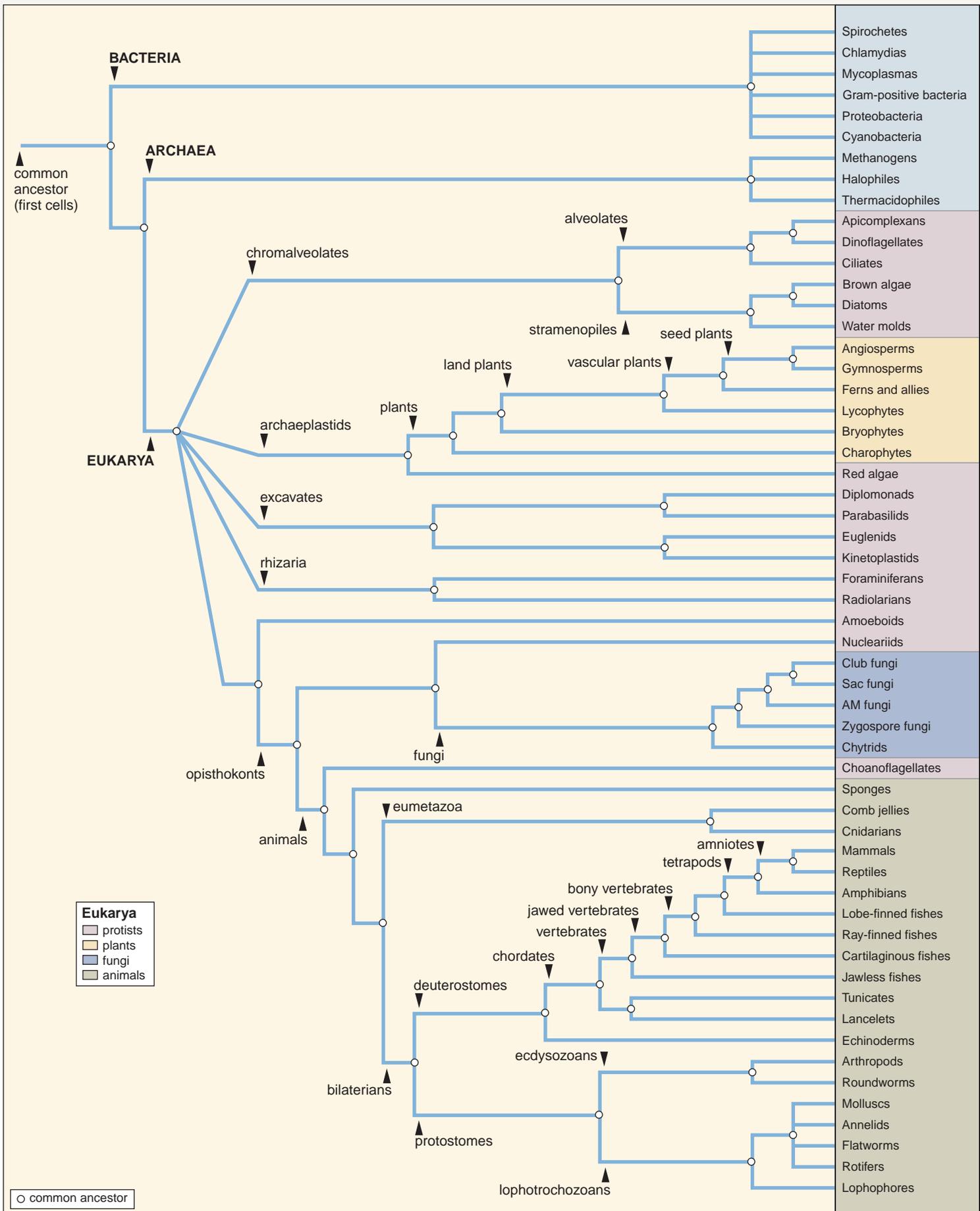
a. biodiversity hotspot; **b.** metapopulation; **c.** source population; **d.** threatened species

Testing Yourself

1. e; 2. b; 3. d; 4. e; 5. e; 6. e; 7. b; 8. e; 9. e; 10. c; 11. c; 12. e; 13. b; 14. e; 15. e; 16. a; 17. e; 18. b, c; 19. **a.** habitat loss; **b.** introduction of exotic species; **c.** pollution; **d.** overexploitation; **e.** disease

Thinking Scientifically

1. Natural history data on all species in the forest. 2. Species that show natural resistance to disease.



APPENDIX B

TREE OF LIFE

The Tree of Life depicted in this appendix is based on the phylogenetic (evolutionary) trees presented in the text. Figure 1.5 showed how the three domains of life—Bacteria, Archaea, and Eukarya—are related. This relationship is also apparent in the Tree of Life, which combines the individual trees given in the text for eukaryotic protists, plants, fungi, and animals. In combining these trees, we show how all organisms may be related to one another through the evolutionary process.

The text also described the organisms that are included in the tree. These descriptions are repeated here.

PROKARYOTES

Domains Bacteria and Archaea (Chapter 20) constitute the prokaryotic organisms that are characterized by their simple structure but a complex metabolism. The chromosome of a prokaryote is not bounded by a nuclear envelope, and therefore, these organisms do not have a nucleus. Prokaryotes carry out all the metabolic processes performed by eukaryotes and many others besides. However, they do not have organelles, except for plentiful ribosomes.

DOMAIN BACTERIA

Bacteria are the most plentiful of all organisms, capable of living in most habitats, and carry out many different metabolic processes. While most bacteria are aerobic heterotrophs, some are photosynthetic, and some are chemosynthetic. Motile forms move by flagella consisting of a single filament. Their cell wall contains peptidoglycan and they have distinctive RNA sequences.

DOMAIN ARCHAEA

Their cell walls lack peptidoglycan, their lipids have a unique branched structure, and their ribosomal RNA sequences are distinctive.

Methanogens. Obtain energy by using hydrogen gas to reduce carbon dioxide to methane gas. They live in swamps, marshes and intestines of mammals.

Extremophiles. Able to grow under conditions that are too hot, too cold, and too acidic for most forms of life to survive.

Nonextreme archaea. Grow in wide variety of environments that are considered within the normal range for living organisms.

DOMAIN EUKARYA

Eukarya have a complex cell structure with a nucleus and several types of organelles that compartmentalize the cell. Mitochondria that produce ATP and chloroplasts that produce carbohydrate are derived from prokaryotes that took up residence in a larger nucleated cell. Protists tend to be unicellular, while plants, fungi, and animals are multicellular with specialized cells. Each multicellular group is characterized by a particular mode of nutrition. Flagella, if present, have a 9 + 2 organization.

PROTISTS

The protists (Chapter 21) are a catchall group for any eukaryote that is not a plant, fungus, or animal. Division into six supergroups is a working hypothesis that is subject to change as more is known about the evolutionary relationships of the protists. A supergroup is a major eukaryotic group and six supergroups encompass all members of the domain Eukarya including protists, plants, fungi, and animals.

Archaeplastids. A supergroup of photosynthesizers with plastids derived from endosymbiotic cyanobacteria. Includes land plants and other photosynthetic organisms, such as green and red algae and charophytes, exemplified by the stoneworts, which share a common ancestor with land plants.

Chromalveolates. A supergroup that includes the Stramenopiles, which have a unique flagella, and the Alveolates, which have small sacs under plasma membrane.

Stramenopiles. Includes brown algae, such as *Laminaria* and *Fucus*, diatoms, golden brown algae, and water molds.

Alveolates. Includes dinoflagellates, ciliates such as *Paramecium*, and apicomplexans, such as *Plasmodium vivax*.

Excavates. Have an excavated oral groove and form a supergroup that includes zooflagellates, such as euglenids (e.g., *Euglena*); diplomonads, such as *Giardia lamblia*; and kinetoplastids (have a DNA granule called a kinetoplast), such as trypanosomes.

Amoebozoans. Supergroup of amoeboid cells that move by pseudopodia. Includes amoeboids, such as *Amoeba proteus*, and slime molds.

Rhizarians. Supergroup of amoeboid cells with tests. They form a supergroup that includes the foraminiferans and the radiolarians.

Opisthokonts. Supergroup named for members that have a single posterior flagellum (Gk., *opistho*, rear and *kontos*, pole). Includes animals and choanoflagellates that may be related to the common ancestor of animals and the fungi.

PLANTS

Plants (Chapter 23) are photosynthetic eukaryotes that became adapted to living on land. Includes aquatic green algae called charophytes, which have a haploid life cycle and share certain traits with the land plants.

Land Plants (embryophytes)

Have an alternation of generation life cycle; protect a multicellular sporophyte embryo; produce gametes in gametangia; possess apical tissue that produces complex tissues; and a waxy cuticle that prevents water loss.

Bryophytes. Low-lying, nonvascular plants that prefer moist locations: the dominant gametophyte produces flagellated sperm. The sporophyte is unbranched, and dependent sporophyte produces windblown spores. Includes mosses, liverworts, and hornworts.

Vascular Plants

Have a dominant, branched sporophyte with vascular tissue: a lignified xylem that transports water, and phloem that transports organic nutrients. Typically produces roots, stems, and leaves; the gametophyte is eventually dependent on the sporophyte.

Lycophytes (club mosses). Have leaves called microphylls, which have a single, unbranched vein. The sporangia, which are borne on sides of leaves, produce windblown spores. The independent and separate gametophyte produces flagellated sperm.

Ferns and their allies. Have leaves called megaphylls that have branched veins. The dominant sporophyte produces windblown spores in sporangia borne on leaves, and the independent and separate gametophyte produces flagellated sperm. Includes ferns, whisk ferns, and horsetails, see pages 417-418.

Seed Plants

Have leaves that are megaphylls; a dominant sporophyte produces heterospores that become dependent male and female gametophytes. Male gametophyte is pollen grain and female gametophyte develops within ovule, which becomes a seed.

Gymnosperms. Large, cone-bearing trees. The sporophyte bears pollen cones, which produce windblown pollen (male gametophyte), and seed cones, which bear ovules. Ovules develop into naked seeds. Includes conifers, gnetophytes, the ginko, and cycads, see pages 420-422.

Angiosperms (flowering plants). Nonwoody or woody plants that live in all habitats. The sporophyte bears flowers, which produce pollen grains, and bear ovules within ovary. Following double fertilization, ovules become seeds that enclose a sporophyte embryo and endosperm (nutrient tissue). Fruit develops from ovary.

FUNGI

Fungi (Chapter 22) have multicellular bodies composed of hyphae; usually absorb food and lack flagella; and produce nonmotile spores during both asexual and sexual reproduction. Chytrids (Chytridiomycota) are aquatic fungi with flagellated spores and gametes.

Zygospor fungi (Zygomycota). Exemplified by black bread mold; produce a thick-walled zygospor during sexual reproduction.

AM fungi (Glomeromycota). Form a mutualistic relationship with plants called mycorrhizae.

Sac fungi (Ascomycota). Exemplified by cup fungi; produce fruiting bodies during sexual reproduction where spores develop fingerlike sacs called asci.

Club fungi (Basidiomycota). Exemplified by mushrooms; produce fruiting bodies during sexual reproduction where spores develop in club-shaped structures called basidia.

ANIMALS

Animals (Chapters 28 and 29) are multicellular, usually with specialized tissues and digestive cavity; ingest or absorb food; and have a diploid life cycle.

Sponges. Have an asymmetrical, saclike body perforated by pores internal cavity lined by food-filtering cells called choanocytes; spicules serve as internal skeleton.

Ctenophores. Have two tentacles; eight rows of cilia that resemble combs; biradial symmetry. Includes comb jellies.

Cnidarians. Radially symmetrical with two tissue layers; sac body plan; and tentacles with nematocysts. Includes hydras, jellyfish, sea anemones, and corals.

Protostomes

Bilaterally symmetrical with protostome development in which the first opening is the mouth.

Lophotrochozoans

Includes lophophores, which have a specific type of ciliated feeding device (see page 516); and trochophores, which have a trochophore larva or their ancestors had one.

Flatworms. Bilaterally symmetrical with cephalization; have three tissue layers and organ systems, including both male and female sex organs. They are acoelomate with an incomplete digestive tract that can be lost in parasites. Planarians are free-living; flukes and tapeworms are parasitic.

Rotifers (aquatic wheel animals). Microscopic aquatic animals with a corona (crown of cilia) that looks like a spinning wheel when in motion.

Annelids. Segmented with body rings and setae. Cephalization occurs in some polychaetes. They utilize the coelom as a hydroskeleton and have a closed circulatory system. Includes earthworms, polychaetes, and leeches.

Molluscs. Have a foot, mantle, and visceral mass. The foot is variously modified; in many, the mantle secretes a calcium carbonate shell. They have a coelom and all organ systems. Includes clams, snails, and squids.

Ecdysozoa

Animals that undergo ecdysis (molting).

Roundworms. Have a pseudocoelom, which they use as a hydroskeleton, and a complete digestive tract. Although many are free-living, parasites such as *Ascaris*, pinworms, hookworms, and filarial worms are well known.

Arthropods. Have a chitinous exoskeleton with jointed appendages, specialized for particular functions. Insects, many of which are winged, are the most numerous of all arthropods and animals. Includes crustaceans, spiders, scorpions, centipedes, and millipedes, in addition to insects.

Deuterostomes

Bilaterally symmetrical with deuterostome development in which the second opening is the mouth.

Echinoderms. Radial symmetry as adults; unique water-vascular system; and associated tube feet. Their endoskeleton is composed of calcium plates. Includes sea stars, sea urchins, sand dollars, and sea cucumbers.

Chordates. Have a notochord, dorsal tubular nerve cord, pharyngeal pouches, and postanal tail at some time; segmentation has led to specialization of parts. Includes tunicates, lancelets, and vertebrates.

Lancelets (Cephalochordates). Marine, nonvertebrate chordates shaped like a lance that retain the four chordate characteristics as an adult. Segmentation of muscles is obvious.

Tunicates (Urochordates). Marine, nonvertebrate chordates that produce a tunic, a tough sac containing mainly cellulose. Only the larva has the characteristics of chordates; the adult has gill slits. Segmentation is not present.

Vertebrates (Vertebrata). Chordates in which the notochord has been replaced with vertebrae. Vertebrae, which make up the spine, are an obvious sign of segmentation.

Fishes. Diverse group of marine or freshwater vertebrates that breathe by means of gills and have a single-looped and closed blood circuit. Vertebral column of bone or cartilage; most have jaws and paired appendages. Includes jawless, cartilaginous, ray-finned, and lobe-finned fishes.

Amphibians. Vertebrates with lungs, cutaneous respiration, and a three-chambered heart. Frogs and salamanders have legs but caecilians do not.

Reptiles. Vertebrates fully adapted to living on land because they have an amniotic-shelled egg, dry, scaly skin, and a rib cage. Turtles, lizards, and snakes have a three-chambered heart but crocodiles and alligators have a four-chambered heart. Birds are crocodylians unique among reptiles because they have feathers and are endothermic.

Mammals. Vertebrates characterized by fur and mammary glands. They are endothermic amniotes that, for the most part, practice internal fertilization and development. Monotremes lay shelled eggs; marsupials have a pouch where offspring finish development; and placental mammals produce young capable of independency.

APPENDIX C

Metric System

Unit and Abbreviation	Metric Equivalent	Approximate English-to-Metric Equivalents	Units of Temperature	
Length				
nanometer (nm)	= 10^{-9} m (10^{-3} μ m)			
micrometer (μ m)	= 10^{-6} m (10^{-3} mm)			
millimeter (mm)	= 0.001 (10^{-3}) m			
centimeter (cm)	= 0.01 (10^{-2}) m	1 inch = 2.54 cm 1 foot = 30.5 cm		
meter (m)	= 100 (10^2) cm = 1,000 mm	1 foot = 0.30 m 1 yard = 0.91 m		
kilometer (km)	= 1,000 (10^3) m	1 mi = 1.6 km		
Weight (mass)				
nanogram (ng)	= 10^{-9} g			
microgram (μ g)	= 10^{-6} g			
milligram (mg)	= 10^{-3} g			
gram (g)	= 1,000 mg	1 ounce = 28.3 g 1 pound = 454 g		
kilogram (kg)	= 1,000 (10^3) g	= 0.45 kg		
metric ton (t)	= 1,000 kg	1 ton = 0.91 t		
Volume				
microliter (μ l)	= 10^{-6} l (10^{-3} ml)			
milliliter (ml)	= 10^{-3} liter = 1 cm ³ (cc) = 1,000 mm ³	1 tsp = 5 ml 1 fl oz = 30 ml		
liter (l)	= 1,000 ml	1 pint = 0.47 liter 1 quart = 0.95 liter 1 gallon = 3.79 liter		
kiloliter (kl)	= 1,000 liter			
°C	°F			
100	212	Water boils at standard temperature and pressure.		
71	160	Flash pasteurization of milk		
57	134	Highest recorded temperature in the United States, Death Valley, July 10, 1913		
41	105.8	Average body temperature of a marathon runner in hot weather		
37	98.6	Human body temperature		
13.7	56.66	Human survival is still possible at this temperature.		
0	32.0	Water freezes at standard temperature and pressure.		

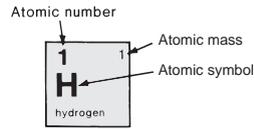
To convert temperature scales:

$$^{\circ}\text{C} = \frac{(^{\circ}\text{F} - 32)}{1.8}$$

$$^{\circ}\text{F} = 1.8 (^{\circ}\text{C}) + 32$$

APPENDIX D

Periodic Table of Elements



group Ia																				VIIIa															
1 H hydrogen									2 He helium																										
3 Li lithium	4 Be beryllium																	5 B boron	6 C carbon	7 N nitrogen	8 O oxygen	9 F fluorine	10 Ne neon												
11 Na sodium	12 Mg magnesium																	13 Al aluminum	14 Si silicon	15 P phosphorus	16 S sulfur	17 Cl chlorine	18 Ar argon												
19 K potassium	20 Ca calcium	21 Sc scandium	22 Ti titanium	23 V vanadium	24 Cr chromium	25 Mn manganese	26 Fe iron	27 Co cobalt	28 Ni nickel	29 Cu copper	30 Zn zinc	31 Ga gallium	32 Ge germanium	33 As arsenic	34 Se selenium	35 Br bromine	36 Kr krypton																		
37 Rb rubidium	38 Sr strontium	39 Y yttrium	40 Zr zirconium	41 Nb niobium	42 Mo molybdenum	43 Tc technetium	44 Ru ruthenium	45 Rh rhodium	46 Pd palladium	47 Ag silver	48 Cd cadmium	49 In indium	50 Sn tin	51 Sb antimony	52 Te tellurium	53 I iodine	54 Xe xenon																		
55 Cs cesium	56 Ba barium	57 La lanthanum	72 Hf hafnium	73 Ta tantalum	74 W tungsten	75 Re rhenium	76 Os osmium	77 Ir iridium	78 Pt platinum	79 Au gold	80 Hg mercury	81 Tl thallium	82 Pb lead	83 Bi bismuth	84 Po polonium	85 At astatine	86 Rn radon																		
87 Fr francium	88 Ra radium	89 Ac actinium	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg Roentgenium	112 ***	114 ***	116 ***																						

58 Ce cerium	59 Pr praseodymium	60 Nd neodymium	61 Pm promethium	62 Sm samarium	63 Eu europium	64 Gd gadolinium	65 Tb terbium	66 Dy dysprosium	67 Ho holmium	68 Er erbium	69 Tm thulium	70 Yb ytterbium	71 Lu lutetium					
90 Th thorium	91 Pa protactinium	92 U uranium	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium					

GLOSSARY

A

- abscisic acid (ABA)** (ab SIH sick) Plant hormone that causes stomata to close and initiates and maintains dormancy. 480
- abscission** (ab SIH shun) Dropping of leaves, fruits, or flowers from a land plant. 480
- absolute dating (of fossils)** Determining the age of a fossil by direct measurement, usually involving radioisotope decay. 324
- absorption spectrum** Pattern of absorption when pigments take up various wave lengths of light.
- acetylcholine (ACh)** (uh see tuhl KOH lean) Neurotransmitter active in both the peripheral and central nervous systems. 686
- acetylcholinesterase (AChE)** (uh see tuhl KOH lean ESS turr raze) Enzyme that breaks down acetylcholine within a synapse. 686
- acid** Molecules tending to raise the hydrogen ion concentration in a solution and to lower its pH numerically. 32
- acid deposition** The return to Earth in rain or snow of sulfate or nitrate salts of acids produced by commercial and industrial activities. 861
- acromegaly** (ack row MEG uh lee) Condition resulting from an increase in growth hormone production after adult height has been achieved. 742
- actin** (ACK tin) One of two major proteins of muscle; makes up thin filaments in myofibrils of muscle fibers. *See also* myosin. 728
- actin filament** Muscle protein filament in a sarcomere; its movement shortens the sarcomere, yielding muscle contraction. Actin filaments play a role in the movement of the cell and its organelles. 78
- action potential** Electrochemical changes that take place across the axomembrane; the nerve impulse. 685
- active immunity** Ability to produce antibodies due to the immune system's response to a microorganism or a vaccine. 620
- active site** Region on the surface of an enzyme where the substrate binds and where the reaction occurs. 108
- active transport** Use of a plasma membrane carrier protein to move a molecule or ion from a region of lower concentration to one of higher concentration; it opposes equilibrium and requires energy. 94
- adaptation** Organism's modification in structure, function, or behavior suitable that better suits the environment. 5, 273
- adaptive radiation** Rapid evolution of several species from a common ancestor into new ecological or geographical zones. 306
- Addison disease** (ADD dih sun) Condition resulting from a deficiency of adrenal cortex hormones; characterized by low blood glucose, weight loss, and weakness. 746
- adenine (A)** (AD duh neen) One of four nitrogen-containing bases in nucleotides composing the structure of DNA and RNA. Pairs with uracil (U) and thymine (T). 214
- adenosine** (ad DEN oh seen) Portion of ATP and ADP that is composed of the base adenine and the sugar ribose. 53
- adhesion junction** (ad HE shun) Junction between cells in which the adjacent plasma membranes do not touch but are held together by intercellular filaments attached to buttonlike thickenings. 98
- adipose tissue** (AD dip ose) Connective tissue in which fat is stored. 580
- ADP (adenosine diphosphate)** (ad DEN oh seen dye FOSS fate) Nucleotide with two phosphate groups that can accept another phosphate group and become ATP. 53, 106
- adrenal cortex** (uh DREEN uhl) Outer portion of the adrenal gland; secretes mineralocorticoids, such as aldosterone, and glucocorticoids, such as cortisol. 745
- adrenal gland** Gland that lies atop a kidney; the *adrenal medulla* produces the hormones epinephrine and norepinephrine, and the *adrenal cortex* produces the glucocorticoid and mineralocorticoid hormones. 745
- adrenal medulla** Inner portion of the adrenal gland; secretes the hormones epinephrine and norepinephrine. 745
- adrenocorticotropic hormone (ACTH)** (uh DREEN oh core tic oh TROH pick) Hormone secreted by the anterior lobe of the pituitary gland that stimulates activity in the adrenal cortex. 740
- adventitious root** (ad vin TIH shus) Fibrous roots that develop from stems or leaves, such as the prop roots of corn or the holdfast roots of ivy. 442
- aerobic** Phase of cellular respiration that requires oxygen. 135
- age structure diagram** In demographics, a display of the age groups of a population; a growing population has a pyramid-shaped diagram. 823
- agglutination** (ag glue tin NAY shun) Clumping of red blood cells due to a reaction between antigens on red blood cell plasma membranes and antibodies in the plasma. 609
- agnathan** (ag NATH uhn) Fishes that lack jaws; Namely, the lampreys and hagfishes. 543
- aldosterone** (al DOSS turr own) Hormone secreted by the adrenal cortex that regulates the sodium and potassium ion balance of the blood. 675, 746
- alkaloid** Bitter-tasting nitrogenous compounds that have a basic pH (e.g., caffeine). 488
- allantois** (uh LANN toys) Extraembryonic membrane that accumulates nitrogenous wastes the eggs of reptiles, including birds; contributes to the formation of umbilical blood vessels in mammals. 787
- allele** (uh LEEL) Alternative form of a gene—alleles occur at the same locus on homologous chromosomes. 170, 193
- allergy** Immune response to substances that usually are not recognized as foreign. 629
- allopatric speciation** (al low PAT trick spee see AY shun) Origin of new species between populations that are separated geographically. 304
- allopolyploidy** Polyploid organism that contains the genomes of two or more different species. 307
- allosteric site** Site on an allosteric enzyme that binds an effector molecule; binding alters the activity of the enzyme. 111
- alpine tundra** Tundra near the peak of a mountain. 869
- alternation of generations life cycle** Life cycle, typical of land plants, in which a diploid sporophyte alternates with a haploid gametophyte. 176, 412
- altruism** (AL true is uhm) Social interaction that has the potential to decrease the lifetime reproductive success of the member exhibiting the behavior. 814
- alveolats** A group of protists that includes unicellular dinoflagellates, apicomplexans, and ciliates; alveoli support plasma membrane. 383
- alveolus (pl., alveoli)** (al VEE oh luss) In humans, terminal, microscopic, grapelike air sac found in lungs. 654
- AM fungi (arbuscular mycorrhiza)** Fungi with branching invaginations used to invade plant roots. 396
- amino acid** (uh MEAN no) Organic molecule composed of an amino group and an acid group; covalently bonds to produce peptide molecules. 49
- ammonia** Nitrogenous end product that takes a limited amount of energy to produce but requires much water to excrete because it is toxic. 666
- amnion** (AM nee ahn) Extraembryonic membrane of birds, reptiles, and mammals that forms an enclosing, fluid-filled sac. 787
- amniote** Vertebrate that produces an egg surrounded by four membranes, one of which is the amnion; amniote groups are the reptiles, (including birds), and mammals. 542
- amniotic egg** (am nee AH tick) Egg that has an amnion, as seen during the development of reptiles, (including birds), and mammals. 548
- amoeboid** (uh ME boid) Cell that moves and engulfs debris with pseudopods. 387
- amboebozoan** Supergroup of eukaryotes that includes amoebas and slime molds and is characterized by lobe-shaped pseudopodia. 387
- amphibian** Member of vertebrate class Amphibia that includes frogs, toads, and salamanders; they are still tied to a watery environment for reproduction. 546
- anabolic steroid** (ann uh BAH lick STARE oid) Synthetic steroid that mimics the effect of testosterone. 750
- anaerobic** (ann air OH bick) Growing or metabolizing in the absence of oxygen. 135
- analogous structure** (ann AL oh gus) Structure that has a similar function in separate lineages but differs in anatomy and ancestry. 278, 345

- analogy** (ann AL oh gee) Similarity of function but not of origin. 345
- anaphase** (ANN uh faze) Mitotic phase during which daughter chromosomes move toward the poles of the spindle. 158
- anaphylactic shock** (ann uh funh LACK tick) Severe systemic form of anaphylaxis involving bronchiolar constriction, impaired breathing, vasodilation, and a rapid drop in blood pressure with a threat of circulatory failure. 629
- androgen** (ANN droh jen) Male sex hormone (e.g., testosterone). 750
- aneuploidy** (ANN you ploid ee) Individual whose chromosome number is not an exact multiple of the haploid number for the species. 180
- angina pectoris** (ann JYE nuh peck TORE iss) Condition characterized by thoracic pain resulting from occluded coronary arteries; precedes a heart attack. 605
- angiogenesis** (ann jee oh JEN uh sis) Formation of new blood vessels; one mechanism by which cancer spreads. 162
- angiosperm** (ANN jee oh sperm) Flowering land plant; the seeds are borne within a fruit. 420, 424
- angiotensin II** Hormone produced from angiotensinogen (a plasma protein) by the kidneys and lungs; raises blood pressure. 675
- animal** Multicellular, heterotrophic eukaryote characterized by the presence of muscular and nervous tissue and undergoing development to achieve its final form. 8
- annelid** (ANN uh lid) The segmented worms, such as the earthworm and the clam worm. 526
- annual ring** Layer of wood (secondary xylem) usually produced during one growing season. 447
- anterior pituitary** (an TEER rih urr pit TWO uh tare ree) Portion of the pituitary gland that is controlled by the hypothalamus and produces six types of hormones, some of which control other endocrine glands. 740
- anther** (ANN thurr) In flowering land plants, pollen-bearing portion of stamen. 495
- antheridia** Sperm-producing structures, as in the moss life cycle. 412
- anthropoid** (ANN throw poid) Group of primates that includes monkeys, apes, and humans. 563
- antibody** Protein produced in response to the presence of an antigen; each antibody combines with a specific antigen. 607
- antibody-mediated immunity** Specific mechanism of defense in which plasma cells derived from B cells produce antibodies that combine with antigens. 619
- anticodon** (ann tie COH don) Three-base sequence in a transfer RNA molecule base that pairs with a complementary codon in mRNA. 224
- antidiuretic hormone (ADH)** (an tee die you REH tick) Hormone secreted by the posterior pituitary that increases the permeability of the collecting ducts in a kidney. 674, 740
- antigen** (ANN tih jen) Foreign substance, usually a protein or a polysaccharide, that stimulates the immune system to react, such as to produce antibodies. 607, 619
- antigen-presenting cell (APC)** Cell that displays the antigen to certain cells of the immune system so they can defend the body against that particular antigen. 619
- antigen receptor** Receptor proteins in the plasma membrane of immune system cells whose shape allows them to combine with a specific antigen. 619
- anus** (AY nuss) Outlet of the digestive tube. 640
- aorta** (ay OR tuh) In humans, the major systemic artery that takes blood from the heart to the tissues. 602
- aortic body** Sensory receptor in the aortic arch sensitive to the O₂, CO₂, and H⁺ content of the blood. 657
- apical dominance** (AY pick uhl) Influence of a terminal bud in suppressing the growth of axillary buds. 475
- apical meristem** (AY pick uhl MARE uh stem) In vascular land plants, masses of cells in the root and shoot that reproduce and elongate as primary growth occurs. 440
- apicomplexan** Parasitic protozoans, formerly called sporozoans that lack mobility and form spores; now named for a unique collection of organelles. 384
- apoptosis** (ay pop TOE sis) Programmed cell death involving a cascade of specific cellular events leading to death and destruction of the cell. 153, 782
- appendicular skeleton** (app pen DICK you lurr) Part of the vertebrate skeleton forming the appendages, shoulder girdle, and hip girdle. 724
- appendix** (app PEN dicks) In humans, small, tubular appendage that extends outward from the cecum of the large intestine. 639
- aquaporin** Channel protein through which water can diffuse across a membrane. 90, 674
- arboreal** (are BORE ree uhl) Living in trees. 560
- archaea** Member of the domain Archaea. 368
- archaeplastid** Supergroup of eukaryotes that includes land plants and red and green algae. Developed from endosymbiotic cyanobacteria. 377
- archegonia** Egg-producing structures, as in the moss life cycle. 412
- Arctic tundra** Biome that encircles the Earth just south of ice-covered polar seas in the Northern Hemisphere. 870
- arteriole** (are TEER ree ohl) Vessel that takes blood from an artery to capillaries. 596
- artery** Blood vessel that transports blood away from the heart. 596
- arthropod** (ARTH throw pod) Invertebrates, with an exoskeleton and jointed appendages, such as crustaceans and insects. 529
- artificial selection** Intentional breeding of certain traits, or combinations of traits, over others to produce a desirable outcome. 273
- ascus** (ASK us) Fingerlike sac in which nuclear fusion, meiosis, and ascospore production occur during sexual reproduction of sac fungi. 398
- asexual reproduction** Reproduction that requires only one parent and does not involve gametes. 164
- associative learning** Acquired ability to associate two stimuli or between a stimulus and a response. 804
- assortative mating** (ah Sor tah tive) Mating of individuals with similar phenotypes. 287
- aster** (ASS turr) Short, radiating fibers produced by the centrosomes in animal cells. 156
- asthma** Condition in which bronchioles constrict and cause difficulty in breathing. 629
- atom** Smallest particle of an element that displays the properties of the element. 22
- atomic mass** Average of atom mass units for all the isotopes of an atom. 23
- atomic number** Number of protons within the nucleus of an atom. 23
- atomic symbol** One or two letters that represent the name of an element—e.g., H stands for a hydrogen atom, and Na stands for a sodium atom. 22
- ATP (adenosine triphosphate)** (ad DEN no seen try FOSS fate) Nucleotide with three phosphate groups. The breakdown of ATP into ADP + P makes energy available for energy-requiring processes in cells. 52, 106
- ATP synthase complex** (SIN thaze) Complex of proteins in the cristae of mitochondria and thylakoid membrane of chloroplast that produces ATP as hydrogen flows down a concentration gradient. 113, 124
- atrial natriuretic hormone (ANH)** (AY tree uhl nat tree you RETT tick) Hormone secreted by the heart that increases sodium excretion. 675, 746
- atrioventricular valve** (ay tree oh vinn TRICK you lurr) Heart valve located between an atrium and a ventricle. 598
- atrium** (AY tree uhm) Chamber; particularly an upper chamber of the heart lying above a ventricle. 598
- auditory communication** Sound that an animal makes for the purpose of sending a message to another individual. 807
- australopithecine (australopith)** (oss stray loh PITH ih seen) One of several species of *Australopithecus*, a genus that contains the first generally recognized humanlike hominins. 566
- Australopithecus afarensis*** Bipedal humanlike hominin that lived 3.9 and 3 MYA, e.g., Lucy, discovered at Hadar, Ethiopia, in 1974. 566
- Australopithecus africanus*** Gracile humanlike hominin that lived between 3 and 2.2 MYA, unearthed in southern Africa in the 1920s; one of the first australopiths to be discovered. 566
- autoimmune disease** (ah toe ih MUENE mick) Disease that results when the immune system mistakenly attacks the body's own tissues. 628
- autonomic system** (ah toe NAHM mick) Portion of the peripheral nervous system that regulates internal organs. 695
- autopolyploidy** Polyploid organism with chromosome sets from the same species. 307
- autosome** (AH toe sohm) Any chromosome other than the sex-determining pair. 198
- autotroph** (AH toe trofe) Organism that can capture energy and synthesize organic molecules from inorganic nutrients. 118, 852
- auxin** (OX sin) Plant hormone regulating growth, particularly cell elongation; also called indoleacetic acid (IAA). 475
- axial skeleton** (AXE ee uhl) Part of the vertebrate skeleton forming the vertical support or axis, including the skull, the rib cage, and the vertebral column. 722
- axillary bud** (AXE ill air ree) Bud located in the axil of a leaf. 435
- axon** (AXE ahn) Elongated portion of a neuron that conducts nerve impulses, typically from the cell body to the synapse. 683
- B**
- bacillus** (buh SILL us) A rod-shaped bacterium; also a genus of bacteria, *Bacillus*. 64
- bacterial vaginosis** Sexually transmitted disease caused by *Gardnerella vaginalis*, *Mobiluncus* spp., *Mycoplasma hominis*, and various anaerobic bacteria. Although a mild disease, it is a risk factor for obstetric infections and pelvic inflammatory disease. 772
- bacteriophage** (back TEER ree oh fahj) Virus that infects bacteria. 358

- bacterium (pl., bacteria)** Member of the domain Bacteria. 364
- bark** External part of a tree, containing cork, cork cambium, and phloem. 446
- Barr body** Dark-staining body (discovered by M. Barr) in the nuclei of female mammals that contains a condensed, inactive X chromosome. 182, 238
- basal body** (BAY zull) A cytoplasmic structure that is located at the base of—and may organize—cilia or flagella. 80
- basal nuclei** (BAY zull NEW clee eye) Subcortical nuclei deep within the white matter that serve as relay stations for motor impulses and produce dopamine to help control skeletal muscle activities. 689
- base** Molecules tending to lower the hydrogen ion concentration in a solution and raise the pH numerically. 32
- basement membrane** Layer of nonliving material that anchors epithelial tissue to underlying connective tissue. 578
- basidium** (buh SIH dee uhm) Clublike structure in which nuclear fusion, meiosis, and basidiospore production occur during sexual reproduction of club fungi. 402
- basophil** (BASE oh fill) White blood cell with a granular cytoplasm; able to be stained with a basic dye. 607
- B cell** Lymphocyte that matures in the bone marrow and, when stimulated by the presence of a specific antigen, gives rise to antibody-producing plasma cells. 615
- B cell receptor (BCR)** Molecule on the surface of a B cell that binds to a specific antigen. 619
- behavior** Observable, coordinated responses to environmental stimuli. 800
- behavioral ecology** Study of how natural selection shapes behavior. 810
- beneficial nutrient** In plants, element that is either required or enhances the growth and production of a plant. 457
- benign** (buh NINE) Mass of cells derived from a single mutated cell that has repeatedly undergone cell division but has remained at the site of origin. 161
- bicarbonate ion** (by CAR boh nate EYE ahn) Ion that participates in buffering the blood, and the form in which carbon dioxide is transported in the bloodstream. 659
- bilateral symmetry** (by LATT turr uhl SIMM met tree) Body plan having two corresponding or complementary halves. 513
- bile** Secretion of the liver that is temporarily stored and concentrated in the gallbladder before being released into the small intestine, where it emulsifies fat. 639
- binary fission** (BY nuh ree FISH uhn) Splitting of a parent cell into two daughter cells; serves as an asexual form of reproduction in bacteria. 164, 364
- binomial nomenclature** (by NO mee uhl) Scientific name of an organism, the first part of which designates the genus and the second part of which designates the specific epithet. 8, 339
- biocultural evolution** Phase of human evolution in which cultural events affect natural selection. 569
- biodiversity** (by oh die VERSE sit tee) Total number of species, the variability of their genes, and the communities in which they live. 10, 890
- biodiversity hotspot** Region of the world that contains unusually large concentrations of species. 891
- biogeochemical cycle** (by oh jee oh KEM ick cull) Circulating pathway of elements such as carbon and nitrogen involving exchange pools, storage areas, and biotic communities. 856
- biogeography** (by oh jee AH gruh fee) Study of the geographical distribution of organisms. 269
- bioinformatics** (by oh in for MAT ticks) Computer technologies used to study the genome. 259, 890
- biological clock** Internal mechanism that maintains a biological rhythm in the absence of environmental stimuli. 485
- biological species concept** The concept that defines species as groups of populations that have the potential to interbreed and that are reproductively isolated from other groups. 300
- biology** Scientific study of life. 11
- biomass** (BY oh mass) The number of organisms multiplied by their weight. 855
- biome** (BY ohm) One of the biosphere's major communities, characterized in particular by certain climatic conditions and particular types of plants. 869
- biomolecule** Organic molecule (macromolecule as a protein or nucleic acid) in living organisms. 38
- biosphere** (BY ohs fear) Zone of air, land, and water at the surface of the Earth in which living organisms are found. 9, 820
- biotechnology products** Commercial or agricultural products that are made with or derived from transgenic organisms. 252
- biotic potential** (by AH tick) Maximum population growth rate under ideal conditions. 822
- bird** Endothermic reptile that has feathers and wings, is often adapted for flight, and lays hard-shelled eggs. 552
- bivalent** (by VAY lent) Homologous chromosomes, each having sister chromatids that are joined by a nucleoprotein lattice during meiosis; also called a tetrad. 171
- bivalve** (BY valve) Type of mollusc with a shell composed of two valves; includes clams, oysters, and scallops. 524
- blade** Broad, expanded portion of a land plant leaf that may be single or compound leaflets. 435
- blastocoel** (BLAST toe seal) Fluid-filled cavity of a blastula. 779
- blastocyst** (BLAST toe sist) Early stage of human embryonic development that consists of a hollow, fluid-filled ball of cells. 788
- blastopore** Opening into the primitive gut formed at gastrulation. 780
- blastula** (BLAST you luh) Hollow, fluid-filled ball of cells occurring during animal development prior to gastrula formation. 779
- blind spot** Region of the retina, lacking rods or cones, where the optic nerve leaves the eye. 708
- blood** Fluid circulated by the heart through a closed system of vessels. 581, 594
- blood pressure** Force of blood pushing against the inside wall of blood vessels. 603
- bog** Wet, spongy ground in a low-lying area, usually acidic and low in organic nutrients. 879
- bone** Connective tissue having protein fibers and a hard matrix of inorganic salts, notably calcium salts. 580
- bony fishes (Osteichthyes)** A fish that has a bony rather than cartilaginous skeleton. 544
- bottleneck effect** Type of genetic drift; occurs when a majority of genotypes are prevented from participating in the production of the next generation as a result of a natural disaster or human interference. 288
- brain** Ganglionic mass at the anterior end of the nerve cord; in vertebrates, the brain is located in the cranial cavity of the skull. 688
- brain stem** In mammals; portion of the brain consisting of the medulla oblongata, pons, and midbrain. 690
- bronchiole** (BRAHN key ohl) In terrestrial vertebrates, small tube that conducts air from a bronchus to the alveoli. 655
- bronchus (pl., bronchi)** (BRAHN cuss, BRAHN kie) In terrestrial vertebrates, branch of the trachea that leads to the lungs. 655
- brown algae** Marine photosynthetic protist with a notable abundance of xanthophyll pigments; this group includes well-known seaweeds of northern rocky shores. 381
- bryophyte** (BRY oh fite) A nonvascular land plant—the mosses, liverworts, and hornworts—in which the gametophyte is dominant. 413
- budding** Asexual form of reproduction whereby a new organism develops as an outgrowth of the body of the parent. 395
- buffer** Substance or group of substances that tend to resist pH changes of a solution, thus stabilizing its relative acidity and basicity. 32
- bulk transport** Movement of elements in an organism in large amount. 90
- bursa** (BURR suh) Saclike, fluid-filled structure, lined with synovial membrane, that occurs near a synovial joint. 725
- C**
- C₃ plant** Plant that fixes carbon dioxide via the Calvin cycle; the first stable product of C₃ photosynthesis is a 3-carbon compound. 128
- C₄ plant** Plant that fixes carbon dioxide to produce a C₄ molecule that releases carbon dioxide to the Calvin cycle. 128
- calcitonin** (cal sit ON in) Hormone secreted by the thyroid gland that increases the blood calcium level. 744
- calorie** Amount of heat energy required to raise the temperature of one gram of water 1°C. 29
- Calvin cycle reaction** Portion of photosynthesis that takes place in the stroma of chloroplasts and can occur in the dark; it uses the products of the light reactions to reduce CO₂ to a carbohydrate. 121
- calyx** The sepals collectively; the outermost flower whorl. 495
- camera-type eye** Type of eye found in vertebrates and certain molluscs; a single lens focuses an image on closely packed photoreceptors. 704
- camouflage** (CAM oh flaj) Process of hiding from predators in which the organism's behavior, form, and pattern of coloration allow it to blend into the background and prevent detection. 845
- cancer** Malignant tumor whose nondifferentiated cells exhibit loss of contact inhibition, uncontrolled growth, and the ability to invade tissue and metastasize. 161
- capillary** (CAP pill air ree) Microscopic blood vessel; gases and other substances are exchanged across the walls of a capillary between blood and tissue fluid. 596
- capsid** (CAP sid) Protective protein containing the genetic material of a virus. 357
- capsule** Gelatinous layer surrounding the cells of

- blue-green algae and certain bacteria. 64
- carbaminohemoglobin** (car buh meen oh HEE muh glow bin) Hemoglobin carrying carbon dioxide. 659
- carbohydrate** (car boh HI drate) Class of organic compounds that includes monosaccharides, disaccharides, and polysaccharides. 41, 643
- carbon dioxide (CO₂) fixation** Photosynthetic reaction in which carbon dioxide is attached to an organic compound. 126
- carbonic anhydrase** (car BAH nick ann HI draze) Enzyme in red blood cells that speeds the formation of carbonic acid from water and carbon dioxide. 659
- carcinogen** (car SIN uh jen) Environmental agent that causes mutations leading to the development of cancer. 243
- cardiac conduction system** System of specialized cardiac muscle fibers that conducts impulses from the SA node to the chambers of the heart, causing them to contract. 600
- cardiac cycle** One complete cycle of systole and diastole for all heart chambers. 600
- cardiac muscle** Striated, involuntary muscle tissue found only in the heart. 582
- cardiac output** Blood volume pumped by each ventricle per minute (not total output pumped by both ventricles). 600
- cardiac pacemaker** Mass of specialized cardiac muscle tissue that controls the rhythm of the heartbeat; the SA node. 601
- cardiovascular system** (car dee oh VASS cue lurr) Organ system in which blood vessels distribute blood under the pumping action of the heart. 594, 596
- carnivore** (CAR nih vore) Consumer in a food chain that eats other animals. 852
- carotenoid** (car RAH ten oid) Yellow or orange pigment that serves as an accessory to chlorophyll in photosynthesis. 122
- carotid body** Structure located at the branching of the carotid arteries; contains chemoreceptors sensitive to the O₂, CO₂, and H⁺ content in blood. 657
- carpel** (CAR pull) Ovule-bearing unit that is a part of a pistil. 425, 495
- carrier** Heterozygous individual who has no apparent abnormality but can pass on an allele for a recessively inherited genetic disorder. 198
- carrier protein** Protein that combines with and transports a molecule or ion across the plasma membrane. 88
- carrying capacity** Largest number of organisms of a particular species that can be maintained indefinitely by a given environment. 827
- cartilage** (CAR tih ledge) Connective tissue in which the cells lie within lacunae embedded in a flexible, proteinaceous matrix. 580
- cartilaginous fishes (Chondrichthyes)** (car tih LAJJ jen us) A fish that has a cartilaginous rather than bony skeleton; includes sharks, rays, and skates. 543
- Casparian strip** (cass PAIR ree uhn) Layer of impermeable lignin and suberin bordering four sides of root endodermal cells; prevents water and solute transport between adjacent cells. 441, 460
- caspase** (CASS pase) Cell cycle regulatory enzyme that initiates apoptosis. 153
- catabolism** (cuh TAB uh liz uhn) Metabolic process that breaks down large molecules into smaller ones; catabolic metabolism. 145
- catastrophism** (cuh TASS troh fizz uhn) Belief espoused by Georges Cuvier that periods of catastrophic extinctions occurred, after which repopulation of surviving species took place, giving the appearance of change through time. 268
- cell** Smallest unit that displays the properties of life; composed of organelle-containing cytoplasm surrounded by a plasma membrane. 2, 60
- cell body** Portion of a neuron that contains a nucleus and from which dendrites and an axon extend. 683
- cell cycle** Repeating sequence of events in eukaryotes that involves cell growth and nuclear division; consists of the stages G₁, S, G₂, and M. 152
- cell envelope** In a prokaryotic cell, the portion composed of the plasma membrane, the cell wall, and the glycocalyx. 64
- cell-mediated immunity** Specific mechanism of defense in which T cells destroy antigen-bearing cells. 619
- cell plate** Structure across a dividing plant cell that signals the location of new plasma membranes and cell walls. 159
- cell recognition protein** Glycoprotein that helps the body defend itself against pathogens. 88
- cell suspension culture** Small clumps of naked plant cells grown in tissue culture that produce drugs, cosmetics, agricultural chemicals, among others. 506
- cell theory** One of the major theories of biology, which states that all organisms are made up of cells; cells are capable of self-reproduction and come only from preexisting cells. 60
- cellular differentiation** Process and developmental stages by which a cell becomes specialized for a particular function. 782
- cellular respiration** Metabolic reactions that use the energy from carbohydrate, fatty acid, or amino acid breakdown to produce ATP molecules. 134
- cellular response** Response to the transduction pathway in which proteins or enzymes change a signal to a format that the cell can understand, resulting in the appropriate response. 474
- cellular slime mold** Free-living amoeboid cells that feed on bacteria and yeasts by phagocytosis and aggregate to form a plasmodium that produces spores. 388
- cellulose** (SELL you lohs) Polysaccharide that is the major complex carbohydrate in plant cell walls. 43
- cell wall** Structure that surrounds a plant, protistan, fungal, or bacterial cell and maintains the cell's shape and rigidity. 64, 99
- centipede** (SEN tih peed) Elongated arthropod characterized by having one pair of legs to each body segment; they may have 15 to 173 pairs of legs. 531
- central nervous system (CNS)** Portion of the nervous system consisting of the brain and spinal cord. 681
- central vacuole** (VACK you ohl) In a plant cell, a large, fluid-filled sac that stores metabolites. During growth, it enlarges, forcing the primary cell wall to expand and the cell surface-area-to-volume ratio to increase. 75
- centriole** (SENT tree ohl) Cell organelle, existing in pairs, that occurs in the centrosome and may help organize a mitotic spindle for chromosome movement during animal cell division. 80, 155
- centromere** (SENT troh meer) Constriction where sister chromatids of a chromosome are held together. 155
- centrosome** (SENT troh sohm) Central microtubule organizing center of cells. In animal cells, it contains two centrioles. 78, 155
- cephalization** (seff full lih ZAY shun) Having a well-recognized anterior head with a brain and sensory receptors. 515, 680
- cephalochordate** Small, fishlike invertebrate that is a member of the phylum Chordata. Probably the closest living relative to vertebrates. 540
- cephalopod** (SEF ful lo pod) Type of mollusc in which the head is prominent and the foot is modified to form two arms and several tentacles; includes squids, cuttlefish, octopuses, and nautilus. 525
- cerebellum** (sair uh BELL uhm) In terrestrial vertebrates, portion of the brain that coordinates skeletal muscles to produce smooth, graceful motions. 690
- cerebral cortex** (sir REE brull CORE tex) Outer layer of cerebral hemispheres; receives sensory information and controls motor activities. 689
- cerebral hemisphere** Either of the two lobes of the cerebrum in vertebrates. 689
- cerebrospinal fluid** (sir ree broh SPY null) Fluid found in the ventricles of the brain, in the central canal of the spinal cord, and in association with the meninges. 688
- cerebrum** (sir REE brumm) Largest part of the brain in mammals. 689
- cervix** Narrow end of the uterus, which leads into the vagina. 762
- channel protein** Protein that forms a channel to allow a particular molecule or ion to cross the plasma membrane. 88
- chaparral** (shapp purr AL) Biome characterized by broad-leaved evergreen shrubs forming dense thickets. 876
- chaperone protein** (shapp purr OHN) Molecule that interacts with a protein so that it folds into its proper shape. 51
- character displacement** Tendency for characteristics to be more divergent when similar species belong to the same community than when they are isolated from one another. 842
- charophyte** Type of living green algae that on the basis of nucleotide sequencing and cellular features is most closely related to land plants. 377, 410
- chelicerate** (shell lih sir AH tuh) Arthropods (e.g., horseshoe crabs, sea spiders, arachnids), that have a pair of pointed appendages used to manipulate food. 533
- chemical energy** Energy associated with the interaction of atoms in a molecule. 104
- chemical evolution** Increase in the complexity of chemicals over time that could have led to the first cells. 318
- chemical signal** Molecule that brings about a change in a cell, tissue, organ, or individual when it binds to a specific receptor. 738
- chemiosmosis** (kim mee oz MOW sis) Process by which mitochondria and chloroplasts use the energy of an electron transport chain to create a hydrogen ion gradient that drives ATP formation. 113, 124, 143
- chemoautotroph** (key mow AH toe trofe) Organism able to synthesize organic molecules by using carbon dioxide as the carbon source and the oxidation of an inorganic substance (such as hydrogen sulfide) as the energy source. 365
- chemoheterotroph** (key mow HETT turr row trofe) Organism that is unable to produce its own organic molecules, and therefore requires organic nutrients in its diet. 365

- chemoreceptor** (key mow ree SEPP turr) Sensory receptor that is sensitive to chemical stimulation—for example, receptors for taste and smell. 702
- chitin** (KITE in) Strong but flexible nitrogenous polysaccharide found in the exoskeleton of arthropods and in the cell walls of fungi. 43, 394, 529
- chlorofluorocarbons (CFCs)** (klore oh flur oh CAR buns) Organic compounds containing carbon, chlorine, and fluorine atoms. CFCs such as Freon can deplete the ozone shield by releasing chlorine atoms in the upper atmosphere. 860
- chlorophyll** (KLORE uh fill) Green pigment that absorbs solar energy and is important in algal and land plant photosynthesis; occurs as chlorophyll *a* and chlorophyll *b*. 119
- chlorophyte** Most abundant and diverse group of green algae, including freshwater, marine, and terrestrial forms that synthesize. Chlorophytes share chemical and anatomical characteristics with land plants. 377
- chloroplast** (KLORE oh plast) Membrane-bounded organelle in algae and land plants with chlorophyll-containing membranous thylakoids; where photosynthesis takes place. 76, 119
- choanoflagellate** Unicellular choanoflagellates have one and colonial forms have many collar cells like those of sponges; choanoflagellates are the protists most closely related to animals. 389
- cholesterol** (koh LESS turr all) A steroid found in animal plasma membrane and from which other types of steroids are derived. 86, 644
- chordate** (CORE date) Animals that have a dorsal tubular nerve cord, a notochord, pharyngeal gill pouches, and a postanal tail at some point in their life cycle; includes a few types of invertebrates (e.g. sea squirts and lancelets) and the vertebrates. 540
- chorion** (CORE ree ahn) Extraembryonic membrane functioning for respiratory exchange in birds and reptiles; contributes to placenta formation in mammals. 787
- chorionic villus** (core ree AH nick VILL us) In placental mammals tree-like extension of the chorion, projecting into the maternal tissues at the placenta. 790
- choroid** (CORE oid) Vascular, pigmented middle layer of the eyeball. 705
- chromalveolate** Supergroup of eukaryotes that includes alveolates and stramenopiles. 381
- chromatid** (CROW muh tid) Following replication a chromosome consists of a pair of sister chromatids, each a single DNA helix, held together at the centromere. Following separation, each chromosome is a single chromatid. 152
- chromatin** (CROW muh tin) Network of DNA strands and associated proteins observed within a nucleus that is not dividing. 70, 155
- chromoplast** Plastid in land plants responsible for orange, yellow, and red color of plants, including the autumn colors in leaves. 76
- chromosome** (CROW muh sohm) An observable structure that results when chromatin condenses and coils, each species has a particular number of chromosomes that is passed on to the next generation. 70
- chyme** (KIME) Thick, semiliquid food material that passes from the stomach to the small intestine. 639
- chytrid** Mostly aquatic fungi with flagellated spores that may represent the most ancestral fungal lineage. 396
- ciliary muscle** (SILL lee air ree) Within the ciliary body of the vertebrate eye, the ciliary muscle controls the shape of the lens. 706
- ciliate** (SILL lee ate) Complex unicellular protist that moves by means of cilia and digests food in food vacuoles. 384
- cilium** (SILL lee uhm) Short, hairlike projections from the plasma membrane, occurring usually in larger numbers (cilia). 80
- circadian rhythm** (sir KAY dee uhn) Biological rhythm with a 24-hour cycle. 484, 750
- circulatory system** In animals, an organ system that moves substances to and from cells, usually via a heart, blood, and blood vessels. 594, 596
- cirrhosis** Chronic, irreversible injury to liver tissue; commonly caused by frequent alcohol consumption. 642
- citric acid cycle** Cycle of reactions in mitochondria that begins with citric acid. This cycle breaks down an acetyl group and produces CO₂, ATP, NADH, and FADH₂; also called the Krebs cycle. 135, 141
- clade** Evolutionary lineage consisting of an ancestral species and all of its descendants, forming a distinct branch on a cladogram. 342
- cladistics** (kluh DISS tick) Method of systematics that uses derived characters to determine monophyletic groups and construct cladograms. 342
- cladogram** (CLAYD doe gram) In cladistics, a branching diagram that shows the relationship among species in regard to their shared derived characters. 342
- class** One of the categories are subgroups used by taxonomists to group species; class within a phylum or division. 6, 340
- classical conditioning** Type of learning whereby an unconditioned stimulus that elicits a specific response is paired with a neutral stimulus so that the response becomes conditioned. 804
- cleavage** (CLEAVE edge) Cell division without cytoplasmic addition or enlargement; occurs during the first stage of animal development. 779
- climate** Generalized weather patterns of an area, primarily determined by temperature and average rainfall. 866
- climax community** In ecology, community that results when succession has come to an end. 850
- cloaca** (kloh AY kuh) Common chamber and opening to the digestive, urinary, and genital tracts in certain vertebrates. 547
- clonal selection model** (KLOH null) States that the antigen selects which lymphocyte will undergo clonal expansion and produce more lymphocytes bearing the same type of receptor. 620
- cloning** Production of identical copies. In organisms, the production of organisms with the same genes; in genetic engineering, the production of many identical copies of a gene. 250
- closed circulatory system** A type of circulatory system where blood is confined to vessels and is kept separate from the interstitial fluid. 594
- club fungi** Fungi that produce spores in club-shaped basidia within a fruiting body; includes mushrooms, shelf fungi and puffballs. 402
- cnidarian** (neye DARE ree uhn) Invertebrates existing as either a polyp or medusa with two tissue layers and radial symmetry. 518
- coacervate droplet** (coh AY sir vate) An aggregate of colloidal droplets held together by electrostatic forces. 320
- coal** Fossil fuel formed millions of years ago from plant material that did not decay. 423
- coccus** (COCK us) A spherical-shaped bacterium. 64
- cochlea** (COKE lee uh) Spiral-shaped structure of the vertebrate inner ear containing the sensory receptors for hearing. 710
- codominance** (koh DAH men unce) Inheritance pattern in which both alleles of a gene are equally expressed in a heterozygote. 202
- codon** (KOH dahn) Three-base sequence in messenger RNA that during translation directs the addition of a particular amino acid into a protein or directs termination of the process. 221
- coenzyme** (koh IN zime) Nonprotein organic molecule that aids the action of the enzyme to which it is loosely bound. 52, 110
- coevolution** Mutual evolution in which two species exert selective pressures on the other species. 498, 847
- cofactor** Nonprotein adjunct required by an enzyme in order to function; many cofactors are metal ions, others are coenzymes. 110
- cohesion-tension model** Explanation for upward transport of water in xylem based upon transpiration-created tension and the cohesive properties of water molecules. 464
- cohort** (KOH hort) Group of individuals having a statistical factor in common, such as year of birth, in a population study. 822
- coleoptile** (koh lee OPP tile) Protective sheath that covers the young leaves of a seedling. 475
- collagen fiber** White fiber in the matrix of connective tissue giving flexibility and strength. 579
- collecting duct** Duct within the kidney that receives fluid from several nephrons; the reabsorption of water occurs here. 671
- collenchyma** (kuh LENN kih muh) Plant tissue composed of cells with unevenly thickened walls; supports growth of stems and petioles. 438
- colony** Loose association of cells each remaining independent for most functions. 378
- columnar epithelium** (kuh LUM nurr epp uih THEE lee uhm) Type of epithelial tissue with cylindrical cells. 578
- comb jelly** Invertebrates that resemble jelly fishes and are the largest animals to be propelled by beating cilia. 518
- commensalism** (kuh MENS suh liz uhm) Symbiotic relationship in which one species is benefited, and the other is neither harmed nor benefited. 365, 846
- common ancestor** Ancestor common to at least two lines of descent. 341
- communication** Signal by a sender that influences the behavior of a receiver. 807
- community** Assemblage of species interacting with one another within the same environment. 9, 820, 840
- compact bone** Type of bone that contains osteons consisting of concentric layers of matrix and osteocytes in lacunae. 580, 720
- companion cell** Cell associated with sieve-tube members in phloem of vascular plants. 462
- comparative genomics** Study of genomes through the direct comparison of their genes and DNA sequences. 258
- competitive exclusion principle** Theory that no two species can occupy the same niche in the same place and at the same time. 842

- competitive inhibition** Form of enzyme inhibition where the substrate and inhibitor are both able to bind to the enzyme's active site. Only when the substrate is at the active site will product form. 111
- complement** Collective name for a series of enzymes and activators in the blood, some of which may bind to antibody and may lead to rupture of a foreign cell. 618
- complementary base pairing** Hydrogen bonding between particular purines and pyrimidines in DNA. 53, 216
- complementary DNA (cDNA)** DNA that has been synthesized from mRNA by the action of reverse transcriptase. 253
- complete digestive tract** Digestive tract that has both a mouth and an anus. 634
- complex tissue** In plants, tissue composed of two or more kinds of cells (e.g., xylem, containing tracheids and vessel elements; phloem, containing sieve-tube members and companion cells). 439
- compound** Substance having two or more different elements united chemically in fixed ratio. 26
- compound eye** Type of eye found in arthropods; it is composed of many independent visual units. 704
- concentration gradient** Gradual change in chemical concentration between two areas of differing concentrations. 90
- conclusion** Statement made following an experiment as to whether or not the results support the hypothesis. 12
- cone** Reproductive structure in conifers comprised of scales bearing sporangia; pollen cones bear microsporangia, and seed cones bear megasporangia. 420
- cone cell** Photoreceptor in vertebrate eyes that responds to bright light and makes color vision possible. 707
- congenital hypothyroidism** Condition that results from the thyroid gland not developing properly; characteristics include stunted growth and possible mental retardation. 743
- conidiospore** (koh NIDD dee uh spore) Spore produced by sac and club fungi during asexual reproduction. 398
- conifer** (KAH nih fur) Member of a group of cone-bearing gymnosperm land plants that includes pine, cedar, and spruce trees. 420
- conjugation** (kahn jew GAY shun) Transfer of genetic material from one cell to another. 364, 378
- conjugation pilus (pl., conjugation pili)** (PIE luss, PIE lie) In a bacterium, elongated, hollow appendage used to transfer DNA to other cells. 65, 364
- conjunctiva** (kahn junk TY vuh) Delicate membrane that lines the eyelid protecting the sclera. 705
- connective tissue** Type of animal tissue that binds structures together, provides support and protection, fills spaces, stores fat, and forms blood cells; adipose tissue, cartilage, bone, and blood are types of connective tissue; living cells in a nonliving matrix. 579
- conservation biology** Discipline that seeks to understand the effects of human activities on species, communities, and ecosystems and to develop practical approaches to preventing the extinction of species and the destruction of ecosystems. 890
- consumer** Organism that feeds on another organism in a food chain generally; primary consumers eat plants, and secondary consumers eat animals. 852
- continental drift** The movement of the Earth's crust by plate tectonics resulting in the movement of continents with respect to one another. 332
- contraceptive vaccine** Under development, this birth control method immunizes against the hormone HCG, crucial to maintaining implantation of the embryo. 767
- contrast** In magnification with a microscope, brightness differences between objects. 63
- control** Sample that goes through all the steps of an experiment but does not contain the variable being tested; a standard against which the results of an experiment are checked. 12
- convergent evolution** (kuhn VERGE ent) Similarity in structure in distantly related groups generally due to similar selective pressures in like environments. 345
- copulation** (cop you LAY shun) Sexual union between a male and a female. 757
- coral reef** Coral formations in shallow tropical waters that support an abundance of diversity. 883
- corepressor** (koh ree PRESS her) Molecule that binds to a repressor, allowing the repressor to bind to an operator in a repressible operon. 235
- cork** Outer covering of the bark of trees; made of dead cells that may be sloughed off. 437
- cork cambium** Lateral meristem that produces cork. 437
- cornea** (CORE nee uh) Transparent, anterior portion of the outer layer of the eyeball. 705
- corolla** The petals, collectively; usually the conspicuously colored flower whorl. 495
- corpus luteum** (CORE pus LU tee uhm) Follicle that has released an egg and increases its secretion of progesterone. 763
- cortex** (CORE tex) In plants, ground tissue bounded by the epidermis and vascular tissue in stems and roots; in animals, outer layer of an organ, such as the cortex of the kidney or adrenal gland. 441
- cortisol** (CORE tih zahl) Glucocorticoid secreted by the adrenal cortex that responds to stress on a long-term basis; reduces inflammation and promotes protein and fat metabolism. 746
- cost-benefit analysis** A weighing-out of the costs and benefits (in terms of contributions to reproductive success) of a particular strategy or behavior. 291
- cotyledon** (cot tih LEE dunn) Seed leaf for embryo of a flowering plant; provides nutrient molecules for the developing plant before photosynthesis begins. 424, 436, 500
- countercurrent exchange** Fluids flow side-by-side in opposite directions, as in the exchange of fluids in the kidneys. 652
- coupled reactions** Reactions that occur simultaneously; one is an exergonic reaction that releases energy, and the other is an endergonic reaction that requires an input of energy in order to occur. 107
- covalent bond** (koh VALE lunt) Chemical bond in which atoms share one pair of electrons. 27
- cranial nerve** (CRANE nee uhl) Nerve that arises from the brain. 692
- crenation** (krin AY shun) In animal cells, shriveling of the cell due to water leaving the cell when the environment is hypertonic. 93
- cristae (sing., crista)** (KRISS tee, KRISS tuh) Short, fingerlike projections formed by the folding of the inner membrane of mitochondria. 77
- Cro-Magnon** (crow MAG nahn) Common name for the first fossils to be designated *Homo sapiens*. 571
- crossing-over** Exchange of segments between nonsister chromatids of a bivalent during meiosis. 172
- crustacean** (crust TAY shun) Member of a group of marine arthropods that contains, among others, shrimps, crabs, crayfish, and lobsters. 530
- cuboidal epithelium** (cube OID uhl epp pih THEE lee uhm) Type of epithelial tissue with cube-shaped cells. 578
- Cushing syndrome** Condition resulting from hypersecretion of glucocorticoids; characterized by thin arms and legs and a "moon face," and accompanied by high blood glucose and sodium levels. 747
- cuticle** Waxy layer covering the epidermis of plants that protects the plant against water loss and disease-causing organisms. 412, 437, 465
- cyanobacterium (pl., cyanobacteria)** (SIGH uhn no back TEER ree uhm) Photosynthetic bacterium that contains chlorophyll and releases oxygen; formerly called a blue-green alga. 65, 367
- cyanogenic glycoside** Plant compound that contains sugar; produces cyanide. 488
- cycad** (SIGH cad) Type of gymnosperm with palmate leaves and massive cones; cycads are most often found in the tropics and subtropics. 420
- cyclic adenosine monophosphate (cAMP)** ATP-related compound that acts as the second messenger in peptide hormone transduction; it initiates activity of the metabolic machinery. 739
- cyclin** (SIGH klin) Protein that cycles in quantity as the cell cycle progresses; combines with and activates the kinases that function to promote the events of the cycle. 153
- cyst** (SIST) In protists and invertebrates, resting structure that contains reproductive bodies or embryos. 374, 522
- cytochrome** (SIGH toe krome) Any of several iron-containing protein molecules that are members of the electron transport chain in photosynthesis and cellular respiration. 142
- cytokine** (SIGH toe kine) Type of protein secreted by a T lymphocyte that attacks viruses, virally infected cells, and cancer cells. 618
- cytokinesis** (sigh toe kin NEE sis) Division of the cytoplasm following mitosis or meiosis. 152
- cytokinin** (sigh toe KINE ninn) Plant hormone that promotes cell division; often works in combination with auxin during organ development in plant embryos. 477
- cytoplasm** (SIGH toe plaz uhm) Contents of a cell between the nucleus (nucleoid) region of bacteria and the plasma membrane. 64
- cytosine (C)** (SIGH toe zeen) One of four nitrogen-containing bases in the nucleotides composing the structure of DNA and RNA; pairs with guanine. 214
- cytoskeleton** (sigh toe SKELL luh ton) Internal framework of the cell, consisting of microtubules, actin filaments, and intermediate filaments. 67
- cytotoxic T cell** (sigh toe TOX ick) T lymphocyte that attacks and kills antigen-bearing cells. 619

- D**
- data** (*sing., datum*) (DAY tuh, DAY tum) Facts or information collected through observation and/or experimentation. 12
- day-neutral plant** Plant whose flowering is not dependent on day length—e.g., tomato and cucumber. 487
- deamination** (dee am in AY shun) Removal of an amino group ($-\text{NH}_2$) from an amino acid or other organic compound. 145
- decapod** (DECK uh pod) Type of crustacean in which the thorax bears five pairs of walking legs; includes shrimps, lobsters, crayfish, and crabs. 530
- deciduous** (dih SIDD you us) Land plant which sheds its leaves annually. 435
- decomposer** Organism, usually a bacterium or fungus, that breaks down organic matter into inorganic nutrients that can be recycled in the environment. 852
- deductive reasoning** Process of logic and reasoning, using “if . . . then” statements. 11
- dehydration reaction** Chemical reaction resulting in a covalent bond with the accompanying loss of a water molecule. 40
- delayed allergic response** Allergic response initiated at the site of the allergen by sensitized T cells, involving macrophages and regulated by cytokines. 629
- deletion** (duh LEE shun) Change in chromosome structure in which the end of a chromosome breaks off or two simultaneous breaks lead to the loss of an internal segment; often causes abnormalities—e.g., cri du chat syndrome. 184
- demographic transition** (dem oh GRAFF ick) Due to industrialization, a decline in the birthrate following a reduction in the death rate so that the population growth rate is lowered. 833
- demography** Properties of the rate of growth and the age structure of populations. 821
- denatured** (dee NATE churd) Loss of an enzyme’s normal shape so that it no longer functions; caused by a less than optimal pH and temperature. 51, 110
- dendrite** (DEN drite) Part of a neuron that sends signals toward the cell body. 683
- dendritic cell** Antigen-presenting cell of the epidermis and mucous membranes. 618
- denitrification** (dee nite trih fih KAY shun) Conversion of nitrate or nitrite to nitrogen gas by bacteria in soil. 861
- dense fibrous connective tissue** Type of connective tissue containing many collagen fibers packed together; found in tendons and ligaments, for example. 580
- density-dependent factor** Biotic factor, such as disease or competition, that affects population size in a direct relationship to the population’s density. 828
- density-independent factor** Abiotic factor, such as fire or flood, that affects population size independent of the population’s density. 828
- deoxyribose** (dee ox ee RYE boh) Pentose sugar found in DNA. 41
- derived trait** Structural, physiological, or behavioral trait that is present in a specific lineage and is not present in the common ancestor for several lineages. 341
- dermis** (DER miss) In mammals, thick layer of the skin underlying the epidermis. 586
- desert** Ecological biome characterized by a limited amount of rainfall; deserts have hot days and cool nights. 878
- desmosome** (DEZ moh sohm) Intercellular junction that connects cytoskeletons of adjacent cells. 98
- detritivore** Any organism that obtains most of its nutrients from the detritus in an ecosystem. 852
- deuterostome** (DEW turr row stome) Group of coelomate animals in which the second embryonic opening is associated with the mouth; the first embryonic opening, the blastopore, is associated with the anus. 515
- diabetes mellitus** Condition characterized by a high blood glucose level and the appearance of glucose in the urine due to a deficiency of insulin production and failure of cells to take up glucose. 748
- diaphragm** (DIE uh framn) In mammals, dome-shaped muscularized sheet separating the thoracic cavity from the abdominal cavity. 656
- diarrhea** Excessively frequent and watery bowel movements. 640
- diastole** (die ASS tuh lee) Relaxation period of a heart chamber during the cardiac cycle. 600
- diatom** (DIE uh tom) Golden-brown alga with a cell wall in two parts, or valves; significant part of phytoplankton. 382
- diencephalon** (die in SEF uh lahn) In vertebrates, portion of the brain in the region of the third ventricle that includes the thalamus and hypothalamus. 690
- differentially permeable** Ability of plasma membranes to regulate the passage of substances into and out of the cell, allowing some to pass through and preventing the passage of others. 90
- diffusion** Movement of molecules or ions from a region of higher to lower concentration; it requires no energy and tends to lead to an equal distribution. 91
- dihybrid cross** (die HIGH brid) Cross between parents that differ in two traits. 194
- dikaryotic** (die care ree AH tick) Having two haploid nuclei that stem from different parent cells; during sexual reproduction, sac and club fungi have dikaryotic cells. 395
- dinoflagellate** (dine no FLAJ ell ate) Photosynthetic unicellular protist with two flagella, one whiplash and the other located within a groove between protective cellulose plates; significant part of phytoplankton. 383
- dioecious** (dye EESH us) Having unisexual flowers or cones, with the male flowers or cones confined to certain land plants and the female flowers or cones of the same species confined to other different plants. 422
- diploid (2n) number** (DIP loid) Cell condition in which two of each type of chromosome are present. 155, 170
- diplomonad** Protist that has modified mitochondria, two equal-sized nuclei, and multiple flagella. 386
- directional selection** Outcome of natural selection in which an extreme phenotype is favored, usually in a changing environment. 290
- disaccharide** (die SACK uh ride) Sugar that contains two units of a monosaccharide; e.g., maltose. 41
- disruptive selection** Outcome of natural selection in which the two extreme phenotypes are favored over the average phenotype, leading to more than one distinct form. 290
- distal convoluted tubule** (DISS tull KAHN vole loot ted TUBE yule) Final portion of a nephron that joins with a collecting duct; associated with tubular secretion. 671
- DNA (deoxyribonucleic acid)** (dee OX ee RYE bow new CLAY ick) Nucleic acid polymer produced from covalent bonding of nucleotide monomers that contain the sugar deoxyribose; the genetic material of nearly all organisms. 52
- DNA ligase** (LIE gaze) Enzyme that links DNA fragments; used during production of recombinant DNA to join foreign DNA to vector DNA. 250
- DNA microarray** Thousands of different single-stranded DNA fragments arranged in an array (grid) on a glass slide; used to detect and measure gene expression. 258
- DNA polymerase** (pah LIMM urr race) During replication, an enzyme that joins the nucleotides complementary to a DNA template. 217
- DNA repair enzyme** One of several enzymes that restore the original base sequence in an altered DNA strand. 244
- DNA replication** Synthesis of a new DNA double helix prior to mitosis and meiosis in eukaryotic cells and during prokaryotic fission in prokaryotic cells. 217
- domain** Largest of the categories, or taxa, used by taxonomists to group species; the three domains are Archaea, Bacteria, and Eukarya. 6, 340
- domain Archaea** One of the three domains of life; contains prokaryotic cells that often live in extreme habitats and have unique genetic, biochemical, and physiological characteristics; its members are sometimes referred to as *archaea*. 7, 348
- domain Bacteria** One of the three domains of life; contains prokaryotic cells that differ from archaea because they have their own unique genetic, biochemical, and physiological characteristics. 7, 348
- domain Eukarya** One of the three domains of life, consisting of organisms with eukaryotic cells; includes protists, fungi, plants, or animals. 7, 348
- dominance hierarchy** Organization of animals in a group that determines the order in which the animals have access to resources. 291
- dominant allele** (uh LEEL) Allele that exerts its phenotypic effect in the heterozygote; it masks the expression of the recessive allele. 193
- dopamine** (DOPE uh meen) Neurotransmitter in the central nervous system. 686
- dormancy** In plants, a cessation of growth under conditions that seem appropriate for growth. 477
- dorsal root ganglion** (GANG lee uhn) Mass of sensory neuron cell bodies located in the dorsal root of a spinal nerve. 692
- double fertilization** In flowering plants, one sperm nucleus unites with the egg nucleus, and a second sperm nucleus unites with the polar nuclei of an embryo sac. 497
- double helix** Double spiral; describes the three-dimensional shape of DNA. 215
- doubling time** Number of years it takes for a population to double in size. 833
- dryopithecine** Tree dwelling primate existing 12–9 MYA; ancestral to apes. 563

duodenum (dew ODD duh num) First part of the small intestine, where chyme enters from the stomach. 639

duplication Change in chromosome structure in which a particular segment is present more than once in the same chromosome. 184

E

ecdysozoa A protostome characterized by periodic molting of their exoskeleton. Includes the roundworms and arthropods. 516

echinoderm (ee KINE oh derm) Invertebrates such as sea stars, sea urchins, and sand dollars; characterized by radial symmetry and a water vascular system. 534

ecological niche Role an organism plays in its community, including its habitat and its interactions with other organisms. 841

ecological pyramid Visual depiction of the biomass, number of organisms, or energy content of various trophic levels in a food web—from the producer to the final consumer populations. 855

ecological succession The gradual replacement of communities in an area following a disturbance (secondary succession) or the creation of new soil (primary succession). 850

ecology Study of the interactions of organisms with other organisms and with the physical and chemical environment. 820

ecosystem Biological community together with the associated abiotic environment; characterized by a flow of energy and a cycling of inorganic nutrients. 9, 820, 852

ecosystem diversity Variety of species in a particular locale, dependent on the species interactions. 891

ectoderm (EK toe derm) Outermost primary tissue layer of an animal embryo; gives rise to the nervous system and the outer layer of the integument. 780

ectotherm (ek toe THERM) Organism having a body temperature that varies according to the environmental temperature. 543

edge effect Phenomenon in which the edges around a landscape patch provide a slightly different habitat than the favorable habitat in the interior of the patch. 902

effector Muscle or gland that receives signals from motor fibers and thereby allows an organism to respond to environmental stimuli. 679

elastic cartilage Type of cartilage composed of elastic fibers, allowing greater flexibility. 580

elastic fiber Yellow fiber in the matrix of connective tissue, providing flexibility. 579

electrocardiogram (ECG) (ee leck troh CARD dee oh gram) Recording of the electrical activity associated with the heartbeat. 601

electron Negative subatomic particle, moving about in an energy level around the nucleus of an atom. 22

electronegativity The ability of an atom to attract electrons toward itself in a chemical bond. 27

electron shell Concentric energy levels in which electrons orbit. 22

electron transport chain (ETC) Passage of electrons along a series of membrane-bound electron carrier molecules from a higher to lower energy level; the energy released is used for the synthesis of ATP. 112, 119, 135, 142

element Substance that cannot be broken down into substances with different properties; composed of only one type atom. 22

El Nino–Southern Oscillation Warming of water in the Eastern Pacific equatorial region such that the Humboldt Current is displaced, with possible negative results such as reduction in marine life. 884

elongation Middle stage of translation in which additional amino acids specified by the mRNA are added to the growing polypeptide. 226

embryo Stage of a multicellular organism that develops from a zygote before it becomes free-living; in seed plants, the embryo is part of the seed. 779

embryonic disk (em bree AHN ick) During human development, flattened area during gastrulation from which the embryo arises. 789

embryonic period First eight weeks of human development, during which the major organ systems are organized. 787

embryophyta Bryophytes and vascular plants; both of which produce embryos. 412

embryo sac Female gametophyte (megagametophyte) of flowering plants. 497

emergent property Quality that appears as biological complexity increases. 2

emerging virus Newly identified viruses that are becoming more prominent usually because they cause serious disease. 361

endangered species A species that is in peril of immediate extinction throughout all or most of its range (e.g., California condor, snow leopard). 890

endergonic reaction (en der GONN ick) Chemical reaction that requires an input of energy; opposite of exergonic reaction. 106

endocrine gland (EN doe crinn) Ductless organ that secretes hormone(s) into the bloodstream. 579, 736

endocrine system Organ system involved in the coordination of body activities; uses hormones as chemical signals secreted into the bloodstream. 736

endocytosis (en doe site TOE sis) Process by which substances are moved into the cell from the environment by phagocytosis (cellular eating) or pinocytosis (cellular drinking); includes receptor-mediated endocytosis. 96

endoderm (EN doe derm) Innermost primary tissue layer of an animal embryo that gives rise to the linings of the digestive tract and associated structures. 780

endodermis (en doe DERM miss) Internal plant root tissue forming a boundary between the cortex and the vascular cylinder. 441

endomembrane system (en doe MEM brain) Cellular system that consists of the nuclear envelope, endoplasmic reticulum, Golgi apparatus, and vesicles. 72

endometrium (en doe MEET tree uhm) Mucous membrane lining the interior surface of the uterus. 762

endoplasmic reticulum (ER) (en doe PLAZ mick ruh TICK you lum) System of membranous saccules and channels in the cytoplasm, often with attached ribosomes. 72

endoskeleton (en doe SKELL uh ton) Protective internal skeleton, as in vertebrates. 718

endosperm (EN doe sperm) In flowering plants, nutritive storage tissue that is derived from the union of a sperm nucleus and polar nuclei in the embryo sac. 497

endospore (EN doe spore) Spore formed within a cell; certain bacteria form endospores. 366

endosymbiotic theory (en doe simm bee AH tick) Explanation of the evolution of eukaryotic organelles by phagocytosis of prokaryotes. 66, 325

endotherm (en doe THERM) Organism in which maintenance of a constant body temperature is independent of the environmental temperature. 552

energy Capacity to do work and bring about change; occurs in a variety of forms. 4, 104

energy of activation Energy that must be added in order for molecules to react with one another. 108

enhancer DNA sequence that acts as a regulatory element to increase the level of transcription when a transcription factor binds to it. 242

entropy (EN truh pee) Measure of disorder or randomness. 105

enzymatic protein (en zih MATT tick) Protein that catalyzes a specific reaction. 88

enzyme (EN zime) Organic catalyst, usually a protein, that speeds a reaction in cells due to its particular shape. 40, 108

enzyme inhibition Means by which cells regulate enzyme activity; may be competitive or noncompetitive inhibition. 111

eosinophil (ee oh SIN uh fill) White blood cell containing cytoplasmic granules that stain with acidic dye. 607, 618

epidermal tissue Exterior tissue, usually one cell thick, of leaves, young stems, roots, and other parts of plants. 437

epidermis (eh pih DERM miss) In mammals, the outer, protective layer of the skin; in plants, tissue that covers roots, leaves, and stems of nonwoody organisms. 437, 585

epigenetic inheritance An inheritance pattern in which a nuclear gene has been modified but the changed expression of the gene is not permanent over many generations. 237

epiglottis (eh pih GLOTT tiss) Structure that covers the glottis, the air-tract opening, during the process of swallowing. 654

epinephrine (eh pih NEFF rinn) Hormone secreted by the adrenal medulla in times of stress; adrenaline. 745

epiphyte (EPP pih fite) Plant that takes its nourishment from the air because its placement in other plants gives it an aerial position. 874

epithelial tissue (eh pih THEE lee uhl) Tissue that lines hollow organs and covers surfaces. 578

erythropoietin (EPO) (eh rih throw poe EE tin) Hormone produced by the kidneys that speeds red blood cell formation. 674, 751

esophagus (eh SOFF uh gus) Muscular tube for moving swallowed food from the pharynx to the stomach. 637

essential nutrient In plants, substance required for normal growth, development, or reproduction. 457

estrogen (ESS truh jen) Female sex hormone that helps maintain sexual organs and secondary sex characteristics. 750, 763

estuary (EST you air ree) Portion of the ocean located where a river enters and fresh water mixes with salt water. 882

ethylene (ETH uh leen) Plant hormone that causes ripening of fruit and is also involved in abscission. 480

- euchromatin** (you CROW muh tin) Chromatin that is extended and accessible for transcription. 229, 239
- eudicot** (you DIE cot) Abbreviation of eudicotyledon. Flowering plant group; members have two embryonic leaves (cotyledons), net-veined leaves, vascular bundles in a ring, flower parts in fours or fives and their multiples, and other characteristics. 424, 436
- Eudicotyledone** One of two major classes of angiosperms; abbreviated as eudicot. 424
- euglenid** (YOU glen id) Flagellated and flexible freshwater unicellular protist that usually contains chloroplasts and has a semirigid cell wall. 386
- eukaryotic cell (eukaryote)** (you care ree AH tick) Type of cell that has a membrane-bounded nucleus and membranous organelles; found in organisms within the domain Eukarya. 7, 64
- euploidy** (you PLOY dee) Cells containing only complete sets of chromosomes. 180
- eutrophication** (you troh fih KAY shun) Enrichment of water by inorganic nutrients used by phytoplankton. Often, overenrichment caused by human activities leads to excessive bacterial growth and oxygen depletion. 859, 880
- evaporate (evaporation)** Conversion of a liquid or a solid into a gas. 29
- evergreen** Land plant that sheds leaves over a long period, so some leaves are always present. 435
- evolution** Descent of organisms from common ancestors with the development of genetic and phenotypic changes over time that make them more suited to the environment. 5, 267
- evolutionary species concept** Every species has its own evolutionary history, which is partly documented in the fossil record. 300
- excavate** Supergroup of eukaryotes that includes euglenids, kinetoplastids, parabasalids, and diplomonads. 386
- excretion** Elimination of metabolic wastes by an organism at exchange boundaries such as the plasma membrane of unicellular organisms and excretory tubules of multicellular animals. 666
- exergonic reaction** (ex urr GONN ick) Chemical reaction that releases energy; opposite of endergonic reaction. 106
- exocrine gland** (EX oh krinn) Gland that secretes its product to an epithelial surface directly or through ducts. 579
- exocytosis** (ex oh sigh TOE sis) Process in which an intracellular vesicle fuses with the plasma membrane so that the vesicle's contents are released outside the cell. 96
- exon** Segment of mRNA containing the protein-coding portion of a gene that remains within the mRNA after splicing has occurred. 223
- exophthalmic goiter** (ex opp THOWL mick GOI turr) Enlargement of the thyroid gland accompanied by an abnormal protrusion of the eyes. 743
- exoskeleton** (ex oh SKELL uh ton) Protective external skeleton, as in arthropods. 529, 718
- exotic species** Nonnative species that migrate or are introduced by humans into a new ecosystem; also called alien species. 897
- experiment** Artificial situation devised to test a hypothesis. 11
- experimental design** Methodology by which an experiment will seek to support the hypothesis. 11
- experimental variable** Factor of the experiment being tested. 14
- expiration** Act of expelling air from the lungs; exhalation. 656
- exponential growth** Growth, particularly of a population, in which the increase occurs in the same manner as compound interest. 825
- extant** Species, or other levels of taxa, that are still living. 267
- external respiration** Exchange of oxygen and carbon dioxide between alveoli and blood. 650
- extinct; extinction** Total disappearance of a species or higher group. 10, 327
- extracellular matrix (ECM)** Nonliving substance in which animal cells are imbedded; is composed of protein and polysaccharides. 87
- extraembryonic membrane** (ex truh em bree AH nick) Membrane that is not a part of the embryo but is necessary to the continued existence and health of the embryo. 757, 787
- ex vivo gene therapy** Gene therapy in which cells are removed from an organism, and DNA injected to correct a genetic defect; the cells are returned to the organism to treat a disease or disorder. 256
- ## F
- facilitated transport** Passive transfer of a substance into or out of a cell along a concentration gradient by a process that requires a carrier. 94
- facultative anaerobe** (fac ull TAY tivh ANN air robe) Prokaryote that is able to grow in either the presence or the absence of gaseous oxygen. 364
- FAD** Flavin adenine dinucleotide; a coenzyme of oxidation-reduction that becomes FADH₂ as oxidation of substrates occurs, and then delivers electrons to the electron transport chain in mitochondria during cellular respiration. 134
- fall overturn** Mixing process that occurs in fall in stratified lakes, whereby oxygen-rich top waters mix with nutrient-rich bottom waters. 880
- family** One of the categories, or taxa, used by taxonomists to group species; the taxon above the genus level. 6, 340
- family pedigree** Chart of genetic relationship of family individuals through the generations. 201
- fat** Organic molecule that contains glycerol and fatty acids and is found in adipose tissue of vertebrates. 44, 644
- fate map** Diagram that traces the differentiation of cells during development from their origin to their final structure and function. 784
- fatty acid** Molecule that contains a hydrocarbon chain and ends with an acid group. 44
- fecundity** Potential capacity of an individual to produce offspring. 830
- female gametophyte** (guh MEET oh fite) In seed plants, the gametophyte that produces an egg; in flowering plants, an embryo sac. Sometimes called a megagametophyte. 496
- fermentation** Anaerobic breakdown of glucose that results in a gain of two ATP and end products such as alcohol and lactate. 135, 138
- fern** Member of a group of land plants that have large fronds; in the sexual life cycle, the independent gametophyte produces flagellated sperm, and the vascular sporophyte produces windblown spores. 418
- fertilization** Fusion of sperm and egg nuclei, producing a zygote that develops into a new individual. 172, 778
- fiber** Plant material that is nondigestible and promotes regularity of elimination. 643
- fibroblast** (FIE broh blast) Cell found in loose connective tissue that synthesizes collagen and elastic fibers in the matrix. 580
- fibrocartilage** Cartilage with a matrix of strong collagenous fibers. 580
- fibrous protein** A protein that has only a secondary structure; generally insoluble; includes collagens, elastins, and keratins. 51
- fibrous root system** In most monocots, a mass of similarly sized roots that cling to the soil. 442
- filament** (FILL uh mint) End-to-end chains of cells that form as cell division occurs in only one plane; in plants, the elongated stalk of a stamen. 378, 495
- fimbria (pl., fimbriae)** (FIMM bree uh, FIMM bree ee) Small, bristlelike fiber on the surface of a bacterial cell, which attaches bacteria to a surface; also fingerlike extension from the oviduct near the ovary. 65, 363
- fin** In fish and other aquatic animals, membranous, winglike, or paddlelike process used to propel, balance, or guide the body. 544
- first messenger** Chemical signal such as a peptide hormone that binds to a plasma membrane receptor protein and alters the metabolism of a cell because a second messenger is activated. 739
- fishes** Aquatic, gill-breathing vertebrate that usually has fins and skin covered with scales; fishes were among the earliest vertebrates that evolved. 543
- fitness** Ability of an organism to reproduce and pass its genes to the next fertile generation; measured against the ability of other organisms to reproduce in the same environment. 271, 291
- five-kingdom system** System of classification that contains the kingdoms Monera, Protista, Plantae, Animalia, and Fungi. 348
- fixed action pattern (FAP)** Innate behavior pattern that is stereotyped, spontaneous, independent of immediate control, genetically encoded, and independent of individual learning. 802
- flagellum (pl., flagella)** (fluh JELL uhm) Long, slender extension used for locomotion by some bacteria, protozoans, and sperm. 65, 80, 363
- flagship species** Species that evoke a strong emotional response in humans; charismatic, cute, regal (e.g., lions, tigers, dolphin, panda). 901
- flame cell** Found along excretory tubules of planarians; functions in propulsion of fluid through the excretory canals and out of the body. 667
- flatworm** Invertebrates such as planarians and tapeworms with extremely thin bodies; a three-branched gastrovascular cavity and a ladder type nervous system 520
- flower** Reproductive organ of a flowering plant, consisting of several kinds of modified leaves arranged in concentric rings and attached to a modified stem called the receptacle. 424, 494
- fluid-mosaic model** Model for the plasma membrane based on the changing location and pattern of protein molecules in a fluid phospholipid bilayer. 87
- follicle** (FOLL lick cull) Structure in the ovary of animals that contains an oocyte; site of oocyte production. 763

follicular phase (foe LICK you lurr) First half of the ovarian cycle, during which the follicle matures and much estrogen (and some progesterone) is produced. 764

fontanel (fahn tuh NELL) Membranous region located between certain cranial bones in the skull of a vertebrate fetus or infant. 722

food chain The order in which one population feeds on another in an ecosystem, thereby showing the flow of energy from a detritivore (detrital food chain) or a producer (grazing food chain) to the final consumer. 855

food web In ecosystems, a complex pattern of interlocking and crisscrossing food chains. 855

foramen magnum (for AY men MAG num) Opening in the occipital bone of the vertebrate skull through which the spinal cord passes. 722

foraminiferan (for am men IF furr uhn) A protist bearing a calcium carbonate test with many openings through which pseudopods extend. 388

foreign antigen An antigen not produced by the organism and to which it will react 619

formula A group of symbols and numbers used to express the composition of a compound. 26

fossil Any past evidence of an organism that has been preserved in the Earth's crust. 276, 322

founder effect Cause of genetic drift due to colonization by a limited number of individuals who, by chance, have different genotype and allele frequencies than the parent population. 288

fovea centralis (FOE vee uh sen TRAHL liss) Region of the retina consisting of densely packed cones; responsible for the greatest visual acuity. 705

frameshift mutation Insertion or deletion of at least one base so that the reading frame of the corresponding mRNA changes. 244

free energy Useful energy in a system that is capable of performing work. 106

frond Leaf of a fern palm, or cycad. 418

fruit Flowering plant structure consisting of one or more ripened ovaries that usually contain seeds. 427, 503

fruiting body Spore-producing and spore-disseminating structure found in sac and club fungi. 398

functional genomics Study of gene function at the genome level. It involves the study of many genes simultaneously and the use of DNA microarrays. 258

functional group Specific cluster of atoms attached to the carbon skeleton of organic molecules that enters into reactions and behaves in a predictable way. 39

fungus (pl., fungi) Saprotrophic decomposer; the body is made up of filaments called hyphae that form a mass called a mycelium. 7, 394

G

gallbladder Organ attached to the liver that serves to store and concentrate bile. 642

gametangia Cell or multicellular structure in which gametes are formed. 396

gamete (GAMM eet) Haploid sex cell; e.g., egg and sperm. 170, 768

gametogenesis (gamm eet oh JEN uh sis) Development of the male and female sex gametes. 179

gametophyte (guh MEET uh fite) Haploid generation of the alternation of generations life cycle of a plant; produces gametes that unite to form a diploid zygote. 178, 412

ganglion (GANG lee ahn) Collection or bundle of neuron cell bodies usually outside the central nervous system. 680

gap junction Junction between cells formed by the joining of two adjacent plasma membranes; it lends strength and allows ions, sugars, and small molecules to pass between cells. 99

gastropod (gas trah POD) Mollusc with a broad, flat foot for crawling (e.g., snails and slugs). 525

gastrovascular cavity (gas troh VASS cue lurr) Blind digestive cavity in animals that have a sac body plan. 518

gastrula (GAS true luh) Stage of animal development during which the germ layers form, at least in part, by invagination. 780

gastrulation (gas true LAY shun) Formation of a gastrula from a blastula; characterized by an invagination to form cell layers of a caplike structure. 780

gene (JEEN) Unit of heredity existing as alleles on the chromosomes; in diploid organisms, typically two alleles are inherited—one from each parent. 5, 70

gene cloning DNA cloning to produce many identical copies of the same gene. 250

gene flow Sharing of genes between two populations through interbreeding. 287

gene locus Specific location of a particular gene on a chromosome. 193

gene mutation Altered gene whose sequence of bases differs from the previous sequence. 243

gene pharming Production of pharmaceuticals using transgenic farm animals. 253

gene pool Total of all the genes of all the individuals in a population. 285

gene therapy Correction of a detrimental mutation by the addition of new DNA and its insertion in a genome. 250

genetically modified organism (GMO) Organism that carries the genes of another organism as a result of DNA technology. 252

genetic code Universal code that has existed for eons and allows for conversion DNA and RNA's chemical code to a sequence of amino acids in a protein. Each codon consists of three bases that stand for one of the 20 amino acids found in proteins or directs the termination of translation. 221

genetic diversity Variety among members of a population. 891

genetic drift Mechanism of evolution due to random changes in the allelic frequencies of a population; more likely to occur in small populations or when only a few individuals of a large population reproduce. 287

genetic profile An individual's genome, including any possible mutations. 258

genetic recombination Process in which chromosomes are broken and rejoined to form novel combinations; in this way offspring receive alleles in combinations different from their parents. 172

genomics Study of whole genomes. 255

genotype (JEEN oh type) Genes of an organism for a particular trait or traits; often designated by letters—for example, *BB* or *Aa*. 193

genus (JEEN us) One of the categories, or taxa, used by taxonomists to group species; contains those species that are most closely related through evolution. 6, 340

geologic timescale History of the earth based on the fossil record and divided into eras, periods, and epochs 324

germ cell During zygote development, cells that are set aside from the somatic cells and that will eventually undergo meiosis to produce gametes. 756

germinate Beginning of growth of a seed, spore, or zygote, especially after a period of dormancy. 504

germ layer Primary tissue layer of a vertebrate embryo—namely, ectoderm, mesoderm, or endoderm. 515, 780

gibberellin (jib urr ELL uhn) Plant hormone promoting increased stem growth; also involved in flowering and seed germination. 476

gills Respiratory organ in most aquatic animals; in fish, an outward extension of the pharynx. 540, 651

ginkgo Member of phylum Ginkgophyta; maidenhair tree. 422

girdling Removing a strip of bark from around a tree. 468

gland Epithelial cell or group of epithelial cells that are specialized to secrete a substance. 579

global warming Predicted increase in the Earth's temperature due to human activities that promote the greenhouse effect. 125, 859, 898

globular protein Most of the proteins in the body; soluble in water or salt solution; includes albumins, globulins, histones. 51

glomerular capsule (glow MARE you lurr) Cuplike structure that is the initial portion of a nephron. 671

glomerular filtration Movement of small molecules from the glomerulus into the glomerular capsule due to the action of blood pressure. 672

glomerulus (glow MARE you luss) Capillary network within the glomerular capsule of a nephron. 671

glottis (GLAH tiss) Opening for airflow in the larynx. 654

glucocorticoid (glue koh CORE tih coid) Type of hormone secreted by the adrenal cortex that influences carbohydrate, fat, and protein metabolism; *See* also cortisol. 745

glucose (GLUE kohs) Six-carbon sugar that organisms degrade as a source of energy during cellular respiration. 41

glycerol (GLISS ur all) Three-carbon carbohydrate with three hydroxyl groups attached; a component of fats and oils. 44

glycocalyx (glie koh KAY licks) Gel-like coating outside the cell wall of a bacterium. If compact, it is called a capsule; if diffuse, it is called a slime layer. 64

glycogen (GLIE kuh jen) Storage polysaccharide found in animals; composed of glucose molecules joined in a linear fashion but having numerous branches. 42

glycolipid (glie koh LIP pidd) Lipid in plasma membranes that bears a carbohydrate chain attached to a hydrophobic tail. 87

glycolysis (glie KAH lih sis) Anaerobic breakdown of glucose that results in a gain of two ATP and the end product pyruvate. 135, 136

glycoprotein (glie koh PRO teen) Protein in plasma membranes that bears a carbohydrate chain. 87

gnathostome Vertebrates with jaws. 542

gnetophyte Member of one of the four phyla of gymnosperms; Gnetophyta has only three living genera, which differ greatly from one another—e.g., *Welwitschia* and *Ephedra*. 422

- golden brown algae** Unicellular organism that contains pigments, including chlorophyll *a* and *c* and carotenoids, that produce its color. 382
- Golgi apparatus** (GOAL ghee app uh RAT us) Organelle consisting of sacs and vesicles that processes, packages, and distributes molecules about or from the cell. 72
- gonad** (GO nadd) Organ that produces gametes; the ovary produces eggs, and the testis produces sperm. 756
- gonadotropic hormone** (go nadd oh TROH pick) Substance secreted by the anterior pituitary that regulates the activity of the ovaries and testes; principally, follicle-stimulating hormone (FSH) and luteinizing hormone (LH). 740
- granum (pl., grana)** (GRA numm) Stack of chlorophyll-containing thylakoids in a chloroplast. 76, 119
- grassland** Biome characterized by rainfall greater than 25 cm/yr, grazing animals, and warm summers; includes the prairie of the U.S. midwest and the African savanna. 876
- gravitational equilibrium** Maintenance of balance when the head and body are motionless. 712
- gravitropism** (grav ih TROPE is uhm) Growth response of roots and stems of plants to the Earth's gravity; roots demonstrate positive gravitropism, and stems demonstrate negative gravitropism. 482
- gray crescent** Gray area that appears in an amphibian egg after being fertilized by the sperm; thought to contain chemical signals that turn on the genes that control development. 783
- gray matter** Nonmyelinated axons and cell bodies in the central nervous system. 688
- green algae** Members of a diverse group of photosynthetic protists; contain chlorophylls *a* and *b* and have other biochemical characteristics like those of plants. 377
- greenhouse effect** Reradiation of solar heat toward the Earth, caused by an atmosphere that allows the sun's rays to pass through but traps the heat in the same manner as the glass of a greenhouse. 859
- greenhouse gases** Gases in the atmosphere such as carbon dioxide, methane, water vapor, ozone, and nitrous oxide that are involved in the greenhouse effect. 858
- ground tissue** Tissue that constitutes most of the body of a plant; consists of parenchyma, collenchyma, and sclerenchyma cells that function in storage, basic metabolism, and support. 437
- growth factor** A hormone or chemical, secreted by one cell, that may stimulate or inhibit growth of another cell or cells. 153
- growth hormone (GH)** Substance secreted by the anterior pituitary; controls size of an individual by promoting cell division, protein synthesis, and bone growth. 740
- guanine (G)** (GWAH neen) One of four nitrogen-containing bases in nucleotides composing the structure of DNA and RNA; pairs with cytosine. 214
- guard cell** One of two cells that surround a leaf stoma; changes in the turgor pressure of these cells cause the stoma to open or close. 466
- guttation** (gutt TAY shun) Liberation of water droplets from the edges and tips of leaves. 464
- gymnosperm** (JIM no sperm) Type of woody seed plant in which the seeds are not enclosed by fruit and are usually borne in cones, such as those of the conifers. 420
- H**
- habitat** Place where an organism lives and is able to survive and reproduce. 820, 841
- hair follicle** Tubelike depression in the skin in which a hair develops. 586
- halophile** (HAL uh file) Type of archaea that lives in extremely salty habitats. 369
- haploid (n) number** (HAP loid) Cell condition in which only one of each type of chromosome is present. 155, 170
- Hardy-Weinberg principle** Law stating that the gene frequencies in a population remain stable if evolution does not occur due to nonrandom mating, selection, migration, and genetic drift. 286
- hay fever** Seasonal variety of allergic reaction to a specific allergen. Characterized by sudden attacks of sneezing, swelling of nasal mucosa, and often asthmatic symptoms. 629
- heart** Muscular organ whose contraction causes blood to circulate in the body of an animal. 598
- heart attack** Damage to the myocardium due to blocked circulation in the coronary arteries; myocardial infarction. 605
- heat** Type of kinetic energy; captured solar energy eventually dissipates as heat in the environment. 104
- helper T cell** Secretes lymphokines, which stimulate all kinds of immune cells. 619
- heme** (HEEM) Iron-containing group found in hemoglobin. 659
- hemizygous** Possessing only one allele for a gene in a diploid organism; males are hemizygous for genes on the X chromosome. 206
- hemocoel** (HEEM uh seel) Residual coelom found in arthropods, which is filled with hemolymph. 523
- hemoglobin (Hb)** (HEEM uh globe in) Iron-containing respiratory pigment occurring in vertebrate red blood cells and in the blood plasma of some invertebrates. 48, 659, 606
- hemolymph** (HEEM uh limf) Circulatory fluid that is a mixture of blood and interstitial fluid; seen in animals that have an open circulatory system, such as molluscs and arthropods. 594
- hepatitis** Inflammation of the liver. Viral hepatitis occurs in several forms. 642
- herbaceous stem** (her BAY shus) Nonwoody stem. 445
- herbivore** (HER bih vore) Primary consumer in a grazing food chain; a plant eater. 852
- hermaphroditic** Type of animal that has both male and female sex organs. 521
- heterochromatin** (hett turr oh CROW muh tin) Highly compacted chromatin that is not accessible for transcription. 229, 240
- heterosporous** Seed plant that produces two types of spores—microspores and megaspores. A plant that produces only one type of spore is *homosporous*. 420
- heterotroph** (HETT turr uh trofe) Organism that cannot synthesize organic compounds from inorganic substances and therefore must take in organic food. 118, 852
- heterozygote advantage** Situation in which individuals heterozygous for a trait have a selective advantage over those who are homozygous dominant or recessive; an example is sickle-cell anemia disease. 295
- heterozygous** (hett turr oh ZYE guss) Possessing unlike alleles for a particular trait. 193
- hexose** (HEX ohs) Six-carbon sugar. 41
- histamine** (HISS tuh mean) Substance, produced by basophils in blood and mast cells in connective tissue, that causes capillaries to dilate. 616
- histone** A group of proteins involved in forming the nucleosome structure of eukaryote chromatin. 155, 228
- holozoic** (hoe low ZOE ick) Obtaining nourishment by ingesting solid food particles. 384
- homeobox** (HOME me oh box) 180-nucleotide sequence located in all homeotic genes. 785
- homeodomain** Conserved DNA-binding region of transcription factors encoded by the homeobox of homeotic genes. 786
- homeostasis** (home me oh STAY sis) Maintenance of normal internal conditions in a cell or an organism by means of self-regulating mechanisms. 4, 588
- homeotic genes** (home me AH tick) Genes that control the overall body plan by controlling the fate of groups of cells during development. 785
- hominid** (HAH men idd) Member of the family Hominidae, including humans, chimpanzees, gorillas, and orangutans. 563
- hominin** Taxon that includes human and species very closely related to humans and chimpanzees. 563
- hominine** Taxon that includes the hominins and gorillas. 563
- hominoid** (HAH men oid) Member of the superfamily Hominoidea, which includes apes, humans, and their recent ancestors. 563
- Homo erectus*** (HOE mow eh RECK tuss) Hominin related to *H. erectus* that remained in Africa. 568
- Homo ergaster*** Extinct hominin; some paleontologists separate it from *H. erectus*, some do not and consider it a part of the African line of *H. erectus*. 568
- homologous chromosome** (hoe MOLL uh gus) Member of a pair of chromosomes that are alike and come together in synapsis during prophase of the first meiotic division; a *homologue*. 170
- homologous gene** Gene that codes for the same protein, even if the base sequence may be different. 260
- homologous structure** In evolution, a structure that is similar in different types of organisms because these organisms are derived from a common ancestor. 278, 345
- homologue** (HOE mow log) Member of a homologous pair of chromosomes. 170
- homology** (hoe MAH low jee) Similarity of parts or organs of different organisms caused by evolutionary derivation from a corresponding part or organ in a remote ancestor, and usually having a similar embryonic origin. 344
- homozygous** (hoe mow ZYE guss) Possessing two identical alleles for a particular trait. 193
- hormone** Chemical messenger produced in one part of the body that controls the activity of other parts. 474, 736
- hornwort** A bryophyte (phylum *Anthocerophyta*) with a thin gametophyte and tiny sporophyte that resembles a broom handle. 414
- horsetail** A seedless vascular plant having only one genus (*Equisetum*) in existence today; characterized by rhizomes, scalelike leaves, strobili, and tough, rigid stems. 417
- host** Organism that provides nourishment and/or shelter for a parasite. 846
- host specific** Parasite that can infect only one type of host. 358

- human chorionic gonadotropin (HCG)** (core ree AH nick go nadd uh TROPE in) Gonadotropic hormone produced by the chorion that functions to maintain the uterine lining. 765, 789
- Human Genome Project (HGP)** Initiative to determine the complete sequence of the human genome and to analyze this information. 255
- human immunodeficiency virus (HIV)** (im you no duh FISH ens see) Virus responsible for AIDS. 770
- humus** (HUE muss) Decomposing organic matter in the soil. 458
- hunter-gatherer** Human that hunted animals and gathered plants for food. 569
- Huntington disease** Genetic disease marked by progressive deterioration of the nervous system and resulting in neuromuscular abnormalities. 689
- hyaline cartilage** Cartilage whose cells lie in lacunae separated by a white translucent matrix containing very fine collagen fibers. 580
- hydra** A freshwater cnidaria that only exists as a polyp with tentacles. 519
- hydrogen bond** Weak bond that arises between a slightly positive hydrogen atom of one molecule and a slightly negative atom of another molecule or between parts of the same molecule. 28
- hydrogen ion (H⁺)** Hydrogen atom that has lost its electron and therefore bears a positive charge. 32
- hydrolysis reaction** (high DRAH lih sis) Splitting of a bond by the addition of water, with the H⁺ going to one molecule and the OH⁻ going to the other. 40
- hydrophilic** (high droh FILL ick) Type of molecule that interacts with water by dissolving in water and/or by forming hydrogen bonds with water molecules. 30, 39
- hydrophobic** (high droh FOE bick) Type of molecule that does not interact with water because it is nonpolar. 30, 39
- hydroponics** (high droh PAH nicks) Technique for growing plants by suspending them with their roots in a nutrient solution. 457
- hydrostatic skeleton** (high droh STAT ick) Fluid-filled body compartment that provides support for muscle contraction resulting in movement; seen in cnidarians, flatworms, roundworms, and segmented worms. 518, 718
- hydrothermal vent** (high droh THERM mull) Hot springs in the seafloor along ocean ridges where heated seawater and sulfate react to produce hydrogen sulfide; here, chemosynthetic bacteria support a community of varied organisms. 883
- hydroxide ion (OH⁻)** (high DROX side EYE ahn) One of two ions that results when a water molecule dissociates; it has gained an electron and therefore bears a negative charge. 32
- hypersensitive response (HR)** Plants respond to pathogens by selectively killing plant cells to block the spread of the pathogen. 489
- hypertonic solution** (high purr TAH nick) Higher solute concentration (less water) than the cytoplasm of a cell; causes cell to lose water by osmosis. 93
- hypha** (HIGH fuh) Filament of the vegetative body of a fungus. 394
- hypothalamic-inhibiting hormone** (high poh THOWL mick) One of many hormones produced by the hypothalamus that inhibits the secretion of an anterior pituitary hormone. 740
- hypothalamic-releasing hormone** One of many hormones produced by the hypothalamus that stimulates the secretion of an anterior pituitary hormone. 740
- hypothalamus** (high poh THOWL uh muss) In vertebrates, part of the brain that helps regulate the internal environment of the body—for example, heart rate, body temperature, and water balance. 690, 740
- hypothesis** (high PAH thuh sis) Supposition established by reasoning after consideration of available evidence; it can be tested by obtaining more data, often by experimentation. 11
- hypotonic solution** (high poh TAH nick) Lower solute (more water) concentration than the cytoplasm of a cell; causes cell to gain water by osmosis. 92
- I**
- IgG** Most abundant immunoglobulin; mostly found in the blood, but also in the lymph and tissue fluid. Y shaped with two binding sites. 621
- immediate allergic response** Allergic response that occurs within seconds of contact with an allergen; caused by the attachment of the allergen to IgE antibodies. 629
- immunity** Ability of the body to protect itself from foreign substances and cells, including disease-causing agents. 616
- immunization** Strategy for achieving immunity to the effects of specific disease-causing agents. 620
- immunoglobulin (Ig)** (imm you no GLOB you linn) Globular plasma protein that functions as an antibody. 621
- implantation** In placental mammals, the embedding of an embryo at the blastocyst stage into the endometrium of the uterus. 787
- imprinting** Learning to make a particular response to only one type of animal or object. 803
- inclusion body** In a bacterium, stored nutrients for later use. 65
- inclusive fitness** Fitness that results from personal reproduction and from helping nondescendant relatives reproduce. 814
- incomplete digestive tract** Digestive tract that has a single opening, usually called a mouth. 634
- incomplete dominance** Inheritance pattern in which the offspring has an intermediate phenotype, as when a red-flowered plant and a white-flowered plant produce pink-flowered offspring. 202
- incomplete penetrance** Dominant alleles that are not always expressed, often for unknown reasons. 202
- independent assortment** Alleles of unlinked genes segregate independently of each other during meiosis so that the gametes contain all possible combinations of alleles. 172
- index fossil** Deposits found in certain layers of strata; similar fossils can be found in the same strata around the world. 322
- induced fit model** Change in the shape of an enzyme's active site that enhances the fit between the active site and its substrate(s). 108
- induced mutation** Mutation that is caused by an outside influence, such as organic chemicals or ionizing radiation. 243
- inducer** Molecule that brings about activity of an operon by joining with a repressor and preventing it from binding to the operator. 236
- inducible operon** (in DOO sih bull AH purr ahn) In a catabolic pathway, an operon causes transcription of the genes controlling a group of enzymes. 236
- induction** Ability of a chemical or a tissue to influence the development of another tissue. 783
- inductive reasoning** Using specific observations and the process of logic and reasoning to arrive at a hypothesis. 11
- industrial melanism** (MELL uh nizz uhm) Increased frequency of darkly pigmented (melanic) forms in a population when soot and pollution make lightly pigmented forms easier for predators to see against a pigmented background. 286
- infertility** Inability to have as many children as desired. 768
- inflammatory response** Tissue response to injury that is characterized by redness, swelling, pain, and heat. 616
- ingroup** In a cladistic study of evolutionary relationships among organisms, the group that is being analyzed. 342
- inheritance of acquired characteristics** Lamarckian belief that characteristics acquired during the lifetime of an organism can be passed on to offspring. 268
- initiation** First stage of translation in which the translational machinery binds an mRNA and assembles. 226
- inner ear** Portion of the ear consisting of a vestibule, semicircular canals, and the cochlea where equilibrium is maintained and sound is transmitted. 710
- inorganic chemistry** Branch of science which deals with compounds that are not unique to the plant or animal worlds. 38
- insect** Type of arthropod. The head has antennae, compound eyes, and simple eyes; the thorax has three pairs of legs and often wings; and the abdomen has internal organs. 532
- insight learning** Ability to apply prior learning to a new situation without trial-and-error activity. 805
- inspiration** Act of taking air into the lungs; inhalation. 656
- integration** Summing up of excitatory and inhibitory signals by a neuron or by some part of the brain. 687
- intercalated disk** (in TURK uh lay tidd) Region that holds adjacent cardiac muscle cells together; disks appear as dense bands at right angles to the muscle striations. 585
- interferon** (in turr FEAR ron) Antiviral agent produced by an infected cell that blocks the infection of another cell. 618
- intergenic sequence** (in tur GEN ic) Region of DNA that lies between genes on a chromosome. 256
- interkinesis** (in turr kuh NEE sis) Period of time between meiosis I and meiosis II during which no DNA replication takes place. 176
- intermediate filament** Rope-like assemblies of fibrous polypeptides in the cytoskeleton that provide support and strength to cells; so called because they are intermediate in size between actin filaments and microtubules. 78
- internal respiration** Exchange of oxygen and carbon dioxide between blood and tissue fluid. 650
- interneuron** (in turr NURE ron) Neuron located within the central nervous system that conveys messages between parts of the central nervous system. 683
- internode** (IN turr node) In vascular plants, the region of a stem between two successive nodes. 435

interphase (IN turr faze) Stages of the cell cycle (G_1 , S, G_2) during which growth and DNA synthesis occur when the nucleus is not actively dividing. 152

interspersed repeat (in tur SPURSED) Repeated DNA sequence that is spread across several regions of a chromosome or across multiple chromosomes. 257

intertidal zone Region along a coastline where the tide recedes and returns. 882

intron (IN trahn) Intervening sequence found between exons in mRNA that is removed before translation. 223

inversion Change in chromosome structure in which a segment of a chromosome is turned around 180° ; this reversed sequence of genes can lead to altered gene activity and abnormalities. 184

invertebrate (in VURR tuh brate) Animal without a vertebral column or back bone. 512

in vivo gene therapy Gene therapy in which normal genes are injected directly into an organism to treat a condition often due to a faulty gene. 256

ion (EYE ahn) Charged particle that carries a negative or positive charge. 26

ionic bond (eye AH nick) Chemical bond in which ions are attracted to one another by opposite charges. 26

iris Muscular ring that surrounds the pupil and regulates the passage of light through this opening. 705

isomer (EYE so murr) Molecules with the same molecular formula but a different structure, and therefore a different shape. 39

isotonic solution (eye so TAH nick) Solution that is equal in solute concentration to that of the cytoplasm of a cell; causes cell to neither lose nor gain water by osmosis. 92

isotope (EYE so tope) Atom of the same element having the same atomic number but a different mass number due to the number of neutrons. 24

iteroparity Repeated production of offspring at intervals throughout the life cycle of an organism. 824

J

jaundice Yellowish tint to the skin caused by an abnormal amount of bilirubin (bile pigment) in the blood, indicating liver malfunction. 642

jawless fishes Type of fish that has no jaws; includes today's hagfishes and lampreys. 543

joint Articulation between two bones of a skeleton. 725

junction protein Protein that assists cell-to-cell communication at the plasma membrane. 88

K

karyokinesis (CARE ree oh kin ee sis) Division of the nucleus. 152

karyotype (CARE ree oh type) Chromosomes arranged by pairs according to their size, shape, and general appearance in mitotic metaphase. 181

keystone species Species whose activities significantly affect community structure. 901

kidneys Paired organs of the vertebrate urinary system that regulate the chemical composition of the blood and produce a waste product called urine. 670

kinetic energy (kin NET tick) Energy associated with motion. 104

kinetochore (kin NET uh core) An assembly of proteins that attaches to the centromere of a chromosome during mitosis. 155, 171

kinetoplastid Unicellular, flagellate protist characterized by the presence in their single mitochondrion of a kinetoplast (a structure containing a large mass of DNA). 386

kingdom One of the categories, or taxa, used by taxonomists to group species; the taxon above phylum. 6, 340

kin selection Indirect selection; adaptation to the environment due to the reproductive success of an individual's relatives. 814

K-selection Favorable life-history strategy under stable environmental conditions characterized by the production of a few offspring with much attention given to offspring survival. 831

L

lactation (lack TAY shun) Secretion of milk by mammary glands, usually for the nourishment of an infant. 766

lacteal (LACK tee uhl) Lymphatic vessel in an intestinal villus; aids in the absorption of fats. 639

lacuna (luh COON uh) Small pit or hollow cavity, as in bone or cartilage, where a cell or cells are located. 580

ladderlike nervous system In planarians, two lateral nerve cords joined by transverse nerves. 680

lake Body of fresh water, often classified by nutrient status, such as oligotrophic (nutrient-poor) or eutrophic (nutrient-rich). 880

landscape A number of interacting ecosystems. 891

landscape diversity Variety of habitat elements within an ecosystem (e.g., plains, mountains, and rivers). 891

large intestine In vertebrates, portion of the digestive tract that follows the small intestine; in humans, consists of the cecum, colon, rectum, and anal canal. 639

larva (LARR vuh) Immature form in the life cycle of some animals; it sometimes undergoes metamorphosis to become the adult form. 757

larynx (LAIR inks) Cartilaginous organ located between the pharynx and the trachea; in humans, contains the vocal cords; sometimes called the voice box. 654

lateral line Canal system containing sensory receptors that allow fishes and amphibians to detect water currents and pressure waves from nearby objects. 713

law See principle 12

laws of thermodynamics Two laws explaining energy and its relationships and exchanges. The first, also called the "law of conservation," says that energy cannot be created or destroyed but can only be changed from one form to another; the second says that energy cannot be changed from one form to another without a loss of usable energy. 104

leaf Lateral appendage of a stem, highly variable in structure, often containing cells that carry out photosynthesis. 435

leaf vein Vascular tissue within a leaf. 439

learning Relatively permanent change in an animal's behavior that results from practice and experience. 802

lens Clear, membranelike structure found in the vertebrate eye behind the iris; brings objects into focus. 705

lenticel (LENN tiss uhl) Frond of usually numerous, lightly raised, somewhat spongy, groups of cells in the bark of woody plants. Permits gas exchange between the interior of a plant and the external atmosphere. 437

leptin Hormone produced by adipose tissue that acts on the hypothalamus to signal satiety (fullness). 751

less-developed country (LDC) Country that is becoming industrialized; typically, population growth is expanding rapidly, and the majority of people live in poverty. 833

leucoplast (LOO coh plast) Plastid, generally colorless, that synthesizes and stores starch and oils. 76

lichen (LIKE in) Symbiotic relationship between certain fungi and algae, in which the fungi possibly provide inorganic food or water and the algae provide organic food. 367, 404

life cycle Recurring pattern of genetically programmed events by which individuals grow, develop, maintain themselves, and reproduce. 178

ligament Tough cord or band of dense fibrous tissue that binds bone to bone at a joint. 580, 725

light reaction Portion of photosynthesis that captures solar energy and takes place in thylakoid membranes of chloroplasts; it produces ATP and NADPH. 120

lignin (LIGG nih) Chemical that hardens the cell walls of land plants. 416, 438

limbic system (LIMM bick) In humans, functional association of various brain centers, including the amygdala and hippocampus; governs learning and memory and various emotions such as pleasure, fear, and happiness. 691

limiting factor Resource or environmental condition that restricts the abundance and distribution of an organism. 821

lipase (LIE pace) Fat-digesting enzyme secreted by the pancreas. 643

lipid (LIP pid) Class of organic compounds that tends to be soluble in nonpolar solvents; includes fats and oils. 44

liposome (LIP uh sohm) Droplet of phospholipid molecules formed in a liquid environment. 320

liver Large, dark red internal organ that produces urea and bile, detoxifies the blood, stores glycogen, and produces the plasma proteins, among other functions. 640

liverwort Bryophyte with a lobed or leafy gametophyte and a sporophyte composed of a stalk and capsule. 413

lobe-finned fishes Type of fishes with limblike fins. 544

logistic growth (luh JISS tick) Population increase that results in an S-shaped curve; growth is slow at first, steepens, and then levels off due to environmental resistance. 826

long-day plant Plant that flowers when day length is longer than a critical length; e.g., wheat, barley, clover, and spinach. 487

loop of the nephron (NEFF ron) Portion of a nephron between the proximal and distal convoluted tubules; functions in water reabsorption. 671

loose fibrous connective tissue Tissue composed mainly of fibroblasts widely separated by a matrix containing collagen and elastic fibers. 580

lophophore A general term to describe several groups of lophotrochoans that have a feeding structure called a lophophore. 516

lophotrochozoa Main group of protostomes; widely diverse. Includes the flatworms, rotifers, annelids, and molluscs. 516

lumen Cavity inside any tubular structure, such as the lumen of the digestive tract. 641

lung fishes Type of lobe-finned fish that utilizes lungs in addition to gills for gas exchange. 544

lungs Internal respiratory organ containing moist surfaces for gas exchange. 651

luteal phase (LOO tee uhl) Second half of the ovarian cycle, during which the corpus luteum develops and much progesterone (and some estrogen) is produced. 764

lycophyte Club mosses, among the first vascular plants to evolve and to have leaves. The leaves of the lycophytes are mirrophylls. 416

lymph (LIMF) Fluid, derived from tissue fluid, that is carried in lymphatic vessels. 581, 608, 614

lymphatic organ (limm FAT ick) Organ other than a lymphatic vessel that is part of the lymphatic system; the lymphatic organs are the lymph nodes, tonsils, spleen, thymus gland, and bone marrow. 614

lymphatic system (limm FAT ick) Organ system consisting of lymphatic vessels and lymphatic organs; transports lymph and lipids, and aids the immune system. 614

lymphatic vessel Vessel that carries lymph. 614

lymph node Mass of lymphatic tissue located along the course of a lymphatic vessel. 615

lymphocyte (LIMM foe site) Specialized white blood cell that functions in specific defense; occurs in two forms—T lymphocytes and B lymphocytes. 607

lysogenic cell Cell that contains a prophage (virus incorporated into DNA), which is replicated when the cell divides. 359

lysogenic cycle (lie so JEN ick) Bacteriophage life cycle in which the virus incorporates its DNA into that of a bacterium; occurs preliminary to the lytic cycle. 358

lysosome (LIÉ so sohm) Membrane-bounded vesicle that contains hydrolytic enzymes for digesting macromolecules. 73

lytic cycle (LIH tick) Bacteriophage life cycle in which the virus takes over the operation of the bacterium immediately upon entering it and subsequently destroys the bacterium. 358

M

macroevolution (mac crow evv oh LOO shun) Large-scale evolutionary change, such as the formation of new species. 310

macronutrient Essential element needed in large amounts for plant growth, such as nitrogen, calcium, or sulfur. 457

macrophage (MAC crow fahj) In vertebrates, large phagocytic cell derived from a monocyte that ingests microbes and debris. 607, 618

magnification Using a microscope, enlarging an object for viewing. 62

male gametophyte (guh MEET toe fite) In seed plants, the gametophyte that produces sperm; a pollen grain. Sometimes called a microgametophyte. 496

malignant (muh LIGG nunt) The power to threaten life; cancerous. 161

Malpighian tubule (mal PIG ee uhn TUBE yule) Blind, threadlike excretory tubule near the anterior end of an insect's hindgut. 532, 667

maltase Enzyme produced in small intestine that breaks down maltose to two glucose molecules. 642

mammal Endothermic vertebrate characterized especially by the presence of hair and mammary glands. 554

mantle In molluscs, an extension of the body wall that covers the visceral mass and may secrete a shell. 523

marsh Soft, wetland, which is treeless. 879

marsupial Member of a group of mammals bearing immature young nursed in a marsupium, or pouch—for example, kangaroo and opossum. 554

mass extinction Episode of large-scale extinction in which large numbers of species disappear in a few million years or less. 327

mass number Mass of an atom equal to the number of protons plus the number of neutrons within the nucleus. 23

mast cell Connective tissue cell that releases histamine in allergic reactions. 618

maternal determinant One of many substances present in the egg that influences the course of development. 782

matrix (MAY tricks) Unstructured semifluid substance that fills the space between cells in connective tissues or inside organelles. 77

matter Anything that takes up space and has mass. 22

maturity In biology, the age of reproduction. 830

mechanical energy A type of kinetic energy, such as walking or running. 104

mechanoreceptor (muh can oh ree SEPP turr) Sensory receptor that responds to mechanical stimuli, such as pressure, sound waves, or gravity. 710

medulla oblongata (muh DULE uh ahb long AH tuh) In vertebrates, part of the brain stem that is continuous with the spinal cord; controls heartbeat, blood pressure, breathing, and other vital functions. 690

medusa Among cnidarians, bell-shaped body form that is directed downward and contains much mesoglea. 518

megaphyll Large leaf with several to many veins. 417

megaspore (MEG uh spore) One of the two types of spores produced by seed plants; develops into a female gametophyte (embryo sac). 420, 426, 494

meiosis (my OH sis) Type of nuclear division that occurs as part of sexual reproduction, in which the daughter cells receive the haploid number of chromosomes in varied combinations. 170

melanocyte (mell ANN oh site) Specialized cell in the epidermis that produces melanin, the pigment responsible for skin color. 586

melanocyte-stimulating hormone (MSH) Substance that causes melanocytes to secrete melanin in most vertebrates. 740

melatonin (mell uh TONE in) Hormone, secreted by the pineal gland, that is involved in biorhythms. 750

memory Capacity of the brain to store and retrieve information about past sensations and perceptions; essential to learning. 691

memory B cell Forms during a primary immune response but enters a resting phase until a secondary immune response occurs. 620

memory T cell T cell that differentiated during an initial infection and responds rapidly during subsequent exposure to the same antigen. 624

menarche Onset of menstruation. 765

meninges (men IN jeez) Protective membranous coverings around the central nervous system. 688

meningitis (men in JIE tuss) A condition that refers to inflammation of the brain or spinal cord meninges (membranes). 688

menopause Termination of the ovarian and uterine cycles in older women. 765

menstruation (men strew AY shun) Periodic shedding of tissue and blood from the inner lining of the uterus in primates. 764

meristem (MARE uh stem) Undifferentiated embryonic tissue in the active growth regions of plants. 437

mesoderm (MESS oh derm) Middle primary tissue layer of an animal embryo that gives rise to muscle, several internal organs, and connective tissue layers. 780

mesoglea Transparent jellylike substance. 518

mesophyll (MESS oh fill) Inner, thickest layer of a leaf consisting of palisade and spongy mesophyll; the site of most of photosynthesis. 450

mesosome (MESS oh sohm) In a bacterium, plasma membrane that folds into the cytoplasm and increases surface area. 64

messenger RNA (mRNA) Type of RNA formed from a DNA template and bearing coded information for the amino acid sequence of a polypeptide. 220

metabolic pathway (met uh BAH lick) Series of linked reactions, beginning with a particular reactant and terminating with an end product. 108

metabolic pool Metabolites that are the products of and/or the substrates for key reactions in cells, allowing one type of molecule to be changed into another type, such as carbohydrates converted to fats. 145

metabolism (met TAB uh liz uhm) All of the chemical reactions that occur in a cell during growth and repair. 4, 106

metamorphosis (met uh MORE foh sis) Change in shape and form that some animals, such as insects, undergo during development. 529, 546

metaphase (MET uh faze) Mitotic phase during which chromosomes are aligned at the metaphase plate. 157

metaphase plate A disk formed during metaphase in which all of a cell's chromosomes lie in a single plane at right angles to the spindle fibers. 157

metapopulation Population subdivided into several small and isolated populations due to habitat fragmentation. 901

metastasis (muh TASS tuh sis) Spread of cancer from the place of origin throughout the body; caused by the ability of cancer cells to migrate and invade tissues. 162

- methanogen** (meth THANN uh jen) Type of archaea that lives in oxygen-free habitats, such as swamps, and releases methane gas. 368
- MHC** (major histocompatibility complex) protein Protein marker that is a part of cell-surface markers anchored in the plasma membrane, which the immune system uses to identify “self.” 624
- microevolution** Change in gene frequencies between populations of a species over time. 285
- micronutrient** Essential element needed in small amounts for plant growth, such as boron, copper, and zinc. 457
- microphyll** Small leaf with one vein. 416
- microRNA** Introns that are processed into smaller signals; after being degraded, they combine with a protein, and the complex binds to mRNAs. These are then destroyed instead of being translated. 243
- microsphere** Formed from proteinoids exposed to water; has properties similar to those of today’s cells. 319
- microspore** (MY crow spore) One of the two types of spores produced by seed plants; develops into a male gametophyte (pollen grain). 420, 426, 494
- microtubule** (my crow TUBE yule) Small, cylindrical organelle composed of tubulin protein around an empty central core; present in the cytoplasm, centrioles, cilia, and flagella. 78
- midbrain** In mammals, the part of the brain located below the thalamus and above the pons. 690
- middle ear** Portion of the ear consisting of the tympanic membrane, the oval and round windows, and the ossicles, where sound is amplified. 710
- migration** Regular back-and-forth movement of animals between two geographic areas at particular times of the year. 804
- millipede** (MILL ih peed) More or less cylindrical arthropod characterized by having two pairs of short legs on most of its body segments; may have 13 to almost 200 pairs of legs. 531
- mimicry** (MIMM ick kree) Superficial resemblance of two or more species; a mechanism that avoids predation by appearing to be noxious. 845
- mineral** Naturally occurring inorganic substance containing two or more elements; certain minerals are needed in the diet. 457, 646
- mineralocorticoid** (men urr ull oh CORE tih coid) Hormones secreted by the adrenal cortex that regulate salt and water balance, leading to increases in blood volume and blood pressure. 745
- mitochondrion** (mite oh KAHN dree uhn) Membrane-bounded organelle in which ATP molecules are produced during the process of cellular respiration. 76, 140
- mitosis** (my TOE sis) Process in which a parent nucleus produces two daughter nuclei, each having the same number and kinds of chromosomes as the parent nucleus. 152
- mixotrophic** Organism that can use autotrophic and heterotrophic means of gaining nutrients. 374
- model** Simulation of a process that aids conceptual understanding until the process can be studied firsthand; a hypothesis that describes how a particular process could possibly be carried out. 12
- mitotic spindle** Microtubule structure that brings about chromosomal movement during nuclear division. 153
- model of island biogeography** Model to explain the biodiversity of an island based on distance from the mainland and the island’s size. 849
- mold** Various fungi whose body consists of a mass of hyphae (filaments) that grow on and receive nourishment from organic matter such as food and clothing. 398
- molecular clock** Idea that the rate at which mutational changes accumulate in certain genes is constant over time and is not involved in adaptation to the environment. 327, 346
- molecule** Union of two or more atoms of the same element; also, the smallest part of a compound that retains the properties of the compound. 26
- mollusc** Invertebrates such as squids, clams, snails, and chitons; characterized by a visceral mass, a mantle, and a foot. 523
- molt** Periodic shedding of the exoskeleton in arthropods and cuticle in roundworms. 516
- monoclonal antibody** (mah no CLONE uhl) One of many antibodies produced by a clone of hybridoma cells that all bind to the same antigen. 622
- monocot** (MAH no cot) Abbreviation of monocotyledon. Flowering plant group; members have one embryonic leaf (cotyledon), parallel-veined leaves, scattered vascular bundles, flower parts in threes or multiples of three, and other characteristics. 424, 436
- monocotyledone** Plant whose embryo has one cotyledon; one of the two classes of angiosperms; abbreviated as monocot. 424
- monocyte** (MAH no site) Type of a granular leukocyte that functions as a phagocyte, particularly after it becomes a macrophage, which is also an antigen-presenting cell. 607
- monoecious** Having unisexual male flowers or cones and unisexual female flowers or cones both on the same plant. 420
- monogamous** Breeding pair of organisms that only reproduce with each other through their lifetime. 811
- monohybrid cross** Cross between parents that differ in only one trait. 192
- monomer** (MAH nuh murr) Small molecule that is a subunit of a polymer—e.g., glucose is a monomer of starch. 40
- monophyletic group** A group of species including the most recent common ancestor and all its descendants. 344
- monosaccharide** (mah no SACK uh ride) Simple sugar; a carbohydrate that cannot be decomposed by hydrolysis—e.g., glucose. 41
- monosomy** (MAH no sohm mee) One less chromosome than usual. 180
- monotreme** (MAH no treem) Egg-laying mammal—e.g., duckbill platypus and spiny anteater. 554
- monsoon** (mahn SOON) Climate in India and southern Asia caused by wet ocean winds that blow onshore for almost half the year. 867
- montane coniferous forest** (MAHN tane kuh NIFF urr us) Coniferous forest of a mountain. 869
- more-developed country (MDC)** Country that is industrialized; typically, population growth is low, and the people enjoy a good standard of living. 833
- morel** Edible fungi having a conical cap with a highly pitted surface. 398
- morphogen** (MORF uh jen) Protein that is part of a gradient that influences morphogenesis. 785
- morphogenesis** (morf oh JEN uh sis) Emergence of shape in tissues, organs, or entire embryo during development. 782
- morula** (MORE you luh) Spherical mass of cells resulting from cleavage during animal development prior to the blastula stage. 779
- mosaic evolution** Concept that human characteristics did not evolve at the same rate; for example, some body parts are more humanlike than others in early hominins. 566
- moss** Type of bryophyte. 414
- motor molecule** Protein that moves along either actin filaments or microtubules and translocates organelles. 78
- motor (efferent) neuron** Nerve cell that conducts nerve impulses away from the central nervous system and innervates effectors (muscle and glands). 683
- mouth** In humans, organ of the digestive tract where food is chewed and mixed with saliva. 636
- mRNA transcript** mRNA molecule formed during transcription that has a sequence of bases complementary to a gene. 222
- mucosa** Epithelial membrane containing cells that secrete mucus; found in the inner cell layers of the digestive (first layer) and respiratory tracts. 641
- multicellular** Organism composed of many cells; usually has organized tissues, organs, and organ systems. 2
- multifactorial trait** Trait controlled by polygenes subject to environmental influences; each dominant allele contributes to the phenotype in an additive and like manner. 204
- multiple alleles** (uh LEEL) Inheritance pattern in which there are more than two alleles for a particular trait; each individual has only two of all possible alleles. 202
- muscularis** Smooth muscle layer found in the digestive tract. 641
- muscular (contractile) tissue** (cunn TRACK tile) Type of animal tissue composed of fibers that shorten and lengthen to produce movements. 582
- mutagen** (MEWT uh jen) Chemical or physical agent that increases the chance of mutation. 245
- mutation** Alternation in chromosome structure or number and also an alteration in a gene due to a change in DNA composition. 287
- mutualism** (mute you uh LIZ uhm) Symbiotic relationship in which both species benefit in terms of growth and reproduction. 848
- mycelium** (my SEE lee uhm) Tangled mass of hyphal filaments composing the vegetative body of a fungus. 394
- mycorrhizae (sing., mycorrhiza)** (my coh RIZE ee) Mutualistic relationship between fungal hyphae and roots of vascular plants. 404, 442, 461
- myelin sheath** (MY uh linn) White, fatty material—derived from the membrane of neurolemmocytes—that forms a covering for nerve fibers. 683
- myofibril** (my oh FIBE rull) Specific muscle cell organelle containing a linear arrangement of sarcomeres, which shorten to produce muscle contraction. 728
- myosin** (MY oh sin) Muscle protein making up the thick filaments in a sarcomere; it pulls

actin to shorten the sarcomere, yielding muscle contraction. 728

myxedema (mikes uh DEEM uh) Condition resulting from a deficiency of thyroid hormone in an adult. 743

N

N₂ (nitrogen) fixation Process whereby free atmospheric nitrogen is converted into compounds, such as ammonium and nitrates, usually by bacteria. 861

NAD⁺ (nicotinamide adenine dinucleotide) (nick coh TIN uh mide ADD uh neen die NUKE klee oh tide) Coenzyme of oxidation-reduction that accepts electrons and hydrogen ions to become NADH + H⁺ as oxidation of substrates occurs. During cellular respiration, NADH carries electrons to the electron transport chain in mitochondria. 112, 134

NADP⁺ (nicotinamide adenine dinucleotide phosphate) (nick coh TIN uh mide ADD uh neen die NUKE klee oh tide FOSS fate) Coenzyme of oxidation-reduction that accepts electrons and hydrogen ions to become NADPH + H⁺. During photosynthesis, NADPH participates in the reduction of carbon dioxide to a carbohydrate. 112

nail Flattened epithelial tissue from the stratum lucidum of the skin; located on the tips of fingers and toes. 586

natural killer (NK) cell Lymphocyte that causes an infected or cancerous cell to burst. 618

natural selection Mechanism of evolution caused by environmental selection of organisms most fit to reproduce; results in adaptation to the environment. 8, 271

navigate Ability to steer or manage a course by adjusting your bearings and follow the result of the adjustment. 805

Neandertal (nee AND urr tall) Hominin with a sturdy build that lived during the last Ice Age in Europe and the Middle East; hunted large game and left evidence of being culturally advanced. 570

negative feedback Mechanism of homeostatic response by which the output of a system suppresses or inhibits activity of the system. 588, 740

nematocyst (nuh MAT uh sist) In cnidarians, a capsule that contains a threadlike fiber, the release of which aids in the capture of prey. 518

nephridium (pl., nephridia) (nuh FRIDD ee uhm, nuh FRIDD ee uh) Segmentally arranged, paired excretory tubules of many invertebrates, as in the earthworm. 526, 667

nephron (NEFF rahn) Microscopic kidney unit that regulates blood composition by glomerular filtration, tubular reabsorption, and tubular secretion. 670

nerve Bundle of long axons outside the central nervous system. 583, 692

nerve fiber Axon; conducts nerve impulses away from the cell. They are classified as either myelinated or unmyelinated based on the presence or absence of a myelin sheath. 683

nerve net Diffuse, noncentralized arrangement of nerve cells in cnidarians. 519, 680

nervous tissue Tissue that contains nerve cells (neurons), which conduct impulses, and

neuroglia, which support, protect, and provide nutrients to neurons. 582

neural plate (NURE uhl) Region of the dorsal surface of the chordate embryo that marks the future location of the neural tube. 781

neural tube Tube formed by closure of the neural groove during development. In vertebrates, the neural tube develops into the spinal cord and brain. 781

neuroglia (nure RAH glee uh) Nonconducting nerve cells that are intimately associated with neurons and function in a supportive capacity. 583, 683

neuromodulator (nure oh MAH dew lay turr) Electrical stimulant of a peripheral nerve, the spinal cord, or the brain; used to ease pain. 687

neuromuscular junction (nure oh MUSS cue lurr) Region where an axon bulb approaches a muscle fiber; contains a presynaptic membrane, a synaptic cleft, and a postsynaptic membrane. 730

neuron (NURE ahn) Nerve cell that characteristically has three parts: dendrites, cell body, and an axon. 582, 683

neurotransmitter (nure oh trans MITT urr) Chemical stored at the ends of axons that is responsible for transmission across a synapse. 686

neurula The early embryo during the development of the neural tube from the neural plate, marking the first appearance of the nervous system; the next stage after the gastrula. 781

neutron (NEW trahn) Neutral subatomic particle, located in the nucleus and assigned one atomic mass unit. 22

neutrophil (NEW troh fill) Granular leukocyte that is the most abundant of the white blood cells; first to respond to infection. 607, 618

nitrification (nite trih fih KAY shun) Process by which nitrogen in ammonia and organic compounds is oxidized to nitrites and nitrates by soil bacteria. 861

node In plants, the place where one or more leaves attach to a stem. 435

nodes of Ranvier (RAN veer) Gap in the myelin sheath around a nerve fiber. 683

noncompetitive inhibition Form of enzyme inhibition where the inhibitor binds to an enzyme at a location other than the active site; while at this site, the enzyme shape changes, the inhibitor is unable to bind to its substrate, and no product forms. 111

nonpolar covalent bond (nahn POH lurr coh VALE lent) Bond in which the sharing of electrons between atoms is fairly equal. 27

nonrandom mating Mating among individuals on the basis of their phenotypic similarities or differences, rather than mating on a random basis. 287

nonseptate (nahn SEPP tate) Lacking cell walls; some fungal species have hyphae that are nonseptate. 395

nonvascular plants Bryophytes, such as mosses and liverworts, that have no vascular tissue and either occur in moist locations or have special adaptations for living in dry locations. 413

norepinephrine (NE) (nor epp pin EFF renn) Neurotransmitter of the postganglionic fibers in the sympathetic division of the autonomic system; also, a hormone produced by the adrenal medulla. 686, 745

notochord (NO toh cord) Cartilaginous-like supportive dorsal rod in all chordates sometime in their life cycle; replaced by vertebrae in vertebrates. 540, 781

nuclear envelope Double membrane that surrounds the nucleus in eukaryotic cells and is connected to the endoplasmic reticulum; has pores that allow substances to pass between the nucleus and the cytoplasm. 70

nuclearioid Protist that may be related to fungi although nuclearioids lack the same type of cell wall and have threadlike pseudopods. 389

nuclear pore Opening in the nuclear envelope that permits the passage of proteins into the nucleus and ribosomal subunits out of the nucleus. 70

nucleic acid (new CLAY ick) Polymer of nucleotides; both DNA and RNA are nucleic acids. 52

nucleoid (NEW klee oid) Region of prokaryotic cells where DNA is located; it is not bounded by a nuclear envelope. 64, 164, 363

nucleolus (new KLEE uh luss) Dark-staining, spherical body in the nucleus that produces ribosomal subunits. 70

nucleoplasm (NEW klee oh plazz uhm) Semifluid medium of the nucleus containing chromatin. 70

nucleosome (NEW klee oh sohm) In the nucleus of a eukaryotic cell, a unit composed of DNA wound around a core of eight histone proteins, giving the appearance of a string of beads. 229

nucleotide (NEW klee oh tide) Monomer of DNA and RNA consisting of a 5-carbon sugar bonded to a nitrogenous base and a phosphate group. 52, 212

nucleus Membrane-bounded organelle within a eukaryotic cell that contains chromosomes and controls the structure and function of the cell. 64

O

obligate anaerobe (AHB lih gate ANN urr robe) Prokaryote unable to grow in the presence of free oxygen. 364

observation Step in the scientific method by which data are collected before a conclusion is drawn. 11

ocean ridge Ridge on the ocean floor where oceanic crust forms and from which it moves laterally in each direction. 319

octet rule The observation that an atom is most stable when its outer shell is complete and contains eight electrons; an exception is hydrogen which requires only two electrons in its outer shell to have a completed shell. 25

oil Triglyceride, usually of plant origin, that is composed of glycerol and three fatty acids and is liquid in consistency due to many unsaturated bonds in the hydrocarbon chains of the fatty acids. 44

oil gland Gland of the skin, associated with hair follicle, that secretes sebum; sebaceous gland. 586

olfactory cell (ohl FACT toh ree) Modified neuron that is a sensory receptor for the sense of smell. 702

- oligodendrocyte** Type of glial cell that forms myelin sheaths around neurons in the CNS. 683
- omnivore** (AHM nih vore) Organism in a food chain that feeds on both plants and animals. 852
- oncogene** (AHN coh jeen) Cancer-causing gene. Oncogenes code for proteins that stimulate the cell cycle and inhibit apoptosis. 162
- oocyte** (OH oh site) Immature egg that is undergoing meiosis; upon completion of meiosis, the oocyte becomes an egg. 762
- oogenesis** (oh JENN us sis) Production of eggs in females by the process of meiosis and maturation. 179
- open circulatory system** Arrangement of internal transport in which blood bathes the organs directly, and there is no distinction between blood and interstitial fluid. 594
- operant conditioning** (AH purr unt) Learning that results from rewarding or reinforcing a particular behavior. 804
- operator** In an operon, the sequence of DNA that serves as a binding site for a repressor, and thereby regulates the expression of structural genes. 234
- operon** (AH purr rahn) Group of structural and regulating genes that function as a single unit. 234
- opisthokont** Supergroup of eukaryotes that choanoflagellates animals, nucleariids and fungi. 389
- opposable thumb** Fingers arranged in such a way that the thumb can touch the ventral surface of the fingertips of all four fingers. 560
- optimal foraging model** Analysis of behavior as a compromise of feeding costs versus feeding benefits. 810
- order** One of the categories, or taxa, used by taxonomists to group species; the taxon above the family level. 6, 340
- organ** Combination of two or more different tissues performing a common function. 434, 585
- organelle** Small, often membranous structure in the cytoplasm having a specific structure and function. 66
- organic chemistry** Branch of science which deals with organic molecules including those that are unique to living things. 38
- organic molecule** Molecule that always contains carbon and hydrogen, and often contains oxygen as well; organic molecules are associated with living things. 38
- organism** Individual living thing. 2
- organ of Corti** (CORE tie) Structure in the vertebrate inner ear that contains auditory receptors (also called spiral organ). 711
- organ system** Group of related organs working together. 585
- orgasm** (OR gazz uhm) Physiological and psychological sensations that occur at the climax of sexual stimulation. 759
- orientation** In birds, the ability to know present location by tracking stimuli in the environment. 804
- osmoregulate** Regulation of the salt water balance to maintain a normal balance within internal fluids. 668
- osmosis** (oz MOH sis) Diffusion of water through a differentially permeable membrane. 92
- osmotic pressure** (oz MAH tick) Measure of the tendency of water to move across a differentially permeable membrane; visible as an increase in liquid on the side of the membrane with higher solute concentration. 92
- ossicle** (AH sick cull) One of the small bones of the vertebrate middle ear—malleus, incus, and stapes. 710
- osteoblast** (AH stee oh blast) Bone-forming cell. 720
- osteoclast** (AH stee oh clast) Cell that causes erosion of bone. 720
- osteocyte** (AH stee oh site) Mature bone cell located within the lacunae of bone. 720
- ostracoderm** (ah STRAH kuh derm) Earliest vertebrate fossils of the Cambrian and Devonian periods; these fishes were small, jawless, and finless. 543
- otolith** (OH toe lith) Calcium carbonate granule associated with sensory receptors for detecting movement of the head; in vertebrates, located in the utricle and saccule. 713
- outer ear** Portion of the ear consisting of the pinna and the auditory canal. 710
- outgroup** In a cladistic study of evolutionary relationships among organisms, a group that has a known relationship to, but not a member of, the taxa being analyzed. 342
- out-of-Africa hypothesis** Proposal that modern humans originated only in Africa; then they migrated and supplanted populations of *Homo* in Asia and Europe about 100,000 years ago. 570
- ovarian cycle** (oh VAIR ree uhn) Monthly changes occurring in the ovary that determine the level of sex hormones in the blood. 763
- ovary** In flowering plants, the enlarged, ovule-bearing portion of the carpel that develops into a fruit; female gonad in animals that produces an egg and female sex hormones. 425, 495, 750, 756
- overexploitation** When the number of individuals taken from a wild population is so great that the population becomes severely reduced in numbers. 900
- oviparous** Type of reproduction in which development occurs in an egg, laid by mother, in reptiles. 757
- ovulation** (ah view LAY shun) Bursting of a follicle when a secondary oocyte is released from the ovary; if fertilization occurs, the secondary oocyte becomes an egg. 763
- ovule** (OH vule) In seed plants, a structure that contains the female gametophyte and has the potential to develop into a seed. 420, 495
- ovum** (OH vuhm) Haploid egg cell that is usually fertilized by a sperm to form a diploid zygote. 763
- oxidation** Loss of one or more electrons from an atom or molecule; in biological systems, generally the loss of hydrogen atoms. 112
- oxygen debt** Amount of oxygen required to oxidize lactic acid produced anaerobically during strenuous muscle activity. 138, 728
- oxyhemoglobin** (ox zee HEEM uh glow bin) Compound formed when oxygen combines with hemoglobin. 659
- oxytocin** (ox zee TOE sin) Hormone released by the posterior pituitary that causes contraction of the uterus and milk letdown. 740
- ozone shield** Accumulation of O₃, formed from oxygen in the upper atmosphere; a filtering layer that protects the Earth from ultraviolet radiation. 325, 860
- P**
- p53** A tumor suppressor gene that (1) attempts to repair DNA damage or (2) stops the cell cycle, or (3) initiates apoptosis. 153
- paleontology** (pale lee uhn TAH loh jee) Study of fossils that results in knowledge about the history of life. 268, 322
- palisade mesophyll** (PAL uh sade MESS oh fill) Layer of tissue in a plant leaf containing elongated cells with many chloroplasts. 450
- pancreas** (PAN kree us) Internal organ that produces digestive enzymes and the hormones insulin and glucagon. 640, 748
- pancreatic amylase** (pan kree AT tick AM uhl laze) Enzyme that digests starch to maltose. 642
- pancreatic islet** (pan kree AT tick EYE lit) Masses of cells that constitute the endocrine portion of the pancreas. 748
- panoramic vision** Vision characterized by having a wide field of vision; found in animals with eyes to the side. 704
- parabasalid** Unicellular protist that lacks mitochondria; possess flagella in clusters near the anterior of the cell. 386
- parasite** Species that is dependent on a host species for survival, usually to the detriment of the host species. 846
- parasitism** (PAIR uh sit tiz uhm) Symbiotic relationship in which one species (the *parasite*) benefits in terms of growth and reproduction to the detriment of the other species (the *host*). 846
- parasympathetic division** (pair uh simm puh THETT ick) Division of the autonomic system that is active under normal conditions; uses acetylcholine as a neurotransmitter. 695
- parathyroid gland** (pair uh THIGH roid) Gland embedded in the posterior surface of the thyroid gland; it produces parathyroid hormone. 744
- parathyroid hormone (PTH)** Hormone secreted by the four parathyroid glands that increases the blood calcium level and decreases the phosphate level. 744
- parenchyma** (puh RENN kih muh) Plant tissue composed of the least-specialized of all plant cells; found in all organs of a plant. 438
- Parkinson disease** Progressive deterioration of the central nervous system due to a deficiency in the neurotransmitter dopamine. 689
- parthenogenesis** (par thin oh JENN uh sis) Development of an egg cell into a whole organism without fertilization. 756
- partial pressure** Pressure exerted by each gas in a mixture of gases. 658
- passive immunity** Protection against infection acquired by transfer of antibodies to a susceptible individual. 621
- pathogen** Disease-causing agent such as viruses, parasitic bacteria, fungi, and animals. 366, 581
- pattern formation** Positioning of cells during development that determines the final shape of an organism. 782
- pectoral girdle** (PECK tore uhl) Portion of the vertebrate skeleton that provides support and attachment for the upper (fore) limbs; consists of the scapula and clavicle on each side of the body. 724
- peduncle** Flower stalk; expands into the receptacle. 424
- pelagic zone** (puh LAJJ ick) Open portion of the sea. 883

- pelvic girdle** Portion of the vertebrate skeleton to which the lower (hind) limbs are attached; consists of the coxal bones. 725
- penis** Male copulatory organ; in humans, the male organ of sexual intercourse. 759
- pentose** (PEN toes) Five-carbon sugar. Deoxyribose is the pentose sugar found in DNA; ribose is the pentose sugar found in RNA. 41
- pepsin** (PEP sin) Enzyme secreted by gastric glands that digests proteins to peptides. 642
- peptidase** Intestinal enzyme that breaks down short chains of amino acids to individual amino acids that are absorbed across the intestinal wall. 642
- peptide** (PEP tide) Two or more amino acids joined together by covalent bonding. 48
- peptide bond** Type of covalent bond that joins two amino acids. 48
- peptide hormone** Type of hormone that is a protein, a peptide, or derived from an amino acid. 738
- peptidoglycan** (pep tih doe GLIKE can) Unique molecule found in bacterial cell walls. 43, 364
- perennial** (purr IN nee uhl) Flowering plant that lives more than one growing season because the underground parts regrow each season. 434
- pericycle** (pair ih SIGH cull) Layer of cells surrounding the vascular tissue of roots; produces branch roots. 441
- periderm** (PAIR ih derm) Protective tissue that replaces epidermis; includes cork, cork cambium. 437
- peripheral nervous system (PNS)** (purr IF fur uhl) Nerves and ganglia that lie outside the central nervous system. 682
- peristalsis** (pair iss STALL sis) Wavelike contractions that propel substances along a tubular structure such as the esophagus. 638
- permafrost** Permanently frozen ground, usually occurring in the tundra, a biome of Arctic regions. 870
- peroxisome** (purr OX ih sohm) Enzyme-filled vesicle in which fatty acids and amino acids are metabolized to hydrogen peroxide that is broken down to harmless products. 75
- petal** A flower part that occurs just inside the sepals; often conspicuously colored to attract pollinators. 425, 494
- petiole** (PET tee ohl) The part of a plant leaf that connects the blade to the stem. 435
- Peyer patches** Lymphatic organs located in small intestine. 615
- phagocytize** (fag OSS sit tize) To ingest extracellular particles by engulfing them, as do amoeboid cells. 387
- phagocytosis** (fag oh site OH sis) Process by which amoeboid-type cells engulf large substances, forming an intracellular vacuole. 96
- pharynx** (FAIR inks) In vertebrates, common passageway for both food intake and air movement; located between the mouth and the esophagus. 637, 654
- phenomenon** (fin NAH men ahn) Observable event. 11
- phenotype** (FEE no type) Visible expression of a genotype—e.g., brown eyes or attached earlobes. 193
- pheromone** (FAIR oh moan) Chemical messenger that works at a distance and alters the behavior of another member of the same species. 738, 807
- phloem** (FLOW emm) Vascular tissue that conducts organic solutes in plants; contains sieve-tube members and companion cells. 416, 439, 462
- phloem sap** Solution of sugars, nutrients, and hormones found in the phloem tissue of a land plant. 462
- phospholipid** (foss foe LIP id) Molecule that forms the bilayer of the cell's membranes; has a polar, hydrophilic head bonded to two nonpolar, hydrophobic tails. 46
- photoautotroph** (foe toe AH toe trofe) Organism able to synthesize organic molecules by using carbon dioxide as the carbon source and sunlight as the energy source. 364
- photoperiodism** Relative lengths of daylight and darkness that affect the physiology and behavior of an organism. 486
- photoreceptor** Sensory receptor that responds to light stimuli. 704
- photorespiration** Series of reactions that occurs in plants when carbon dioxide levels are depleted but oxygen continues to accumulate, and the enzyme RuBP carboxylase fixes oxygen instead of carbon dioxide. 128
- photosynthesis** (foe toe SIN thuh sis) Process occurring usually within chloroplasts whereby chlorophyll-containing organelles trap solar energy to reduce carbon dioxide to carbohydrate. 4, 118
- photosystem** Photosynthetic unit where solar energy is absorbed and high-energy electrons are generated; contains a pigment complex and an electron acceptor; occurs as PS (photosystem) I and PS II. 122
- phototropism** (foe toe TROH piz uhm) Growth response of plant stems to light; stems demonstrate positive phototropism. 483
- pH scale** Measurement scale for hydrogen ion concentration. 32
- phylogenetic tree** (file oh jenn ETT ick) Diagram that indicates common ancestors and lines of descent among a group of organisms. 341
- phylogeny** (file AH jenn ee) Evolutionary history of a group of organisms. 341
- phylum** (FILE uhm) One of the categories, or taxa, used by taxonomists to group species; the taxon above the class level. 6, 340
- phytochrome** (FITE toe chrome) Photoreversible plant pigment that is involved in photoperiodism and other responses of plants, such as etiolation. 486
- phytoplankton** (fite oh PLANK ton) Part of plankton containing organisms that photosynthesize, releasing oxygen to the atmosphere and serving as food producers in aquatic ecosystems. 382, 881
- phytoremediation** (FITE toe ruh mee dee AY shun) The use of plants to restore a natural area to its original condition. 467
- pineal gland** (PIN nee uhl) Gland—either at the skin surface (fish, amphibians) or in the third ventricle of the brain (mammals)—that produces melatonin. 690, 750
- pinocytosis** (pie no site OH sis) Process by which vesicle formation brings macromolecules into the cell. 96
- pioneer species** Early colonizer of barren or disturbed habitats that usually has rapid growth and a high dispersal rate. 850
- pit** Any depression or opening; usually in reference to the small openings in the cell walls of xylem cells that function in providing a continuum between adjacent xylem cells. 439
- pith** Parenchyma tissue in the center of some stems and roots. 441
- pituitary dwarfism** (pit TWO it air ree) Condition caused by inadequate growth hormone in which affected individual has normal proportions but small stature. 741
- pituitary gland** Small gland that lies just inferior to the hypothalamus; consists of the anterior and posterior pituitary, both of which produce hormones. 740
- placenta** (pluh SENT uh) Organ formed during the development of placental mammals from the chorion and the uterine wall; allows the embryo, and then the fetus, to acquire nutrients and rid itself of wastes; produces hormones that regulate pregnancy. 555, 757, 791
- placental mammal** A group of species that rely on internal development whereby the fetus exchanges nutrients and wastes with its mother via a placenta. 555
- placoderm** (PLACK uh derm) First jawed vertebrates; heavily armored fishes of the Devonian period. 543
- plankton** (PLANK ton) Freshwater and marine organisms that are suspended on or near the surface of the water; includes phytoplankton and zooplankton. 374
- plant** Multicellular, photosynthetic, eukaryotes that increasingly become adapted to live on land. 7, 410
- plasma** (PLAZZ muh) In vertebrates, the liquid portion of blood; contains nutrients, wastes, salts, and proteins. 606
- plasma cell** Mature B cell that mass-produces antibodies. 619
- plasma membrane** Membrane surrounding the cytoplasm that consists of a phospholipid bilayer with embedded proteins; functions to regulate the entrance and exit of molecules from cell. 64
- plasmid** (PLAZZ mid) Extrachromosomal ring of accessory DNA in the cytoplasm of bacteria. 64, 250, 363
- plasmodesmata** (plazz moh dezz MAH tuh) In plants, cytoplasmic strands that extend through pores in the cell wall and connect the cytoplasm of two adjacent cells. 99
- plasmodial slime mold** (plazz MOH dee uhl) Free-living mass of cytoplasm that moves by pseudopods on a forest floor or in a field, feeding on decaying plant material by phagocytosis; reproduces by spore formation. 388
- plasmolysis** (plazz MOLL ih sis) Contraction of the cell contents due to the loss of water. 93
- plastid** (PLASS tidd) Organelles of plants and algae that are bounded by a double membrane and contain internal membranes and/or vesicles (i.e., chloroplasts, chromoplasts, leucoplasts). 76
- platelet** (PLATE let) Component of blood that is necessary to blood clotting. 581, 607
- plate tectonics** (tec TAH nicks) Concept that the Earth's crust is divided into a number of fairly rigid plates whose movements account for continental drift. 332
- pleiotropy** (ply AH troh pee) Inheritance pattern in which one gene affects many phenotypic characteristics of the individual. 203
- point mutation** Change of one base only in the sequence of bases in a gene. 244
- polar body** In oogenesis, a nonfunctional product; two to three meiotic products are of this type. 179

- polar covalent bond** Bond in which the sharing of electrons between atoms is unequal. 27
- pollen grain** In seed plants, structure that is derived from a microspore and develops into a male gametophyte. 420, 496
- pollen tube** In seed plants, a tube that forms when a pollen grain lands on the stigma and germinates. The tube grows, passing between the cells of the stigma and the style to reach the egg inside an ovule, where fertilization occurs. 420, 427
- pollination** In gymnosperms, the transfer of pollen from pollen cone to seed cone; in angiosperms, the transfer of pollen from anther to stigma. 420, 497
- pollution** Any environmental change that adversely affects the lives and health of living things. 897
- polyandrous** Practice of female animals having several male mates; found in the New World monkeys where the males help in rearing the offspring. 811
- polygamous** Practice of males having several female mates. 811
- polygenic inheritance** (pah lee JENN ick) Pattern of inheritance in which a trait is controlled by several allelic pairs; each dominant allele contributes to the phenotype in an additive and like manner. 204
- polymer** (PAH lee murr) Macromolecule consisting of covalently bonded monomers; for example, a polypeptide is a polymer of monomers called amino acids. 40
- polymerase chain reaction (PCR)** (pah LIMM mare raze) Technique that uses the enzyme DNA polymerase to produce millions of copies of a particular piece of DNA. 252
- polyp** (PAH lip) Among cnidarians, body form that is directed upward and contains much mesoglea; in anatomy; small, abnormal growth that arises from the epithelial lining. 518, 640
- polypeptide** (pah lee PEP tide) Polymer of many amino acids linked by peptide bonds. 48
- polyploidy** (PAH lee ploid) Having a chromosome number that is a multiple greater than twice that of the monoploid number. 307
- polyribosome** (pah lee RIBE uh sohm) String of ribosomes simultaneously translating regions of the same mRNA strand during protein synthesis. 71, 225
- polysaccharide** (pah lee SACK uh ride) Polymer made from sugar monomers; the polysaccharides starch and glycogen are polymers of glucose monomers. 42
- pons** (PAHNS) Portion of the brain stem above the medulla oblongata and below the midbrain; assists the medulla oblongata in regulating the breathing rate. 690
- population** Group of organisms of the same species occupying a certain area and sharing a common gene pool. 9, 284, 820
- population density** The number of individuals per unit area or volume living in a particular habitat. 821
- population distribution** The pattern of dispersal of individuals living within a certain area. 821
- population genetics** The study of gene frequencies and their changes within a population. 284
- portal system** Pathway of blood flow that begins and ends in capillaries, such as the portal system located between the small intestine and liver. 602
- positive feedback** Mechanism of homeostatic response in which the output of the system intensifies and increases the activity of the system. 740
- posterior pituitary** (pit YOU ih tare rree) Portion of the pituitary gland that stores and secretes oxytocin and antidiuretic hormone produced by the hypothalamus. 740
- posttranscriptional control** Gene expression following translation regulated by the way mRNA transcripts are processed. 240
- posttranslational control** Alternation of gene expression by changing a protein's activity after it is translated. 242
- postzygotic isolating mechanism** (post zie GAH tick) Anatomical or physiological difference between two species that prevents successful reproduction after mating has taken place. 303
- potential energy** Stored energy as a result of location or spatial arrangement. 104
- predation** (preh DAY shun) Interaction in which one organism (the *predator*) uses another (the *prey*) as a food source. 843
- predator** Organism that practices predation. 843
- prediction** Step of the scientific process that follows the formulation of a hypothesis and assists in creating the experimental design. 11
- preparatory (prep) reaction** Reaction that oxidizes pyruvate with the release of carbon dioxide; results in acetyl CoA and connects glycolysis to the citric acid cycle. 135, 140
- pressure-flow model** Explanation for phloem transport; osmotic pressure following active transport of sugar into phloem brings a flow of sap from a source to a sink. 468
- prey** Organism that provides nourishment for a predator. 843
- prezygotic isolating mechanism** (pree zie GAH tick) Anatomical or behavioral difference between two species that prevents the possibility of mating. 302
- primary motor area** Area in the frontal lobe where voluntary commands begin; each section controls a part of the body. 689
- primary root** Original root that grows straight down and remains the dominant root of the plant; contrasts with fibrous root system. 442
- primary somatosensory area** (so mat oh SENSE uh ree) Area dorsal to the central sulcus where sensory information arrives from the skin and skeletal muscles. 689
- primate** Member of the order Primate; includes prosimians, monkeys, apes, and hominins, all of whom have adaptations for living in trees. 560
- principle** Theory that is generally accepted by an overwhelming number of scientists; also called a law. 12
- prion** (PRY ahn) Infectious particle consisting of protein only and no nucleic acid. 51, 362
- producer** Photosynthetic organism at the start of a grazing food chain that makes its own food—e.g., green plants on land and algae in water. 852
- product** Substance that forms as a result of a reaction. 106
- progesterone** (pro JEST turr ohn) Female sex hormone that helps maintain sexual organs and secondary sex characteristics. 750, 763
- proglottid** (pro GLAH tid) Segment of a tapeworm that contains both male and female sex organs and becomes a bag of eggs. 522
- prokaryote** (pro CARE ree oat) Organism that lacks the membrane-bounded nucleus and membranous organelles typical of eukaryotes. 7, 362
- prokaryotic cell** (pro care ree AH tick) Lacking a membrane-bounded nucleus and organelles; the cell type within the domains Bacteria and Archaea. 64
- prolactin (PRL)** (pro LACK tin) Hormone secreted by the anterior pituitary that stimulates the production of milk from the mammary glands. 740
- prometaphase** (pro MET uh faze) Phase of mitosis during which the chromosomes are condensed but not fully aligned at the metaphase plate. 157
- promoter** In an operon, a sequence of DNA where RNA polymerase binds prior to transcription. 222, 234
- prophase** (PRO faze) Mitotic phase during which chromatin condenses so that chromosomes appear; chromosomes are scattered. 156
- prosimian** (pro SIMM me uh) Group of primates that includes lemurs and tarsiers, and may resemble the first primates to have evolved. 563
- prostaglandin** (pro stah GLAN din) Hormone that has various and powerful local effects. 751
- protein** (PRO teen) Molecule consisting of one or more polypeptides. 48, 644
- protein-first hypothesis** In chemical evolution, the proposal that protein originated before other macromolecules and made possible the formation of protocells. 319
- proteinoid** (PRO tin oid) Abiotically polymerized amino acids that, when exposed to water, become microspheres having cellular characteristics. 319
- proteome** Collection of proteins resulting from the translation of genes into proteins. 258
- proteomics** Study of the complete collection of proteins that an organism produces. 227, 258
- protist** (PRO teest) A eukaryotic organism that is not a plant, fungus, or animal. Protists are generally a microscopic complex single cell; they evolved before other types of eukaryotes in the history of Earth 7, 374
- protobiont** Also called protocell, possible first cell. 320
- protocell** (PRO toe cell) In biological evolution, a possible cell forerunner that became a cell once it acquired genes. 320
- proton** (PRO tahn) Positive subatomic particle located in the nucleus and assigned one atomic mass unit. 22
- proto-oncogene** (pro toe AHN coh jeen) Normal gene that can become an oncogene through mutation. 162
- protostome** (PRO toe stome) Group of coelomate animals in which the first embryonic opening (the blastopore) is associated with the mouth. 515
- protozoan** (pro toe ZOH uhn) Heterotrophic, unicellular protist that moves by flagella, cilia, or pseudopodia. 374
- proximal convoluted tubule** Portion of a nephron following the glomerular capsule where tubular reabsorption of filtrate occurs. 671
- pseudocoelom** Body cavity lying between the digestive tract and body wall that is incompletely lined by mesoderm. 528
- pseudopod** (SUE doe pod) Cytoplasmic extension of amoeboid protists; used for locomotion and engulfing food. 78, 387

- pteridophyte** Ferns and their allies (horsetail and whisk ferns). 417
- puberty** Period of life when secondary sex changes occur in humans; marked by the onset of menses in females and sperm production in males. 761
- pulmonary circuit** (PULL moh nair ree) Circulatory pathway between the lungs and the heart. 597
- pulse** Vibration felt in arterial walls due to expansion of the aorta following ventricle contraction. 600
- Punnett square** (PUN net) Grid used to calculate the expected results of simple genetic crosses. 196
- pupil** Opening in the center of the iris of the vertebrate eye. 705
- pyruvate** (pie ROO vate) End product of glycolysis; its further fate, involving fermentation or entry into a mitochondrion, depends on oxygen availability. 135
- R**
- radial symmetry** (RAY dee uhl SIM meh tree) Body plan in which similar parts are arranged around a central axis, like spokes of a wheel. 513
- radiolarian** (ray dee oh LAIR ree uhn) Protist that has a glassy silicon test, usually with a radial arrangement of spines; pseudopods are external to the test. 388
- radula** (RADD you luh) Tonguelike organ found in molluscs that bears rows of tiny teeth, which point backward; used to obtain food. 523, 635
- rain shadow** Leeward side (side sheltered from the wind) of a mountainous barrier, which receives much less precipitation than the windward side. 867
- rate of natural increase (r)** Growth rate dependent on the number of individuals that are born each year and the number of individuals that die each year. 822
- ray-finned bony fishes** Group of bony fishes with fins supported by parallel bony rays connected by webs of thin tissue. 544
- RB** Tumor suppressor genes whose protein interprets growth signals and nutrient availability before allowing the cell cycle to proceed. 153
- reactant** (ree ACT unt) Substance that participates in a reaction. 104
- receptacle** Area where a flower attaches to a floral stalk. 424
- receptor** Type of membrane protein that binds to specific molecules in the environment, providing a mechanism for the cell to sense and adjust to its surroundings. 474
- receptor-mediated endocytosis** (en doe site TOE sis) Selective uptake of molecules into a cell by vacuole formation after they bind to specific receptor proteins in the plasma membrane. 96
- receptor protein** Protein located in the plasma membrane or within the cell; binds to a substance that alters some metabolic aspect of the cell. 88
- recessive allele** (re SESS ihv uh LEEL) Allele that exerts its phenotypic effect only in the homozygote; its expression is masked by a dominant allele. 193
- reciprocal altruism** The trading of helpful or cooperative acts, such as helping at the nest, by individuals—the animal that was helped will repay the debt at some later time. 815
- recombinant DNA (rDNA)** (ree CAHM bih nunt) DNA that contains genes from more than one source. 250
- red algae** Marine photosynthetic protists with a notable abundance of phycobilin pigments; include coralline algae of coral reefs. 379
- red blood cell** Erythrocyte; contains hemoglobin and carries oxygen from the lungs or gills to the tissues in vertebrates. 581, 606
- red bone marrow** Vascularized, modified connective tissue that is sometimes found in the cavities of spongy bone; site of blood cell formation. 614, 720
- red bread mold** Sac fungus that grows on bread and was the experimental material in the formulation of the one gene, one enzyme hypothesis. 398
- red tide** A population bloom of dinoflagellates that causes coastal waters to turn red. Releases a toxin that can lead to paralytic shellfish poisoning. 383
- reduction** Gain of electrons by an atom or molecule with a concurrent storage of energy; in biological systems, the electrons are accompanied by hydrogen ions. 112
- reflex action** Automatic, involuntary response of an organism to a stimulus. 688
- refractory period** Time following an action potential when a neuron is unable to conduct another nerve impulse. 685
- regulator gene** In an operon, a gene that codes for a protein that regulates the expression of other genes. 235
- relative dating (of fossils)** Determining the age of fossils by noting their sequential relationships in strata; *absolute dating* relies on radioactive dating techniques to assign an actual date. 322
- renal cortex** (REE null CORE tex) Outer portion of the kidney that more appears granular. 670
- renal medulla** (REE null muh DOO luh) Inner portion of the kidney that consists of renal pyramids. 670
- renal pelvis** Hollow chamber in the kidney that lies inside the renal medulla and receives freshly prepared urine from the collecting ducts. 670
- renin** (REN ninn) Enzyme released by the kidneys that leads to the secretion of aldosterone and a rise in blood pressure. 746
- repetitive DNA element** Sequence of DNA on a chromosome that is repeated several times. 256
- replacement model** Proposal that modern humans originated only in Africa; then they migrated and supplanted populations of *Homo* in Asia and Europe about 100,000 years ago. 570
- replacement reproduction** Population in which each person is replaced by only one child. 834
- replication fork** In eukaryotes, the point where the two parental DNA strands separate to allow replication. 219
- repressible operon** (AH purr ahn) Operon that is normally active because the repressor is normally inactive. 235
- repressor** In an operon, protein molecule that binds to an operator, preventing transcription of structural genes. 234
- reproduce** To produce a new individual of the same kind. 5
- reproductive cloning** Used to create an organism that is genetically identical to the original individual. 159
- reptile** Terrestrial vertebrate with internal fertilization, scaly skin, and an egg with a leathery shell; includes snakes, lizards, turtles, crocodiles, and birds. 548
- resolution** Capability of a microscope to distinguish the separate parts of an object. 63
- resource partitioning** Mechanism that increases the number of niches by apportioning the supply of a resource such as food or living space between species. 842
- respiration** Sequence of events that results in gas exchange between the cells of the body and the environment. 650
- respiratory center** Group of nerve cells in the medulla oblongata that send out nerve impulses on a rhythmic basis, resulting in involuntary inspiration on an ongoing basis. 657
- responding variable** Result or change that occurs when an experimental variable is utilized in an experiment. 14
- resting potential** Membrane potential of an inactive neuron. 684
- restoration ecology** Subdiscipline of conservation biology that seeks ways to return ecosystems to their former state. 902
- restriction enzyme** Bacterial enzyme that stops viral reproduction by cleaving viral DNA; used to cut DNA at specific points during production of recombinant DNA. 250
- reticular fiber** (reh TICK cue lurr) Very thin collagen fibers in the matrix of connective tissue, highly branched and forming delicate supporting networks. 579
- retina** (RETT tih nuh) Innermost layer of the vertebrate eyeball containing the photoreceptors—rod cells and cone cells. 705
- retrovirus** (rett troh VIE russ) RNA virus containing the enzyme reverse transcriptase that carries out RNA/DNA transcription. 361
- reverse transcriptase** Viral enzyme found in retroviruses that is capable of converting their RNA genome into a DNA copy. 361
- rhizarian** Supergroup of eukaryotes that includes foraminiferans and radiolarians. 388
- rhizoid** (RYE zoid) Rootlike hair that anchors a plant and absorbs minerals and water from the soil. 413
- rhizome** (RYE zohm) Rootlike underground stem. 416, 448, 505
- rhodopsin** (rode AHP sin) Light-absorbing molecule in rod cells and cone cells that contains a pigment and the protein opsin. 707
- ribose** (RYE boh) Pentose sugar found in RNA. 41
- ribosomal RNA (rRNA)** (rye boh SOHM uhl) Type of RNA found in ribosomes that translate messenger RNAs to produce proteins. 220
- ribosome** (RYE boh sohm) RNA and protein in two subunits; site of protein synthesis in the cytoplasm. 64, 71
- ribozyme** (RYE boh zime) RNA molecule that can catalyze chemical reactions. 108, 223
- RNA (ribonucleic acid)** (rye boh new CLAY ick) Nucleic acid produced from covalent bonding of nucleotide monomers that contain the sugar ribose; occurs in three forms: messenger RNA, ribosomal RNA, and transfer RNA. 52
- RNA-first hypothesis** In chemical evolution, the proposal that RNA originated before other macromolecules and allowed the formation of the first cell(s). 319

- RNA polymerase** (pah LIMM mare raze) During transcription, an enzyme that creates an mRNA transcript by joining nucleotides complementary to a DNA template. 222
- rod cell** Photoreceptor in vertebrate eyes that responds to dim light. 707
- root cap** Protective cover of the root tip, whose cells are constantly replaced as they are ground off when the root pushes through rough soil particles. 440
- root hair** Extension of a root epidermal cell that collectively increases the surface area for the absorption of water and minerals. 437, 460
- root nodule** (NOD yule) Structure on plant root that contains nitrogen-fixing bacteria. 442, 461
- root pressure** Osmotic pressure caused by active movement of mineral into root cells; serves to elevate water in xylem for a short distance. 464
- root system** Includes the main root and any and all of its lateral (side) branches. 434
- rotational equilibrium** Maintenance of balance when the head and body are suddenly moved or rotated. 711
- rotifer** Microscopic invertebrates characterized by ciliated corona that when beating looks like a rotating wheel. 523
- rough ER (endoplasmic reticulum)** (in doe PLAZZ mick ruh TICK you lumm) Membranous system of tubules, vesicles, and sacs in cells; has attached ribosomes. 72
- roundworm** Invertebrates with nonsegmented cylindrical body covered by a cuticle that molts; some forms are free-living in water and soil, and many are parasitic. 528
- r-selection** Favorable life history strategy under certain environmental conditions; characterized by a high reproductive rate with little or no attention given to offspring survival. 830
- RuBP carboxylase** (car BOX ill laze) An enzyme that starts the Calvin cycle reactions by catalyzing attachment of the carbon atom from CO₂ to RuBP. 126
- S**
- sacculle** (SACK yule) Saclike cavity in the vestibule of the vertebrate inner ear; contains sensory receptors for gravitational equilibrium. 713
- sac fungi** Fungi that produce spores in fingerlike sacs called asci within a fruiting body; includes morels, truffles, yeasts and molds. 398
- salivary amylase** (SAL lih vair ree AM uh laze) In humans, enzyme in saliva that digests starch to maltose. 637, 642
- salivary gland** In humans, gland associated with the mouth that secretes saliva. 636
- salt** Ionic compound that results from a classical acid-base reaction. 26
- saltatory conduction** (SALT tuh tore ree) Movement of nerve impulses from one neurolemmal node to another along a myelinated axon. 685
- saprotroph** (SAP pro trofe) Organism that secretes digestive enzymes and absorbs the resulting nutrients back across the plasma membrane. 365, 394
- sarcolemma** (sark oh LIMM uh) Plasma membrane of a muscle fiber; also forms the tubules of the T system involved in muscular contraction. 728
- sarcomere** (SARK oh meer) One of many units, arranged linearly within a myofibril, whose contraction produces muscle contraction. 728
- sarcoplasmic reticulum** (sark oh PLAZZ mick ruh TICK you lumm) Smooth endoplasmic reticulum of skeletal muscle cells; surrounds the myofibrils and stores calcium ions. 728
- sarcopterygii** Mesozoic marine reptiles. 544
- saturated fatty acid** Fatty acid molecule that lacks double bonds between the carbons of its hydrocarbon chain. The chain bears the maximum number of hydrogens possible. 44
- savanna** (suh VANN uh) Terrestrial biome that is a grassland in Africa, characterized by few trees and a severe dry season. 876
- Schwann cell** Cell that surrounds a fiber of a peripheral nerve and forms the myelin sheath. 683
- scientific method** Process by which scientists formulate a hypothesis, gather data by observation and experimentation, and come to a conclusion. 11
- scientific theory** Concept supported by a broad range of observations, experiments, and data. 12
- sclera** (SKLARE uh) White, fibrous, outer layer of the eyeball. 704
- sclerenchyma** (skluh RINK ih muh) Plant tissue composed of cells with heavily lignified cell walls; functions in support. 438
- scolex** (SCOLE lex) Tapeworm head region; contains hooks and suckers for attachment to host. 522
- sea star** An echinoderm with noticeable 5-pointed radial symmetry; found along rocky coasts where they feed on bivalves. 534
- seaweed** Multicellular forms of red, green, and brown algae found in marine habitats. 380
- secondary metabolite** Molecule not directly involved in growth, development, or reproduction of an organism; in plants, these molecules, which include nicotine, caffeine, tannins, and menthols, can discourage herbivores. 488
- secondary oocyte** (OH oh site) In oogenesis, the functional product of meiosis I; becomes the egg. 179
- secondary sex characteristic** Trait that is sometimes helpful but not absolutely necessary for reproduction and is maintained by the sex hormones in males and females. 761
- second messenger** Chemical signal such as cyclic AMP that causes the cell to respond to the first messenger—a hormone bound to plasma membrane receptor protein. 739
- secretion** (suh KREE shun) Release of a substance by exocytosis from a cell that may be a gland or part of a gland. 72
- sedimentation** (sed ih men TAY shun) Process by which particulate material accumulates and forms a stratum. 322
- seed** Mature ovule that contains an embryo, with stored food enclosed in a protective coat. 420, 494
- seedless vascular plant** Collective name for club mosses (lycophyte) and ferns (pteridophyte) characterized by windblown spores. 416
- segmentation** (seg men TAY shun) Repetition of body units as seen in the earthworm. 526
- self-antigen** Antigen that is produced by an organism. 619
- semelparity** Condition of having a single reproductive effort in a lifetime. 824
- semen (seminal fluid)** (SEE men, SIMM in uh) Thick, whitish fluid consisting of sperm and secretions from several glands of the male reproductive tract. 759
- semicircular canal** One of three half-circle-shaped canals of the vertebrate inner ear; contains sensory receptors for rotational equilibrium. 710
- semiconservative replication** Duplication of DNA resulting in two double helix molecules, each having one parental and one new strand. 217
- semilunar valve** Valve resembling a half moon located between the ventricles and their attached vessels. 598
- seminiferous tubule** (seh men IF furr us TUBE yule) Long, coiled structure contained within chambers of the testis where sperm are produced. 760
- senescence** (seh NESS sense) Sum of the processes involving aging, decline, and eventual death of a plant or plant part. 477
- sensory (afferent) neuron** Nerve cell that transmits nerve impulses to the central nervous system after a sensory receptor has been stimulated. 683
- sensory receptor** Structure that receives either external or internal environmental stimuli and is a part of a sensory neuron or transmits signals to a sensory neuron. 679
- sepal** (SEE pull) Outermost, sterile, leaflike covering of the flower; usually green in color. 425, 494
- septate** (SEPP tate) Having cell walls; some fungal species have hyphae that are septate. 395
- septum** (SEPP tum) Partition or wall that divides two areas; the septum in the heart separates the right half from the left half. 598
- serosa** Outer embryonic membrane of birds and reptiles; chorion. 641
- serotonin** A neurotransmitter. 686
- sessile** (SESS isle) Tending to stay in one place. 515
- seta (pl., setae)** (SEE tuh, SEE tee) A needlelike, chitinous bristle in annelids, arthropods, and others. 526
- sexual reproduction** Reproduction involving meiosis, gamete formation, and fertilization; produces offspring with chromosomes inherited from each parent with a unique combination of genes. 170
- sexual selection** Changes in males and females, often due to male competition and female selectivity, leading to increased fitness. 291, 811
- shoot apical meristem** (AY pick uhl MARE ih stem) Group of actively dividing embryonic cells at the tips of plant shoots. 444
- shoot system** Aboveground portion of a plant consisting of the stem, leaves, and flowers. 434
- short-day plant** Plant that flowers when day length is shorter than a critical length—e.g., cocklebur, poinsettia, and chrysanthemum. 487
- short tandem repeat (STR) profiling** Procedure of analyzing DNA in which PCR and gel electrophoresis are used to create an individuals band pattern with each one being unique because each person has their own number of repeats at different locations. 253
- shrubland** Arid terrestrial biome characterized by shrubs and tending to occur along coasts

- that have dry summers and receive most of their rainfall in the winter. 876
- sieve-tube member** Member that joins with others in the phloem tissue of plants as a means of transport for nutrient sap. 439, 462
- signal** Molecule that stimulates or inhibits an event in the cell cycle. 153
- signal peptide** Sequence of amino acids that binds with a SRP, causing a ribosome to bind to ER. 71
- simple goiter** Condition in which an enlarged thyroid produces low levels of thyroxine. 743
- single nucleotide polymorphism (SNP)** Site present in at least 1% of the population at which individuals differ by a single nucleotide. These can be used as genetic markers to map unknown genes or traits. 284
- sink** In the pressure-flow model of phloem transport, the location (roots) from which sugar is constantly being removed. Sugar will flow to the roots from the source. 469
- sink population** Population that is found in an unfavorable area where at best the birthrate equals the death rate; sink populations receive new members from source populations. 901
- sister chromatid** (CROW muh tid) One of two genetically identical chromosomal units that are the result of DNA replication and are attached to each other at the centromere. 155
- skeletal muscle** Striated, voluntary muscle tissue that comprises skeletal muscles; also called striated muscle. 582
- skin** Outer covering of the body; can be called the integumentary system because it contains organs such as sense organs. 585
- sliding filament model** An explanation for muscle contraction based on the movement of actin filaments in relation to myosin filaments. 728
- small intestine** In vertebrates, the portion of the digestive tract that precedes the large intestine; in humans, consists of the duodenum, jejunum, and ileum. 639
- smooth (visceral) muscle** Nonstriated, involuntary muscles found in the walls of internal organs. 582
- smooth ER (endoplasmic reticulum)** (in doe PLAZZ mick ruh TICK cue lumm) Membranous system of tubules, vesicles, and sacs in eukaryotic cells; lacks attached ribosomes. 72
- society** Group in which members of species are organized in a cooperative manner, extending beyond sexual and parental behavior. 807
- sodium-potassium pump** Carrier protein in the plasma membrane that moves sodium ions out of and potassium ions into animal cells; important in nerve and muscle cells. 94
- soil** Accumulation of inorganic rock material and organic matter that is capable of supporting the growth of vegetation. 458
- soil erosion** Movement of topsoil to a new location due to the action of wind or running water. 459
- soil horizon** Major layer of soil visible in vertical profile; for example, topsoil is the A horizon. 459
- soil profile** Vertical section of soil from the ground surface to the unaltered rock below. 459
- solute** (SAHL yute) Substance that is dissolved in a solvent, forming a solution. 29, 91
- solution** Fluid (the solvent) that contains a dissolved solid (the solute). 29, 91
- solvent** (SAHL vent) Liquid portion of a solution that serves to dissolve a solute. 91
- somatic cell** (so MAT tick) Body cell; excludes cells that undergo meiosis and become sperm or egg. 153
- somatic system** Portion of the peripheral nervous system containing motor neurons that control skeletal muscles. 693
- source** In the pressure-flow model of phloem transport, the location (leaves) of sugar production. Sugar will flow from the leaves to the sink. 469
- source population** Population that can provide members to other populations of the species because it lives in a favorable area, and the birthrate is most likely higher than the death rate. 901
- speciation** (spee see AY shun) Origin of new species due to the evolutionary process of descent with modification. 304
- species** Group of similarly constructed organisms capable of interbreeding and producing fertile offspring; organisms that share a common gene pool; the taxon at the lowest level of classification. 6, 340
- species diversity** Variety of species that make up a community. 840
- species richness** Number of species in a community. 840
- specific epithet** (spuh SIFF ick EPP pih thett) In the binomial system of taxonomy, the second part of an organism's name; it may be descriptive. 339
- sperm** Male gamete having a haploid number of chromosomes and the ability to fertilize an egg, the female gamete. 761
- spermatogenesis** (sperm mat oh JENN uh sis) Production of sperm in males by the process of meiosis and maturation. 179
- sphygmomanometer** (sfig moh mah NAHM met turr) Device consisting of inflatable cuff and pressure gauge for measuring arterial blood pressure. 603
- spicule** (SPICK yule) Skeletal structure of sponges composed of calcium carbonate or silicate. 517
- spinal cord** In vertebrates, the nerve cord that is continuous with the base of the brain and housed within the vertebral column. 688
- spinal nerve** Nerve that arises from the spinal cord. 692
- spirillum (pl., spirilla)** (spy RILL lumm) Long, rod-shaped bacterium that is twisted into a rigid spiral; if the spiral is flexible rather than rigid, it is called a spirochete. 64
- spirochete** (SPY roe keet) Long, rod-shaped bacterium that is twisted into a flexible spiral; if the spiral is rigid rather than flexible, it is called a spirillum. 64
- spleen** Large, glandular organ located in the upper left region of the abdomen; stores and purifies blood. 615
- sponge** Invertebrates that are pore-bearing filter feeders whose inner body wall is lined by collar cells that resemble a unicellular choanoflagellate. 517
- spongy bone** Type of bone that has an irregular, meshlike arrangement of thin plates of bone. 581, 720
- spongy mesophyll** (MESS oh fill) Layer of tissue in a plant leaf containing loosely packed cells, increasing the amount of surface area for gas exchange. 450
- spontaneous mutation** Mutation that arises as a result of anomalies in normal biological processes, such as mistakes made during DNA replication. 243
- sporangium (pl., sporangia)** (spore RAN jee uhm) Structure that produces spores. 388, 396, 412
- spore** Asexual reproductive or resting cell capable of developing into a new organism without fusion with another cell, in contrast to a gamete. 176, 395, 412
- sporophyll** Modified leaf that bears a sporangium or sporangia. 416
- sporophyte** (SPORE oh fite) Diploid generation of the alternation of generations life cycle of a plant; produces haploid spores that develop into the haploid generation. 178, 412
- sporopollenin** Tough substance that the outer wall of spores and pollen grains is composed. 412
- spring overturn** Mixing process that occurs in spring in stratified lakes whereby oxygen-rich top waters mix with nutrient-rich bottom waters. 881
- squamous epithelium** (SQUAY muss epp pih THEE lee uhm) Type of epithelial tissue that contains flat cells. 578
- stabilizing selection** Outcome of natural selection in which extreme phenotypes are eliminated and the average phenotype is conserved. 289
- stamen** (STAY men) In flowering plants, the portion of the flower that consists of a filament and an anther containing pollen sacs where pollen is produced. 425, 495
- starch** Storage polysaccharide found in plants that is composed of glucose molecules joined in a linear fashion with few side chains. 42
- statistical phylogenetics** System of creating phylogenetic trees using statistical tools rather than parsimony. 343
- statolith** (STAT oh lith) Sensors found in root cap cells that cause a plant to demonstrate gravitropism. 482
- stem** Usually the upright, vertical portion of a plant that transports substances to and from the leaves. 435
- stereoscopic vision** Vision characterized by depth perception and three-dimensionality. 560, 704
- steroid** (STARE oid) Type of lipid molecule having a complex of four carbon rings—e.g., cholesterol, estrogen, progesterone, and testosterone. 46
- steroid hormone** Type of hormone that has the same complex of four carbon rings, but each one has different side chains. 739
- stigma** (STIG muh) In flowering plants, portion of the carpel where pollen grains adhere and germinate before fertilization can occur. 425, 495
- stolon** (STOLE uhn) Stem that grows horizontally along the ground and may give rise to new plants where it contacts the soil—e.g., the runners of a strawberry plant. 448, 505
- stoma (pl., stomata)** (STOME muh, stoh MAH tuh) Small opening between two guard cells on the underside of leaf epidermis through which gases pass. 119, 412, 437, 466
- stomach** In vertebrates, muscular sac that mixes food with gastric juices to form chyme, which enters the small intestine. 638
- stramenopile** Group of protists that includes water molds, diatoms, and golden brown algae and is characterized by a "hairy" flagellum. 381

- stratum** (STRAY tum) Ancient layer of sedimentary rock; results from slow deposition of silt, volcanic ash, and other materials. 322
- striated** (STRY ate ted) Having bands; in cardiac and skeletal muscle, alternating light and dark bands produced by the distribution of contractile proteins. 582
- strobilus** (stroh BILL us) In club mosses, terminal clusters of leaves that bear sporangia. 416
- stroke** Condition resulting when an arteriole in the brain bursts or becomes blocked by an embolism; cerebrovascular accident. 605
- stroma** (STROH muh) Fluid within a chloroplast that contains enzymes involved in the synthesis of carbohydrates during photosynthesis. 76, 119
- stromatolite** (stroh MAT oh lite) Domed structure found in shallow seas consisting of cyanobacteria bound to calcium carbonate. 324
- structural gene** Gene that codes for an enzyme in a metabolic pathway. 234
- structural genomics** Study of the sequence of DNA bases and the amount of genes in organisms. 255
- style** Elongated, central portion of the carpel between the ovary and stigma. 425, 495
- subcutaneous layer** A sheet that lies just beneath the skin and consists of loose connective and adipose tissue. 585
- submucosa** Tissue layer just under the epithelial lining of the lumen of the digestive tract (second layer). 641
- substrate** Reactant in a reaction controlled by an enzyme. 108
- substrate-level ATP synthesis** (foss for ill LAY shun) Process in which ATP is formed by transferring a phosphate from a metabolic substrate to ADP. 136
- supergroup** In this text, refers to the major groups of eukaryotes. 374
- surface-area-to-volume ratio** Ratio of a cell's outside area to its internal volume. 61
- surface tension** Force that holds moist membranes together due to the attraction of water molecules. 30
- survivorship** Probability of newborn individuals of a cohort surviving to particular ages. 822
- sustainable development** Management of an ecosystem so that it maintains itself while providing services to human beings. 902
- suture** Line of union between two nonarticulating bones, as in the skull. 722
- swamp** Wet, spongy land that is saturated and sometimes partially or intermittently covered with water. 879
- sweat gland** Skin gland that secretes a fluid substance for evaporative cooling; sudoriferous gland. 587
- swim bladder** In fishes, a gas-filled sac whose pressure can be altered to change buoyancy. 544
- symbiosis** Relationship that occurs when two different species live together in a unique way; it may be beneficial, neutral, or detrimental to one and/or the other species. 846
- symbiotic relationship** See symbiosis. 365
- sympathetic division** Division of the autonomic system that is active when an organism is under stress; uses norepinephrine as a neurotransmitter. 695
- sympatric speciation** (simm PAT trick spee see AY shun) Origin of new species in populations that overlap geographically. 307
- synapomorphy** In systematics, a derived character that is shared by clade members. 343
- synapse** (SIN naps) Junction between neurons consisting of the presynaptic (axon) membrane, the synaptic cleft, and the postsynaptic (usually dendrite) membrane. 686
- synapsis** (sin NAP sis) Pairing of homologous chromosomes during meiosis I. 171
- synaptic cleft** (sin NAP tick) Small gap between presynaptic and postsynaptic membranes of a synapse. 686
- synovial joint** (sin OH vee uhl) Freely moving joint in which two bones are separated by a cavity. 725
- systematics** (sis tim MAT ticks) Study of the diversity of organisms to classify them and determine their evolutionary relationships. 338
- systemic circuit** (sis TIM mick SIR kit) Circulatory pathway of blood flow between the tissues and the heart. 597
- systemin** In plants, an 18-amino-acid peptide that is produced by damaged or injured leaves that leads to the wound response. 488
- ystole** (SIS toe lee) Contraction period of the heart during the cardiac cycle. 600
- T**
- tactile communication** Communication through touch; for example, when a chick pecks its mother for food, chimpanzees grooming each other, and honeybees "dance." 809
- taiga** (TIE guh) Terrestrial biome that is a coniferous forest extending in a broad belt across northern Eurasia and North America. 871
- tandem repeat** Repetitive DNA sequence in which the repeats occur one after another in the same region of a chromosome. 256
- taproot** Main axis of a root that penetrates deeply and is used by certain plants (such as carrots) for food storage. 442
- taste bud** Structure in the vertebrate mouth containing sensory receptors for taste; in humans, most taste buds are on the tongue. 702
- taxon (pl., taxa)** (TAX ahn, TAX uh) Group of organisms that fills a particular classification category. 340
- taxonomy** (tax AH no mee) Branch of biology concerned with identifying, describing, and naming organisms. 6, 338
- T cell** Lymphocyte that matures in the thymus and exists in four varieties, one of which kills antigen-bearing cells outright. 615
- T cell receptor (TCR)** Molecule on the surface of a T cell that can bind to a specific antigen fragment in combination with an MHC molecule. 619
- telomere** (TELL oh meer) Tip of the end of a chromosome that shortens with each cell division and may thereby regulate the number of times a cell can divide. 162, 218
- telophase** (TELL oh faze) Mitotic phase during which daughter cells are located at each pole. 158
- temperate deciduous forest** (TIM purr utt duh SIDD you us) Forest found south of the taiga; characterized by deciduous trees such as oak, beech, and maple, moderate climate, relatively high rainfall, stratified plant growth, and plentiful ground life. 872
- temperate rain forest** Coniferous forest—e.g., that running along the west coast of Canada and the United States—characterized by plentiful rainfall and rich soil. 871
- template** (TEM plate) Parental strand of DNA that serves as a guide for the complementary daughter strand produced during DNA replication. 217
- tendon** Strap of fibrous connective tissue that connects skeletal muscle to bone. 580, 727
- terminal bud** Bud that develops at the apex of a shoot. 444
- termination** End of translation that occurs when a ribosome reaches a stop codon on the mRNA that it is translating, causing release of the completed protein. 227
- territoriality** Marking and/or defending a particular area against invasion by another species member; area often used for the purpose of feeding, mating, and caring for young. 292, 810
- territory** Area occupied and defended exclusively by an animal or group of animals. 291, 810
- test** Loose-fitting shell of a foraminiferan or a radiolarian; made of calcium carbonate or silicon, respectively. 388
- testcross** Cross between an individual with the dominant phenotype and an individual with the recessive phenotype. The resulting phenotypic ratio indicates whether the dominant phenotype is homozygous or heterozygous. 197
- testes (sing., testis)** (TEST tiss, TEST teez) Male gonad that produces sperm and the male sex hormones. 750, 756
- testosterone** (test TOSS turr ohn) Male sex hormone that helps maintain sexual organs and secondary sex characteristics. 750, 761
- tetanus** (TETT uh nuss) Sustained muscle contraction without relaxation. 727
- tetany** (TETT uh nee) Severe twitching caused by involuntary contraction of the skeletal muscles due to a calcium imbalance. 744
- tetrapod** (TETT truh pod) Four-footed vertebrate; includes amphibians, reptiles, birds, and mammals. 542
- thalamus** (THAL uh muss) In vertebrates, the portion of the diencephalon that passes on selected sensory information to the cerebrum. 690
- therapeutic cloning** Used to create mature cells of various cell types. Also, used to learn about specialization of cells and provide cells and tissue to treat human illnesses. 159
- therapsid** (thurr RAP sid) Mammal-like reptiles appearing in the middle Permian period; ancestral to mammals. 549
- thermoacidophile** (therm moh uh SIDD oh file) Type of archaea that lives in hot, acidic, aquatic habitats, such as hot springs or near hydrothermal vents. 369
- thigmotropism** (thig MAH troh piz uhm) In plants, unequal growth due to contact with solid objects, as the coiling of tendrils around a pole. 483
- threatened species** Species that is likely to become an endangered species in the

- foreseeable future (e.g., bald eagle, gray wolf, Louisiana black bear). 890
- thylakoid** (THIGH luh koid) Flattened sac within a granum whose membrane contains chlorophyll and where the light reactions of photosynthesis occur. 65, 76, 119
- thymine (T)** (THIGH men) One of four nitrogen-containing bases in nucleotides composing the structure of DNA; pairs with adenine. 214
- thymus gland** (THIGH muss) Lymphoid organ involved in the development and functioning of the immune system; T lymphocytes mature in the thymus gland. 615, 750
- thyroid gland** (THIGH roid) Large gland in the neck that produces several important hormones, including thyroxine, triiodothyronine, and calcitonin. 743
- thyroid-stimulating hormone (TSH)** Substance produced by the anterior pituitary that causes the thyroid to secrete thyroxine and triiodothyronine. 740
- thyroxine (T₄)** (thigh ROCKS sin) Hormone secreted from the thyroid gland that promotes growth and development; in general, it increases the metabolic rate in cells. 743
- tight junction** Junction between cells when adjacent plasma membrane proteins join to form an impermeable barrier. 99
- tissue** Group of similar cells combined to perform a common function. 578
- tissue culture** Process of growing tissue artificially, usually in a liquid medium in laboratory glassware. 505
- tissue fluid** Fluid that surrounds the body's cells; consists of dissolved substances that leave the blood capillaries by filtration and diffusion. 581, 608
- tone** Continuous, partial contraction of muscle. 727
- tonicity** (tone ISS ih tee) Osmolarity of a solution compared to that of a cell. If the solution is isotonic to the cell, there is no net movement of water; if the solution is hypotonic, the cell gains water; and if the solution is hypertonic, the cell loses water. 92
- tonsils** Partially encapsulated lymph nodules located in the pharynx. 615
- topography** Surface features of the Earth. 867
- totipotent** (toe TIP uh tent) Cell that has the full genetic potential of the organism, including the potential to develop into a complete organism. 505, 782
- toxin** Poisonous substance produced by living cells or organisms. Toxins are nearly always proteins that are capable of causing disease on contact or absorption with body tissues. 366
- tracer** Substance having an attached radioactive isotope that allows a researcher to track its whereabouts in a biological system. 24
- trachea (pl., tracheae)** (TRAY kee uh, TRAY kee ee) In insects, air tubes located between the spiracles and the tracheoles. In tetrapod vertebrates, air tube (windpipe) that runs between the larynx and the bronchi. 529, 653, 654
- tracheid** (TRAY kee id) In vascular plants, type of cell in xylem that has tapered ends and pits through which water and minerals flow. 439, 462
- tract** Bundle of myelinated axons in the central nervous system. 688
- transcription** Process whereby a DNA strand serves as a template for the formation of mRNA. 220
- transcription activator** Protein that speeds transcription. 240
- transcriptional control** Control of gene expression during the transcriptional phase determined by mechanisms that control whether transcription occurs or the rate at which it occurs. 242
- transcription factor** In eukaryotes, protein required for the initiation of transcription by RNA polymerase. 242
- transduction** (trans DUCK shun) Exchange of DNA between bacteria by means of a bacteriophage. 364
- transduction pathway** Series of proteins or enzymes that change a signal to one understood by the cell. 474
- transfer rate** Amount of a substance that moves from one component of the environment to another within a specified period of time. 857
- transfer RNA (tRNA)** Type of RNA that transfers a particular amino acid to a ribosome during protein synthesis; at one end, it binds to the amino acid, and at the other end it has an anticodon that binds to an mRNA codon. 220
- transformation** Taking up of extraneous genetic material from the environment by bacteria. 364
- transgenic organism** (trans JENN ick) Free-living organism in the environment that has had a foreign gene inserted into it. 252
- transitional fossil** Fossil that bears a resemblance to two groups that in present day are classified separately. 276
- translation** Process whereby ribosomes use the sequence of codons in mRNA to produce a polypeptide with a particular sequence of amino acids. 220
- translational control** Gene expression regulated by the activity of mRNA transcripts. 241
- translocation** (trans low KAY shun) Movement of a chromosomal segment from one chromosome to another nonhomologous chromosome, leading to abnormalities—e.g., Down syndrome. 184, 227
- transpiration** Plant's loss of water to the atmosphere, mainly through evaporation at leaf stomata. 465
- transposon** (trans POSE ahn) DNA sequence capable of randomly moving from one site to another in the genome. 257
- trichocyst** (TRICK oh sist) Found in ciliates; contains long, barbed threads useful for defense and capturing prey. 384
- trichomes** (TRY coh mz) In plants, specialized outgrowth of the epidermis (e.g., root hairs). 437
- trichomoniasis** (trih coh moh NIE uh sis) Sexually transmitted disease caused by the parasitic protozoan *Trichomonas vaginalis*. 772
- triglyceride** (try GLISS suh ride) Neutral fat composed of glycerol and three fatty acids. 44, 644
- triplet code** During gene expression, each sequence of three nucleotide bases stands for a particular amino acid. 221
- trisomy** (try SO mee) Having three of a particular type of chromosome ($2n + 1$). 180
- trochophore** Type of protosome that produces a trochophore larva; also has two bands of cilia around its middle. 516
- trophic level** (TROFE ick) Feeding level of one or more populations in a food web. 855
- trophoblast** (TROFE oh blast) Outer membrane surrounding the embryo in mammals; when thickened by a layer of mesoderm, it becomes the chorion, an extraembryonic membrane. 788
- tropical rain forest** Biome near the equator in South America, Africa, and the Indo-Malay regions; characterized by warm weather, plentiful rainfall, a diversity of species, and mainly tree-living animal life. 874
- tropism** (TROPE iz uhm) In plants, a growth response toward or away from a directional stimulus. 482
- true coelom** Body cavity completely lined with mesoderm; found in certain protostomes and all deuterostomes. 516
- truffle** Subterranean edible fungi. 398
- trypsin** (TRIP sin) Protein-digesting enzyme secreted by the pancreas. 642
- tube foot** Part of the water vascular system in sea stars, located on the oral surface of each arm; functions in locomotion. 534
- tubular reabsorption** (TUBE yule lurr ree ab SORP shun) Movement of primarily nutrient molecules and water from the contents of the nephron into blood at the proximal convoluted tubule. 672
- tubular secretion** Movement of certain molecules from blood into the distal convoluted tubule of a nephron so that they are added to urine. 673
- tumor** Cells derived from a single mutated cell that has repeatedly undergone cell division; benign tumors remain at the site of origin, while malignant tumors metastasize. 161
- tumor suppressor gene** Gene that codes for a protein that ordinarily suppresses the cell cycle; inactivity due to a mutation can lead to a tumor. 162
- turgor movement** In plant cells, pressure of the cell contents against the cell wall when the central vacuole is full. 484
- turgor pressure** (TURR gurr) Pressure of the cell contents against the cell wall; in plant cells, determined by the water content of the vacuole and provides internal support. 93
- tympenic membrane** (tim PAN ick) Membranous region that receives air vibrations in an auditory organ; in humans, the eardrum. 710
- typhlosole** (TIFE low sole) Expanded dorsal surface of long intestine of earthworms, allowing additional surface for absorption. 526, 634

U

- umbilical cord** (uhm BILL lick cull) Cord connecting the fetus to the placenta through which blood vessels pass. 790
- unicellular** (you nih SELL you lurr) Made up of but a single cell, as in the bacteria. 2
- uniformitarianism** (you nih form ih TARE ree uhn iz uhm) Belief espoused by James Hutton that geological forces act at a continuous, uniform rate. 269
- unsaturated fatty acid** Fatty acid molecule that carbons of its hydrocarbon chain. The chain bears fewer hydrogens than the maximum number possible. 44
- upwelling** Upward movement of deep, nutrient-rich water along coasts; it replaces surface

waters that move away from shore when the direction of prevailing wind shifts. 884

uracil (U) (YUR a sill) Pyrimidine base that occurs in RNA, replacing thymine. 220

urea (you REE uh) Main nitrogenous waste of terrestrial amphibians and most mammals. 666

ureter (you REE turr) Tubular structure conducting urine from the kidney to the urinary bladder. 670

urethra (you REE thruh) Tubular structure that receives urine from the bladder and carries it to the outside of the body. 670

uric acid (YOUR rick) Main nitrogenous waste of insects, reptiles, and birds. 666

urinary bladder (YOUR rinn air ree) Organ where urine is stored. 670

urine Liquid waste product made by the nephrons of the vertebrate kidney through the processes of glomerular filtration, tubular reabsorption, and tubular secretion. 670

uterine cycle (YOU turr rinn) Cycle that runs concurrently with the ovarian cycle; it prepares the uterus to receive a developing zygote. 764

uterus (YOU turr us) In mammals, expanded portion of the female reproductive tract through which eggs pass to the environment or in which an embryo develops and is nourished before birth. 762

utricle (YOU trick cull) Cavity in the vestibule of the vertebrate inner ear; contains sensory receptors for gravitational equilibrium. 713

V

vacuole (VAC you ohl) Membrane-bounded sac, larger than a vesicle; usually functions in storage and can contain a variety of substances. In plants, the central vacuole fills much of the interior of the cell. 75

valence shell Outer shell of an atom. 25

vascular bundle (VASS cue lurr) In plants, primary phloem and primary xylem enclosed by a bundle sheath. 439

vascular cambium (VASS cue lurr CAMM bee uhm) In plants, lateral meristem that produces secondary phloem and secondary xylem. 444

vascular cylinder In eudicots, the tissues in the middle of a root, consisting of the pericycle and vascular tissues. 439

vascular plant Plant that has xylem and phloem. 416

vascular tissue Transport tissue in plants, consisting of xylem and phloem. 413, 437

vector (VECK turr) In genetic engineering, a means to transfer foreign genetic material into a cell—e.g., a plasmid. 250

vegetative organ Nonreproductive plant part. 434

vein Blood vessel that arises from venules and transports blood toward the heart. 596

vena cava (VEE nuh CAVE uh) Large systemic vein that returns blood to the right atrium of the heart in tetrapods; either the superior or inferior vena cava. 602

ventilation (venn tih LAY shun) Process of moving air into and out of the lungs; breathing. 650

ventricle (VENT trih cull) Cavity in an organ, such as a lower chamber of the heart or the ventricles of the brain. 598, 688

venule (VENN yule) Vessel that takes blood from capillaries to a vein. 596

vertebral column (VERT tih brull) Portion of the vertebrate endoskeleton that houses the spinal cord; consists of many vertebrae separated by intervertebral disks. 722

vertebrate (VERT tih brate) Chordate in which the notochord is replaced by a vertebral column. 512

vesicle (VESS sick cull) Small, membrane-bounded sac that stores substances within a cell. 66

vessel element Cell that joins with others to form a major conducting tube found in xylem. 439, 462

vestibule (VESS tihb yule) Space or cavity at the entrance to a canal, such as the cavity that lies between the semicircular canals and the cochlea. 710

vestigial structure (vest TIH jee uhl) Remains of a structure that was functional in some ancestor but is no longer functional in the organism in question. 267, 278

villus (VILL us) Small, fingerlike projection of the inner small intestinal wall. 639

viroid (VYE roid) Infectious strand of RNA devoid of a capsid and much smaller than a virus. 361

virus Noncellular parasitic agent consisting of an outer capsid and an inner core of nucleic acid. 356

visible light Portion of the electromagnetic spectrum that is visible to the human eye. 122

visual accommodation Ability of the eye to focus at different distances by changing the curvature of the lens. 706

visual communication Form of communication between animals using their bodies, includes fighting. 808

vitamin Essential requirement in the diet, needed in small amounts. Vitamins are often part of coenzymes. 110, 646, 666

vitamin D Fat-soluble compound; deficiency tends to cause rickets in children. 586

viviparous (vie VIP purr us) Animal that gives birth after partial development of offspring within mother. 757

vocal cord In humans, fold of tissue within the larynx; creates vocal sounds when it vibrates. 654

W

water column In plants, water molecules joined together in xylem from the leaves to the roots. 464

water (hydrologic) cycle (high droh LAH jick) Interdependent and continuous circulation of water from the ocean, to the atmosphere, to the land, and back to the ocean. 857

water mold Filamentous organisms having cell walls made of cellulose; typically decomposers of dead freshwater organisms, but some are parasites of aquatic or terrestrial organisms. 382

water potential Potential energy of water; a measure of the capability to release or take up water relative to another substance. 463

water vascular system Series of canals that takes water to the tube feet of an echinoderm, allowing them to expand. 534

wax Sticky, solid, waterproof lipid consisting of many long-chain fatty acids usually linked to long-chain alcohols. 47

wetland Wet area. (See also bog or swamp.) 879

whisk fern Common name for seedless vascular plant that consists only of stems and has no leaves or roots. 418

white blood cell Leukocyte, of which there are several types, each having a specific function in protecting the body from invasion by foreign substances and organisms. 581, 607

white matter Myelinated axons in the central nervous system. 688

wobble hypothesis Ability of the tRNAs to recognize more than one codon; the codons differ in their third nucleotide. 224

wood Secondary xylem that builds up year after year in woody plants and becomes the annual rings. 446

X

xenotransplantation Use of animal organs, instead of human organs, in human transplant patients. 254

X-linked Allele that is located on an X chromosome but may control a trait that has nothing to do with the sexual characteristics of an animal. 205

xylem (ZIE lumm) Vascular tissue that transports water and mineral solutes upward through the plant body; it contains vessel elements and tracheids. 416, 439, 462

xylem sap Solution of inorganic nutrients moves from a plant's roots to its shoots through xylem tissue. 462

Y

yeast Unicellular fungus that has a single nucleus and reproduces asexually by budding or fission, or sexually through spore formation. 398

yolk Dense nutrient material in the egg of a bird or reptile. 757, 779

yolk sac One of the extraembryonic membranes that, in shelled vertebrates, contains yolk for the nourishment of the embryo, and in placental mammals is the first site for blood cell formation. 787

Z

zero population growth No growth in population size. 834

zooflagellate (zoh oh FLAJ jell ate) Nonphotosynthetic protist that moves by flagella; typically zooflagellates enter into symbiotic relationships, and some are parasitic. 386

zooplankton (zoe oh PLANK ton) Part of plankton containing protozoans and other types of microscopic animals. 387, 881

zoospore Spore that is motile by one or more flagella. 377, 396

zygospore (ZIE go spore) Thick-walled resting cell formed during sexual reproduction of zygospore fungi. 396

zygospore fungi Fungi such as black bread mold that reproduces by forming windblown spores in sporangia; sexual reproduction involves a thick-walled zygospore. 396

zygote (ZIE goat) Diploid cell formed by the union of two gametes; the product of fertilization. 170

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About the Cover

Evidence for evolution, which explains the adaptations of a blue-footed booby, and also the unity that joins all living things together, is stressed in this edition of *Biology*.

A blue-footed booby takes its name from its bright blue feet and its clumsy appearance on land. When courting, the male takes the stance shown in the cover photo, and he also dances to show off his attractive feet. Females choose their mates, and thus males today have blue feet because this trait was preferred by females. Natural selection has also made blue-footed boobies suited to their marine way of life. The male, which can dive like a torpedo to reach a depth of 25 m (82 ft), is charged with feeding the newly hatched young.

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