UNIT 1

Ecology

Chapter 2
Principles of Ecology

BIG Idea Energy is required to cycle materials through living and nonliving systems.

Chapter 3
Communities, Biomes, and Ecosystems

BIG Idea Limiting factors and ranges of tolerance are factors that determine where terrestrial biomes and aquatic ecosystems exist.

Chapter 4
Population Ecology

BIG Idea Population growth is a critical factor in a species' ability to maintain homeostasis within its environment.

Chapter 5
Biodiversity and Conservation

BIG Idea Community and ecosystem homeostasis depend on a complex set of interactions among biologically diverse individuals.

CAREERS IN BIOLOGY
Wildlife Biologist

As the oystercatcher researchers are doing in this photograph, **wildlife biologists** perform scientific research to study how species interact with each other and the environment. They protect and conserve wildlife species and also help maintain and increase wildlife populations.

WRITING in **Biology** Visit biologygmh.com to learn more about wildlife biology. Then write a description of the job responsibilities of wildlife biologists.

Ron Niebrugge

Biology Online

To read more about wildlife biologists in action, visit biologygmh.com.

CHAPTER 2

Principles of Ecology

Section 1
Organisms and Their Relationships

MAIN Idea Biotic and abiotic factors interact in complex ways in communities and ecosystems.

Section 2
Flow of Energy in an Ecosystem

MAIN Idea Autotrophs capture energy, making it available for all members of a food web.

Section 3
Cycling of Matter

MAIN Idea Essential nutrients are cycled through biogeochemical processes.

BioFacts

- The Pacific tree frog can change from light colored to dark colored quickly. This could be a response to changes in temperature and humidity.
- The spotted owl nests only in old growth forests and might be in danger of becoming extinct due to the loss of these forests.

(t)Galen Rowell/CORBIS, (c)Paul Souders/Getty Images, (b)Dan Suzio/Photo Researchers, (bkgd)CORBIS

Start-Up Activities

LAUNCH Lab

Problems in *Drosophila* world?

As the photos on the left illustrate, what we understand to be the world is many smaller worlds combined to form one large world. Within the large world, there are populations of creatures interacting with each other and their environment. In this lab, you will observe an example of a small part of the world.

Procedure

1. Read and complete the lab safety form.
2. Prepare a data table to record your observations.
3. Your teacher has prepared a **container housing several fruit flies** *(Drosophila melanogaster)* with food for the flies in the bottom. Observe how many fruit flies are present.
4. Observe the fruit flies over a period of one week and record any changes.

Analysis

1. **Summarize** the results of your observations.
2. **Evaluate** whether or not this would be a reasonable way to study a real population.

Biology Online

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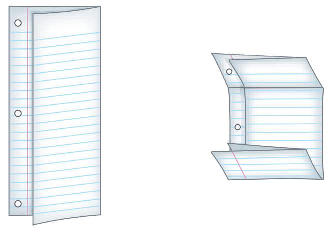
- explore the Interactive Time Line, Concepts in Motion, Microscopy Links, Virtual Labs, and links to virtual dissections
- access Web links for more information, projects, and activities
- review content online with the Interactive Tutor and take Self-Check Quizzes

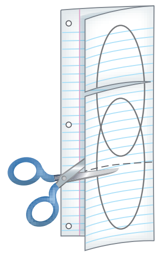
FOLDABLES™ Study Organizer

Natural Cycles Make this Foldable to help you compare and contrast the water cycle and the carbon cycle.

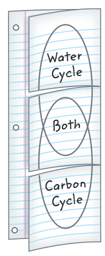
STEP 1 Fold a sheet of notebook paper in half lengthwise so that the side without holes is 2.5 cm shorter than the side with the holes. Then fold the paper into thirds as shown.



STEP 2 Unfold the paper and draw the Venn diagram. Then cut along the two fold lines of the top layer only. This makes three tabs.



STEP 3 Label the tabs as illustrated.



FOLDABLES Use this Foldable with Section 2.3. As you study the section, record what you learn about the two cycles under the appropriate tabs and determine what the cycles have in common.

Section 2.1

Objectives

- **Explain** the difference between abiotic factors and biotic factors.
- **Describe** the levels of biological organization.
- **Differentiate** between an organism's habitat and its niche.

Review Vocabulary

species: group of organisms that can interbreed and produce fertile offspring in nature

New Vocabulary

ecology
biosphere
biotic factor
abiotic factor
population
biological community
ecosystem
biome
habitat
niche
predation
symbiosis
mutualism
commensalism
parasitism

Organisms and Their Relationships

MAIN Idea Biotic and abiotic factors interact in complex ways in communities and ecosystems.

Real-World Reading Link On whom do you depend for your basic needs such as food, shelter, and clothing? Humans are not the only organisms that depend on others for their needs. All living things are interdependent. Their relationships are important to their survival.

Ecology

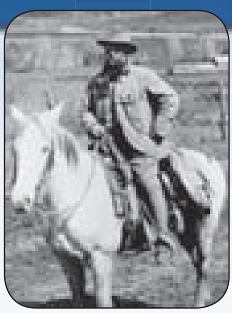
Scientists can gain valuable insight about the interactions between organisms and their environments and between different species of organisms by observing them in their natural environments. Each organism, regardless of where it lives, depends on nonliving factors found in its environment and on other organisms living in the same environment for survival. For example, green plants provide a source of food for many organisms as well as a place to live. The animals that eat the plants provide a source of food for other animals. The interactions and interdependence of organisms with each other and their environments are not unique. The same type of dependency occurs whether the environment is a barren desert, a tropical rain forest, or a grassy meadow. **Ecology** is the scientific discipline in which the relationships among living organisms and the interaction the organisms have with their environments are studied.

Figure 2.1

Milestones in Ecology

Ecologists have worked to preserve and protect natural resources.

1872 Yellowstone becomes the first national park in the U.S.



1905 Theodore Roosevelt urges the U.S. Congress to set aside over 70 million hectares of land to protect the natural resources found on them.

1900

1962 Rachel Carson publishes a best-selling book warning of the environmental danger of pollution and pesticides.

1960

1967 The government of Rwanda and international conservation groups begin efforts to protect mountain gorillas, due in a large part to the work of Dian Fossey.

1970

1971 Marjorie Carr stops the construction of the Cross Florida Barge Canal because of the environmental damage the project would cause.

(t)Flip Nicklin/Minden Pictures

■ **Figure 2.2** Ecologists work in the field and in laboratories. This ecologist is enduring harsh conditions to examine a seal.

The study of organisms and their environments is not new. The word *ecology* was first introduced in 1866 by Ernst Haeckel, a German biologist. Since that time, there have been many significant milestones in ecology, as shown in **Figure 2.1.**

Scientists who study ecology are called ecologists. Ecologists observe, experiment, and model using a variety of tools and methods. For example, ecologists, like the one shown in **Figure 2.2,** perform tests in organisms' environments. Results from these tests might give clues as to why organisms are able to survive in the water, why organisms become ill or die from drinking the water, or what organisms could live in or near the water. Ecologists also observe organisms to understand the interactions between them. Some observations and analyses must be made over long periods of time in a process called longitudinal analysis.

A model allows a scientist to represent or simulate a process or system. Studying organisms in the field can be difficult because there often are too many variables to study at one time. Models allow ecologists to control the number of variables present and to slowly introduce new variables in order to fully understand the effect of each variable.

Reading Check **Describe** a collection of organisms and their environment that an ecologist might study in your community.

Vocabulary

Word origin

Ecology
comes from the Greek words *oikos,* meaning *house,* and *ology,* meaning *to study.*

1990 The Indigenous Environmental Network (IEN), directed by Tom Goldtooth, is formed by Native Americans to protect their tribal lands and communities from environmental damage.

2004 Wangari Maathai wins a Nobel Prize. She began the Green Belt Movement in Africa, which hires women to plant trees to slow the process of deforestation and desertification.

1987 The United States and other countries sign the Montreal Protocol, an agreement to phase out the use of chemical compounds that destroy atmospheric ozone.

1996 Completing a phase-out that was begun in 1973, the U.S. Environmental Protection Agency bans the sale of leaded gasoline for vehicle use.

Concepts in Motion **Interactive Time Line**
To learn more about these milestones and others, visit biologygmh.com.

(bl)Nic Paget-Clark/In Motion Magazine, (br)Radu Sigheti/Reuters/CORBIS

■ **Figure 2.3** This color-enhanced satellite photo of Earth taken from space shows a large portion of the biosphere.

The Biosphere

Because ecologists study organisms and their environments, their studies take place in the biosphere. The **biosphere** (BI uh sfihr) is the portion of Earth that supports life. The photo of Earth taken from space shown in **Figure 2.3** shows why the meaning of the term *biosphere* should be easy to remember. The term *bio* means "life," and a sphere is a geometric shape that looks like a ball. When you look at Earth from this vantage point, you can see how it is considered to be "a ball of life."

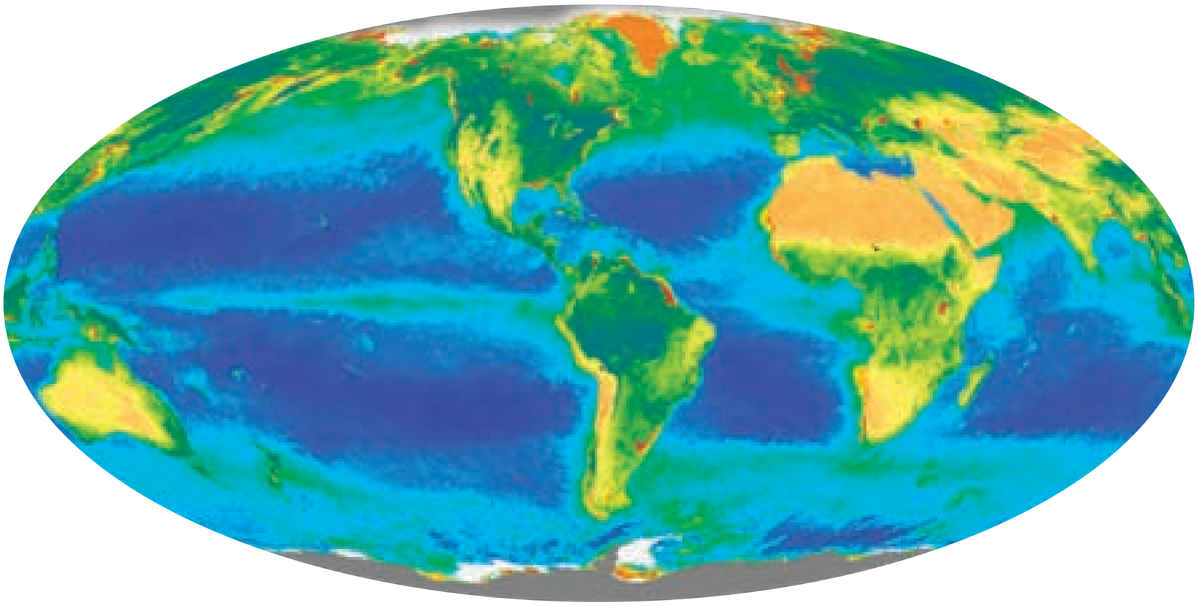
Although "ball of life" is the literal meaning of the word *biosphere,* this is somewhat misleading. The biosphere includes only the portion of Earth that includes life. The biosphere forms a thin layer around Earth. It extends several kilometers above the Earth's surface into the atmosphere and extends several kilometers below the ocean's surface to the deep-ocean vents. It includes landmasses, bodies of freshwater and saltwater, and all locations below Earth's surface that support life.

Figure 2.4 shows a satellite image of Earth's biosphere on the surface of Earth. The photo is color-coded to represent the distribution of chlorophyll. Chlorophyll is a green pigment found in green plants and algae that you will learn about in later chapters. Because most organisms depend on green plants or algae for survival, green plants are a good indicator of the distribution of living organisms in an area. In the oceans, red represents areas with the highest density of chlorophyll followed by yellow, then blue, and then pink, representing the lowest density. On land, dark green represents the area with highest chlorophyll density and pale yellow represents the area with the lowest chlorophyll density.

Reading Check **Describe** the general distribution of green plants across the United States using **Figure 2.4.**

The biosphere also includes areas such as the frozen polar regions, deserts, oceans, and rain forests. These diverse locations contain organisms that are able to survive in the unique conditions found in their particular environment. Ecologists study these organisms and the factors in their environment. These factors are divided into two large groups—the living factors and the nonliving factors.

■ **Figure 2.4** This color-coded satellite photo shows the relative distribution of life on Earth's biosphere based on the distribution of chlorophyll.



■ **Figure 2.5** The salmon swimming upstream are biotic factors in the stream community. Other organisms in the water, such as frogs and algae, also are biotic factors.
Explain ***How are organisms dependent on other organisms?***

Biotic factors The living factors in an organism's environment are called the **biotic** (by AH tihk) **factors.** Consider the biotic factors in the habitat of salmon shown in **Figure 2.5.** These biotic factors include all of the organisms that live in the water, such as other fish, algae, frogs, and microscopic organisms. In addition, organisms that live on the land adjacent to the water might be biotic factors for the salmon. Migratory animals, such as birds that pass through the area, also are biotic factors. The interactions among organisms are necessary for the health of all species in the same geographic location. For example, the salmon need other members of their species to reproduce. Salmon also depend on other organisms for food and, in turn, are a food source for other organisms.

Abiotic factors The nonliving factors in an organism's environment are called **abiotic** (ay bi AH tihk) **factors.** The abiotic factors for different organisms vary across the biosphere, but organisms that live in the same geographic area might share the same abiotic factors. These factors might include temperature, air or water currents, sunlight, soil type, rainfall, or available nutrients. Organisms depend on abiotic factors for survival. For example, the abiotic factors important to a particular plant might be the amount of rainfall, the amount of sunlight, the type of soil, the range of temperature, and the nutrients available in the soil. The abiotic factors for the salmon in **Figure 2.5** might be the temperature range of the water, the pH of the water, and the salt concentration of the water.

Organisms are adapted to surviving in the abiotic factors that are present in their natural environments. If an organism moves to another location with a different set of abiotic factors, the organism might die if it cannot adjust quickly to its new surroundings. For example, if a lush green plant that normally grows in a swampy area is transplanted to a dry desert, the plant likely will die because it cannot adjust to abiotic factors present in the desert.

Reading Check **Compare and contrast** abiotic and biotic factors for a plant or animal in your community.

CAREERS IN BIOLOGY

Ecologist The field of ecology is vast. Ecologists study the organisms in the world and the environments in which they live. Many ecologists specialize in a particular area such as marine ecology. For more information on biology careers, visit biologygmh.com.

Levels of Organization

The biosphere is too large and complex for most ecological studies. To study relationships within the biosphere, ecologists look at different levels of organization or smaller pieces of the biosphere. The levels increase in complexity as the numbers and interactions between organisms increase. The levels of organization are

- organism;
- population;
- biological community;
- ecosystem;
- biome;
- biosphere.

Refer to **Figure 2.6** as you read about each level.

Organisms, populations, and biological communities

The lowest level of organization is the individual organism itself. In **Figure 2.6,** the organism is represented by a single fish. Individual organisms of a single species that share the same geographic location at the same time make up a **population.** The school of fish represents a population of organisms. Individual organisms often compete for the same resources, and if resources are plentiful, the population can grow. However, usually there are factors that prevent populations from becoming extremely large. For example, when the population has grown beyond what the available resources can support, the population size begins to decline until it reaches the number of individuals that the available resources can support.

The next level of organization is the biological community. A **biological community** is a group of interacting populations that occupy the same geographic area at the same time. Organisms might or might not compete for the same resources in a biological community. The collection of plant and animal populations, including the school of fish, represents a biological community.

Ecosystems, biomes, and the biosphere The next level of organization after a biological community is an ecosystem. An **ecosystem** is a biological community and all of the abiotic factors that affect it. As you can see in **Figure 2.6,** an ecosystem might contain an even larger collection of organisms than a biological community. In addition, it contains the abiotic factors present, such as water temperature and light availability. Although **Figure 2.6** represents an ecosystem as a large area, an ecosystem also can be small, such as an aquarium or tiny puddle. The boundaries of an ecosystem are somewhat flexible and can change, and ecosystems even might overlap.

The next level of organization is called the biome and is one that you will learn more about in Chapter 3. A **biome** is a large group of ecosystems that share the same climate and have similar types of communities. The biome shown in **Figure 2.6** is a marine biome. All of the biomes on Earth combine to form the highest level of organization—the biosphere.

Reading Check **Infer** what other types of biomes might be found in the biosphere if the one shown in **Figure 2.6** is called a marine biome.

Study Tip

Question Session Study the levels of organization illustrated in **Figure 2.6** with a partner. Question each other about the topic to deepen your knowledge.

LAUNCH Lab

Review Based on what you've read about populations, how would you now answer the analysis questions?

Visualizing Levels of Organization

NATIONAL GEOGRAPHIC

Figure 2.6
In order to study relationships within the biosphere, it is divided into smaller levels of organization. The most complex level, the biosphere, is followed by biome, ecosystem, biological community, population, and organism. Organisms are further divided into organ systems, organs, tissues, cells, molecules, and finally atoms.

Biosphere The highest level of organization is the biosphere, which is the layer of Earth—from high in the atmosphere to deep in the ocean—that supports life.

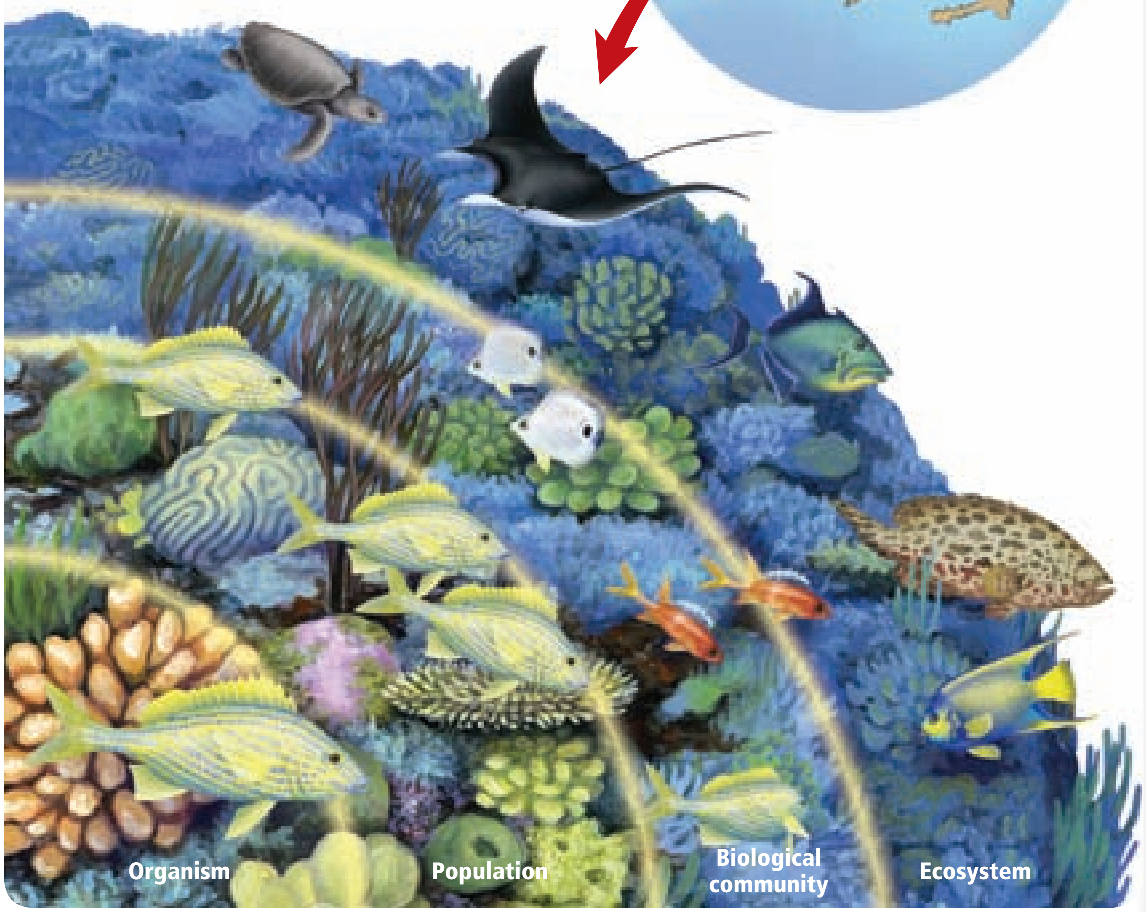
Biome A biome is formed by a group of ecosystems, such as the coral reefs off the coast of the Florida Keys, that share the same climate and have similar types of communities.

Ecosystem A biological community, such as the coral reef, and all of the abiotic factors, such as the sea water, that affect it make up an ecosystem.

Biological Community All of the populations of species—fishes, coral, and marine plants—that live in the same place at the same time make up a biological community.

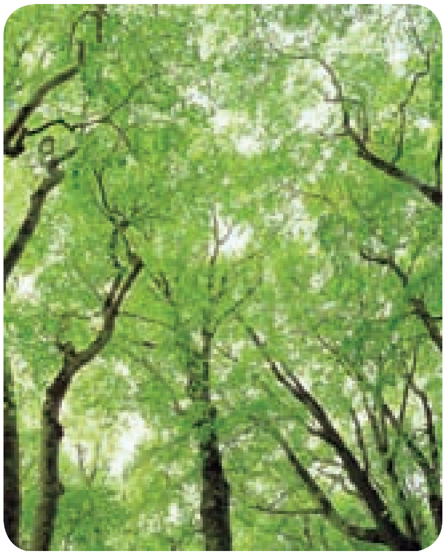
Population A group of organisms of the same species that interbreed and live in the same place at the same time, such as the school of striped fish, is a population.

Organism An individual living thing, such as one striped fish, is an organism.



Concepts in Motion **Interactive Figure** To see an animation of the levels of organization, visit biologygmh.com.

Biology Online



■ **Figure 2.7** These trees are the habitat for the community of organisms that live there.

Ecosystem Interactions

The interactions between organisms are important in an ecosystem. A community of organisms increases the chances for survival of any one species by using the available resources in different ways. If you look closely at a tree in the forest, like the one shown in **Figure 2.7,** you will find a community of different birds using the resources of the tree in different ways. For example, one bird species might eat insects on the leaves while another species of bird eats the ants found on the bark. The chance of survival for the birds increases because they are using different resources.

The trees shown in **Figure 2.7** also are habitats. A **habitat** is an area where an organism lives. A habitat might be a single tree for an organism that spends its life on one tree. If the organism moves from tree to tree, its habitat would be a grove of trees.

Organisms not only have a habitat—they have a niche as well. A **niche** (NIHCH) is the role or position that an organism has in its environment. An organism's niche is how it meets its needs for food, shelter, and reproduction. The niche might be described in terms of requirements for living space, temperature, moisture, or in terms of appropriate mating or reproduction conditions.

Reading Check **Compare and contrast** a habitat and a niche.

Community Interactions

Organisms that live together in a biological community constantly interact. These interactions, along with the abiotic factors, shape an ecosystem. Interactions include competition for basic needs such as food, shelter, and mates, as well as relationships in which organisms depend on each other for survival.

Competition Competition occurs when more than one organism uses a resource at the same time. Resources are necessary for life and might include food, water, space, and light. For example, during a drought, as shown in **Figure 2.8,** water might be scarce for many organisms. The strong organisms directly compete with the weak organisms for survival. Usually the strong survive and the weak die. Some organisms might move to another location where water is available. At times when water is plentiful, all organisms share the resources and competition is not as fierce.

Predation Many, but not all, species get their food by eating other organisms. The act of one organism consuming another organism for food is **predation** (prih DAY shun). The organism that pursues another organism is the predator, and the organism that is pursued is the prey. If you have watched a cat catch a bird or mouse, you have witnessed a predator catch its prey.

■ **Figure 2.8** During droughts, animals compete for water; when water is plentiful, organisms share this resource.

(t)CORBIS

(b)Martin Harvey/Foto Natura/Minden Pictures

Ken Lucas/Visuals Unlimited

Some insects also prey on other insects. Ladybugs and praying mantises are two examples of insects that are predators. Some insect predators also are called beneficial insects because they are used by organic gardeners for insect control. Instead of using insecticides, organic gardeners use beneficial insects to control other insect populations.

Animals are not the only organisms that are predators. The Venus flytrap, a plant native to some regions of North and South Carolina, has modified leaves that form small traps for insects and other small animals. The plant emits a sweet, sticky substance that attracts insects. When the insect lands on the leaf, the leaf trap snaps shut. Then, the plant secretes a substance that digests the insect over several days.

Symbiotic relationships Some species survive because of relationships they have developed with other species. The close relationship that exists when two or more species live together is **symbiosis** (sihm bee OH sus). There are three different kinds of symbiosis: mutualism, commensalism, and parasitism.

Mutualism The relationship between two or more organisms that live closely together and benefit from each other is **mutualism** (MYEW chuh wuh lih zum). Lichens, shown in **Figure 2.9,** display an example of a mutualistic relationship between fungi and algae. The tree merely provides a habitat for lichens, allowing it to receive ample sunlight. The algae provide food for the fungi, and the fungi provide a habitat for the algae. The close association of these two organisms provides two basic needs for the organisms—food and shelter.

Figure 2.9 Algae and fungi form lichens through a mutualistic relationship.
Explain *why lichens are an example of a mutualistic relationship.*

DATA ANALYSIS LAB 2.1

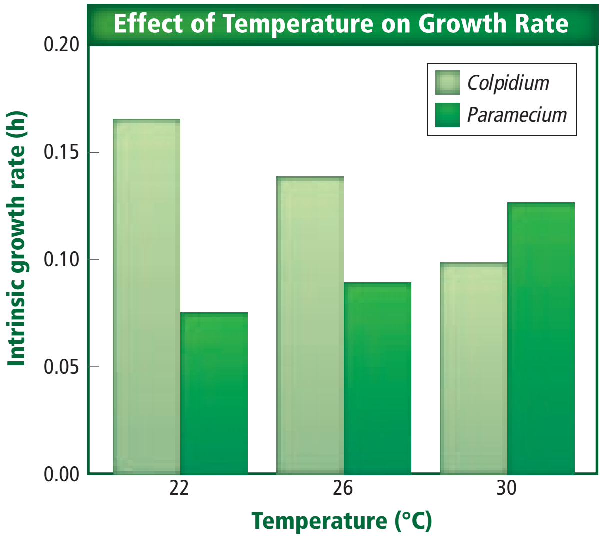
Based on Real Data*

Analyze the Data

Does temperature affect growth rates of protozoans? Researchers studied the effect of temperature on the growth rates of protozoans. They hypothesized that increasing temperature would increase the growth rate of the protozoans.

Data and Observations

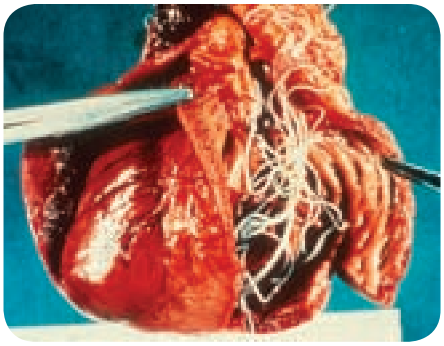
The graph shows the effect of temperature on the growth rate of *Colpidium* and *Paramecium*.



Think Critically

1. **Describe** the differences in population growth for the two species.
2. **Evaluate** What could be the next step in the researcher's investigation?

*Data obtained from: Jiang, L. and Kulczycki, A. 2004. Competition, predation, and species responses to environmental change. *Oikos* 106: 217–224.



RC Hall/Custom Medical Stock Photo

■ **Figure 2.10** This heart from a dog is infected with internal parasites called heartworms. Internal parasites depend on a host to supply their nutrients and habitat.

Commensalism Look back at **Figure 2.9.** This time, think about the relationship between the lichens and the tree. The lichens benefit from the relationship by gaining more exposure to sunlight, but they do not harm the tree. This type of relationship is commensalism. **Commensalism** (kuh MEN suh lih zum) is a relationship in which one organism benefits and the other organism is neither helped nor harmed.

The relationship between clownfish and sea anemones is another example of commensalism. Clownfish are small, tropical marine fish. Clownfish swim among the stinging tentacles of sea anemones without harm. The sea anemones protect the fish from predators while the clownfish eat bits of food missed by the sea anemones. This is a commensal relationship because the clownfish receives food and protection while the sea anemones are not harmed, nor do they benefit from this relationship.

Parasitism A symbiotic relationship in which one organism benefits at the expense of another organism is **parasitism** (PER us suh tih zum). Parasites can be external, such as ticks and fleas, or internal, such as bacteria, tapeworms, and roundworms, which are discussed in detail in Chapters 18 and 25. The heartworms in **Figure 2.10** show how destructive parasites can be. Pet dogs in many areas of the United States are treated to prevent heartworm infestation. Usually the heartworm, the parasite, does not kill the host, but it might harm or weaken it. In parasitism, if the host dies, the parasite also would die unless it quickly finds another host.

Another type of parasitism is brood parasitism. Brown-headed cowbirds demonstrate brood parasitism because they rely on other bird species to build their nests and incubate their eggs. A brown-headed cowbird lays its eggs in another bird's nest and abandons the eggs. The host bird incubates and feeds the young cowbirds. Often the baby cowbirds push the host's eggs or young from the nest, resulting in the survival of only the cowbirds. In some areas, the brown-headed cowbirds have significantly lowered the population of songbirds through this type of parasitism.

Section 2.1 Assessment

Section Summary

- Ecology is the branch of biology in which interrelationships between organisms and their environments are studied.
- Levels of organization in ecological studies include individual, population, biological community, ecosystem, biome, and biosphere.
- Abiotic and biotic factors shape an ecosystem and determine the communities that will be successful in it.
- Symbiosis is the close relationship that exists when two or more species live together.

Understand Main Ideas

1. MAIN Idea **Compare and contrast** biotic and abiotic factors.
2. **Describe** the levels of organization of an organism that lives in your biome.
3. **List** at least two populations that share your home.
4. **Differentiate** between the habitat and niche of an organism that is found in your community.

Think Scientifically

5. *Design an experiment* that determines the symbiotic relationship between a sloth, which is a slow-moving mammal, and a species of green algae that lives in the sloth's fur.
6. WRITING in **Biology** Write a short story that demonstrates the dependence of all organisms on other organisms.

Section 2.2

Objectives

- **Describe** the flow of energy through an ecosystem.
- **Identify** the ultimate energy source for photosynthetic producers.
- **Describe** food chains, food webs, and pyramid models.

Review Vocabulary

energy: the ability to cause change; energy cannot be created or destroyed, only transformed

New Vocabulary

autotroph
heterotroph
herbivore
carnivore
omnivore
detritivore
trophic level
food chain
food web
biomass

Flow of Energy in an Ecosystem

MAIN Idea Autotrophs capture energy, making it available for all members of a food web.

Real-World Reading Link When you eat a slice of pizza, you are supplying your body with energy from the Sun. You might be surprised to learn that the Sun is the original source of energy for your body. How did the Sun's energy get into the pizza?

Energy in an Ecosystem

One way to study the interactions of organisms within an ecosystem is to follow the energy that flows through an ecosystem. Organisms differ in how they obtain energy, and they are classified as autotrophs or heterotrophs based on how they obtain their energy in an ecosystem.

Autotrophs All of the green plants and other organisms that produce their own food in an ecosystem are primary producers called autotrophs. An **autotroph** (AW tuh trohf) is an organism that collects energy from sunlight or inorganic substances to produce food. As you will learn in Chapter 8, organisms that have chlorophyll absorb energy during photosynthesis and use it to convert the inorganic substances carbon dioxide and water to organic molecules. In places where sunlight is unavailable, some bacteria use hydrogen sulfide and carbon dioxide to make organic molecules to use as food. Autotrophs are the foundation of all ecosystems because they make energy available for all other organisms in an ecosystem.

Heterotrophs A **heterotroph** (HE tuh roh trohf) is an organism that gets its energy requirements by consuming other organisms. Therefore, heterotrophs also are called consumers. A heterotroph that eats only plants is an **herbivore** (HUR buh vor) such as a cow, a rabbit, or grasshopper. Heterotrophs that prey on other heterotrophs, such as wolves, lions, and lynxes, shown in **Figure 2.11,** are called **carnivores** (KAR nuh vorz).

VOCABULARY

ACADEMIC VOCABULARY

Foundation:
a basis upon which something stands or is supported.
Autotrophs provide the foundation of the food supply for other organisms.

Figure 2.11 This lynx is a heterotroph that is about to consume another heterotroph.
Identify *What is an additional classification for each of these animals?*

Jeffrey Lepore/Photo Researchers

Michael P. Gadomski/Photo Researchers

Figure 2.12 This fungus is obtaining food energy from the dead log. Fungi are decomposers that recycle materials found in dead organisms.
Explain *why decomposers are important in an ecosystem.*

In addition to herbivores and carnivores, there are organisms that eat both plants and animals, called **omnivores** (AHM nih vorz). Bears, humans, and mockingbirds are examples of omnivores.

The **detritivores** (duh TRYD uh vorz), which eat fragments of dead matter in an ecosystem, return nutrients to the soil, air, and water where the nutrients can be reused by organisms. Detritivores include worms and many aquatic insects that live on stream bottoms. They feed on small pieces of dead plants and animals. Decomposers, similar to detritivores, break down dead organisms by releasing digestive enzymes. Fungi, such as those in **Figure 2.12,** and bacteria are decomposers.

All heterotrophs, including detritivores, perform some decomposition when they consume another organism and break down its body into organic compounds. However, it is primarily the decomposers that break down organic compounds and make nutrients available to producers for reuse. Without the detritivores and decomposers, the entire biosphere would be littered with dead organisms. Their bodies would contain nutrients that would no longer be available to other organisms. The detritivores are an important part of the cycle of life because they make nutrients available for all other organisms.

Models of Energy Flow

Ecologists use food chains and food webs to model the energy flow through an ecosystem. Like any model, food chains and food webs are simplified representations of the flow of energy. Each step in a food chain or food web is called a **trophic** (TROH fihk) **level.** Autotrophs make up the first trophic level in all ecosystems. Heterotrophs make up the remaining levels. With the exception of the first trophic level, organisms at each trophic level get their energy from the trophic level before it.

MiniLab 2.1

Construct a Food Web

How is energy passed from organism to organism in an ecosystem? A food chain shows a single path for energy flow in an ecosystem. The overlapping relationships between food chains are shown in a food web.

Procedure

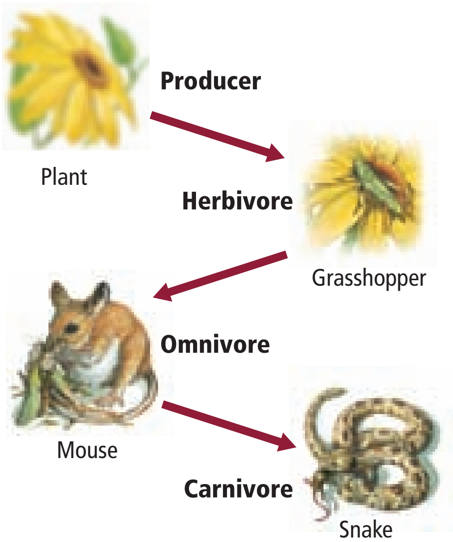
1. Read and complete the lab safety form.
2. Use the following information to construct a food web in a meadow ecosystem:
   - Red foxes feed on raccoons, crayfishes, grasshoppers, red clover, meadow voles, and gray squirrels.
   - Red clover is eaten by grasshoppers, muskrats, red foxes, and meadow voles.
   - Meadow voles, gray squirrels, and raccoons all eat parts of the white oak tree.
   - Crayfishes feed on green algae and detritus, and they are eaten by muskrats and red foxes.
   - Raccoons feed on muskrats, meadow voles, gray squirrels, and white oak trees.

Analysis

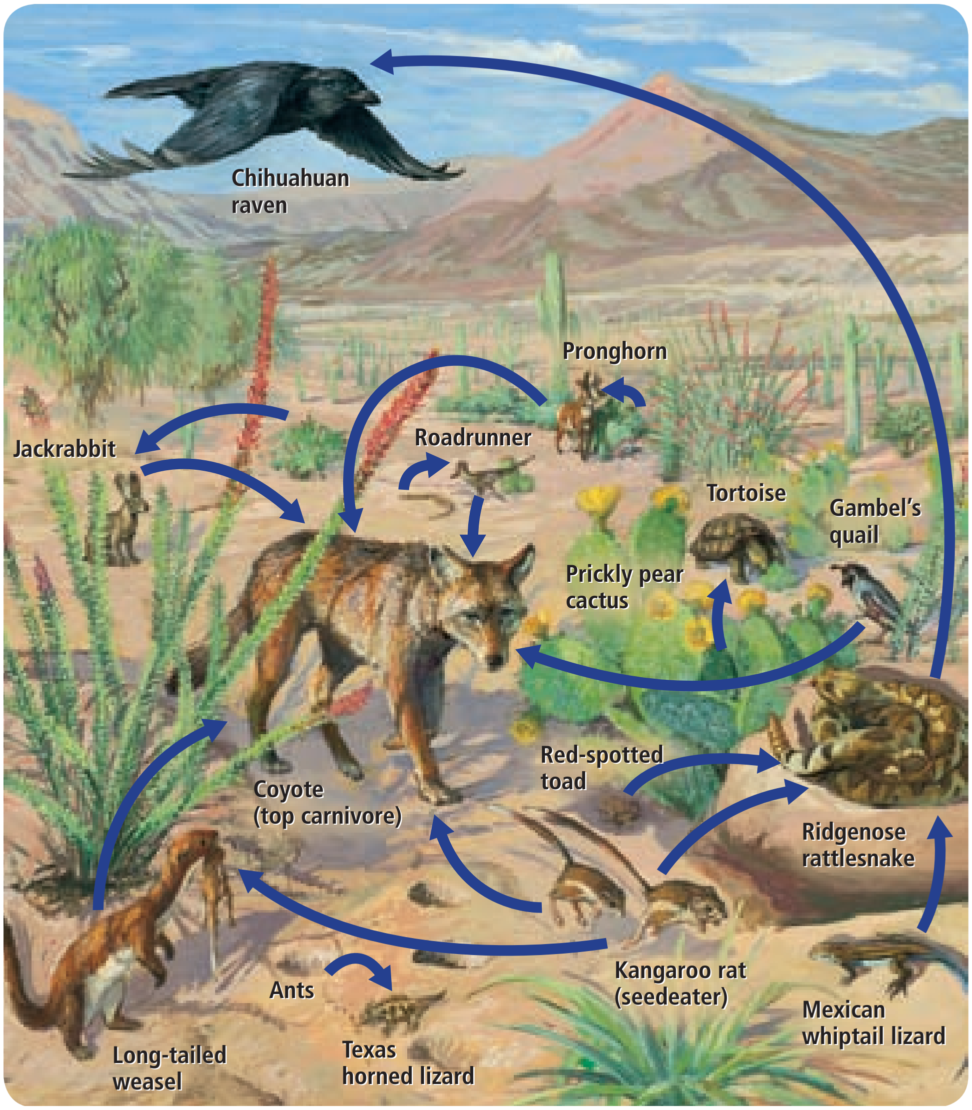
1. **Identify** all of the herbivores, carnivores, omnivores, and detritivores in the food web.
2. **Describe** how the muskrats would be affected if disease kills the white oak trees.

Food chains A **food chain** is a simple model that shows how energy flows through an ecosystem. **Figure 2.13** shows a typical grassland food chain. Arrows represent the one-way energy flow which typically starts with autotrophs and moves to heterotrophs. The flower uses energy from the Sun to make its own food. The grasshopper gets its energy from eating the flower. The mouse gets its energy from eating the grasshopper. Finally, the snake gets its energy from eating the mouse. Each organism uses a portion of the energy it obtains from the organism it eats for cellular processes to build new cells and tissues. The remaining energy is released into the surrounding environment and no longer is available to these organisms.

Food webs Feeding relationships usually are more complex than a single food chain because most organisms feed on more than one species. Birds, for instance, eat a variety of seeds, fruits, and insects. The model most often used to represent the feeding relationships in an ecosystem is a food web. A **food web** is a model representing the many interconnected food chains and pathways in which energy flows through a group of organisms. **Figure 2.14** shows a food web illustrating the feeding relationships in a desert community.



■ **Figure 2.13** A food chain is a simplified model representing the transfer of energy from organism to organism.



CLICK HERE

■ **Figure 2.14** A food web is a model of the many ways in which energy flows through organisms.

Concepts In Motion

Interactive Figure To see an animation of a food web in a desert environment, visit biologygmh.com.

Pyramid of Energy

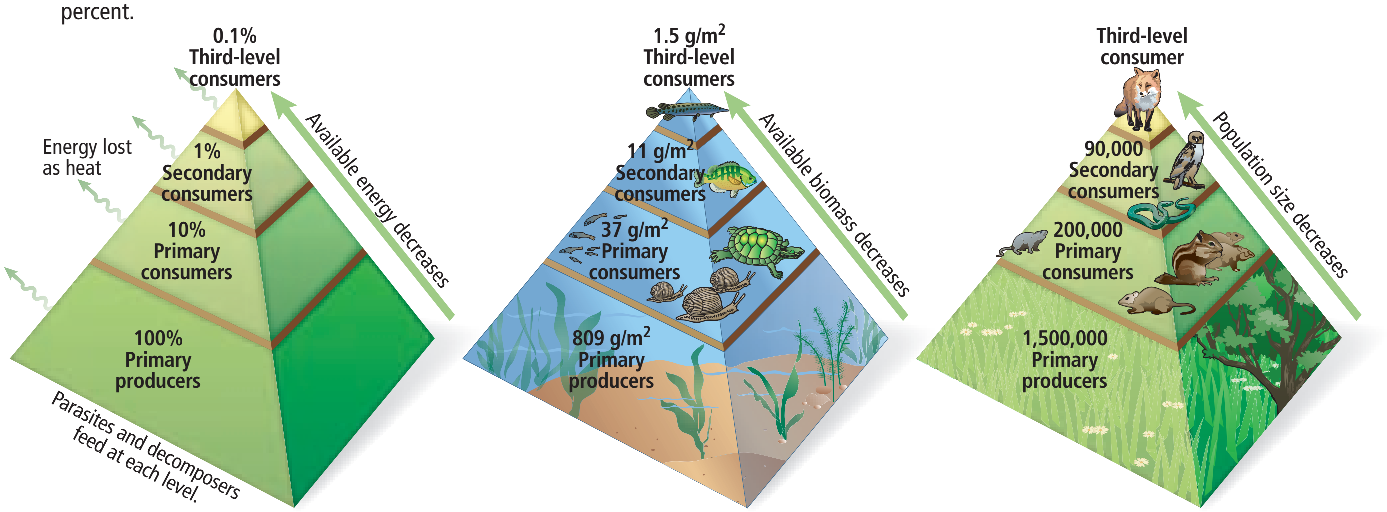
In a pyramid of energy, each level represents the amount of energy that is available to that trophic level. With each step up, there is an energy loss of 90 percent.

Pyramid of Biomass

In a pyramid of biomass, each level represents the amount of biomass consumed by the level above it.

Pyramid of Numbers

In a pyramid of numbers, each level represents the number of individual organisms consumed by the level above it.



■ **Figure 2.15** Ecological pyramids are models used to represent trophic levels in ecosystems.

Ecological pyramids Another model that ecologists use to show how energy flows through ecosystems is the ecological pyramid. An ecological pyramid is a diagram that can show the relative amounts of energy, biomass, or numbers of organisms at each trophic level in an ecosystem.

Notice in **Figure 2.15** that in a pyramid of energy, approximately 90 percent of all energy is not transferred to the level above it. This occurs because most of the energy contained in the organisms at each level is consumed by cellular processes or released to the environment as heat. Usually, the amount of **biomass**—the total mass of living matter at each trophic level—decreases at each trophic level. As shown in the pyramid of numbers, the relative number of organisms at each trophic level also decreases because there is less energy available to support organisms.

Section 2.2 Assessment

Section Summary

- Autotrophs capture energy from the Sun or use energy from certain chemical substances to make food.
- Heterotrophs include herbivores, carnivores, omnivores, and detritivores.
- A trophic level is a step in a food chain or food web.
- Food chains, food webs, and ecological pyramids are models used to show how energy moves through ecosystems.

Understand Main Ideas

1. MAIN Idea **Compare and contrast** autotrophs and heterotrophs.
2. **Describe** the flow of energy through a simple food chain that ends with a lion as the final consumer.
3. **Classify** a pet dog as an autotroph or heterotroph and as an herbivore, carnivore, or omnivore. Explain.
4. **Evaluate** the impact on living organisms if the Sun began to produce less energy and then finally burned out.

Think Scientifically

5. *Use a Model* Create a simple food web of organisms in your community.
6. MATH in **Biology** Draw an energy pyramid for a food chain made up of grass, a caterpillar, tiger beetle, lizard, snake, and a roadrunner. Assume that 100 percent of the energy is available for the grass. At each stage, show how much energy is lost and how much is available to the next trophic level.

Section 2.3

Objectives

- **Describe** how nutrients move through the biotic and abiotic parts of an ecosystem.
- **Explain** the importance of nutrients to living organisms.
- **Compare** the biogeochemical cycles of nutrients.

Review Vocabulary

cycle: a series of events that occur in a regular repeating pattern

New Vocabulary

matter
nutrient
biogeochemical cycle
nitrogen fixation
denitrification

Cycling of Matter

MAIN Idea Essential nutrients are cycled through biogeochemical processes.

Real-World Reading Link Do you recycle your empty soda cans? If so, then you know that materials such as glass, aluminum, and paper are reused. Organisms and natural processes in the environment also cycle nutrients and make them available for use by other organisms.

Cycles in the Biosphere

Energy is transformed into usable forms to support the functions of an ecosystem. A constant supply of usable energy for the biosphere is needed, but this is not true of matter. The law of conservation of mass states that matter is not created or destroyed. Therefore, natural processes cycle matter through the biosphere. **Matter**—anything that takes up space and has mass—provides the nutrients needed for organisms to function. A **nutrient** is a chemical substance that an organism must obtain from its environment to sustain life and to undergo life processes. The bodies of all organisms are built from water and nutrients such as carbon, nitrogen, and phosphorus.

Connection to Chemistry In most ecosystems, plants obtain nutrients, in the form of elements and compounds, from the air, soil, or water. Plants convert some elements and compounds into organic molecules that they use. The nutrients flow through organisms in an ecosystem such as the ecosystem shown in **Figure 2.16.** The green grass captures substances from the air, soil, and water, and then converts them into usable nutrients. The grass provides nutrients for the cow. If an organism eats the cow, the nutrients found in the cow are passed on to the next consumer. The nutrients are passed from producer—the green grass—to consumers. Decomposers return the nutrients to the cycle at every level.

The cycling of nutrients in the biosphere involves both matter in living organisms and physical processes found in the environment such as weathering. Weathering breaks down large rocks into particles that become part of the soil used by plants and other organisms. The exchange of matter through the biosphere is called the **biogeochemical cycle.** As the name suggests, these cycles involve living organisms (*bio*), geological processes (*geo*), and chemical processes (*chemical*).

Reading Check Explain why it is important to living organisms that nutrients cycle.

K. Oster/CORBIS

Figure 2.16 Nutrients are cycled through the biosphere through organisms. In this example, the grasses are the producers and begin the cycle by capturing energy from the Sun.
Explain *how nutrients continue to be cycled through the biosphere in this photo.*

VOCABULARY

WORD ORIGIN

Biogeochemical cycle
comes from the Greek word *bios* meaning *life*, *geo* meaning *earth*, and *kyklos*, meaning *circle*, along with the Latin word *chemicus*, meaning *chemical*.

CAREERS IN BIOLOGY

Hydrologist A hydrologist studies water processes, such as the distribution in nature, the water flow in a dam or river, or the water flow in a sewer or a city drinking-water system. For more information on biology careers, visit biologygmh.com.

CLICK HERE

Concepts in Motion

Interactive Figure To see an animation of the water cycle, visit biologygmh.com.

The water cycle Living organisms cannot live without water. Hydrologists study water found underground, in the atmosphere, and on the surface of Earth in the form of lakes, streams, rivers, glaciers, ice caps, and oceans. Use **Figure 2.17** to trace processes that cycle water through the biosphere.

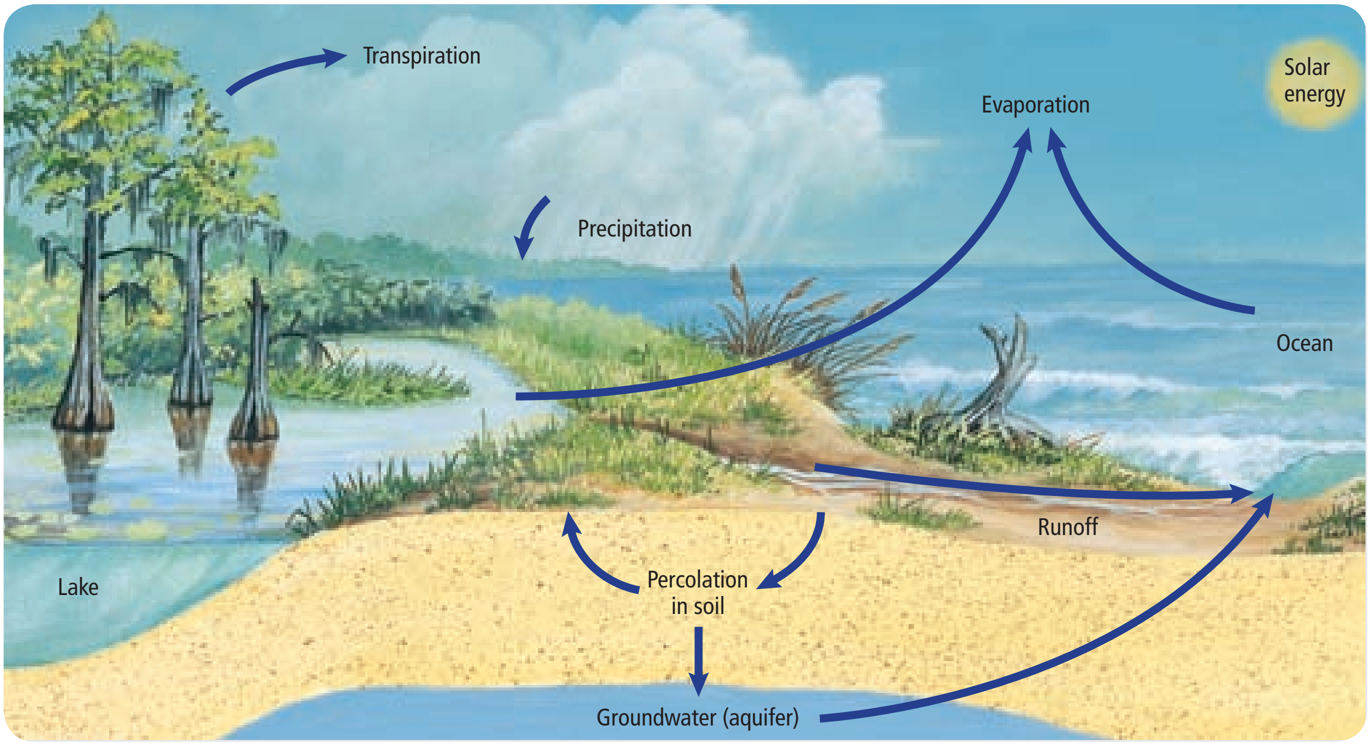
Connection to **Earth Science** Water is constantly evaporating into the atmosphere from bodies of water, soil, and organisms. Water in the atmosphere is called water vapor. Water vapor rises and begins to cool in the atmosphere. Clouds form when the cooling water vapor condenses into droplets around dust particles in the atmosphere. Water falls from clouds as precipitation in the form of rain, sleet, or hail, transferring water to the Earth's surface. As you can see in **Figure 2.17,** groundwater and runoff from land surfaces flow into streams, rivers, lakes, and oceans, only to evaporate into the atmosphere to continue the water cycle. Approximately 90 percent of water vapor evaporates from oceans, lakes, and rivers; about 10 percent evaporates from the surface of plants through a process called transpiration. You will learn more about transpiration in Chapter 22.

All living organisms rely on freshwater. Freshwater constitutes only about 3 percent of all water on Earth. Water available for living organisms is about 31 percent of all freshwater. About 69 percent of all freshwater is found in ice caps and glaciers, which then is unavailable for use by living organisms. Even ocean-dwelling organisms rely on freshwater flowing to oceans to prevent high saline content and maintain ocean volume.

Reading Check **Identify** three processes in the water cycle.

Figure 2.17 The water cycle is the natural process by which water is continuously cycled through the biosphere.

Infer *What are the largest reservoirs of water on Earth?*



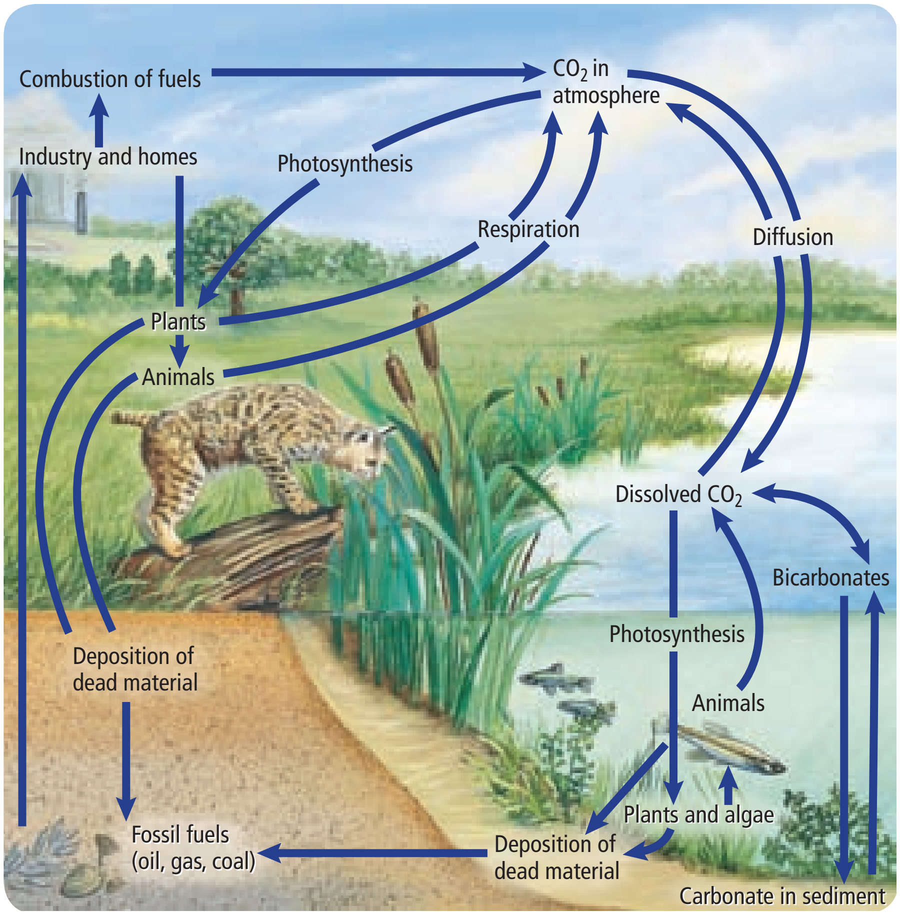


Figure 2.18 The diagram shows how carbon and oxygen cycle through the environment.
Describe ***How does carbon move from the abiotic to the biotic parts of the ecosystem?***

Concepts in Motion
Interactive Figure To see an animation of the carbon cycle, visit biologygmh.com.

CLICK HERE

The carbon and oxygen cycles As you will learn in Chapter 6, all living things are composed of molecules that contain carbon. Atoms of carbon form the framework for important molecules such as proteins, carbohydrates, and fats. Oxygen is another element that is important to many life processes. Carbon and oxygen often make up molecules essential for life, including carbon dioxide and simple sugar.

Look at the cycles illustrated in **Figure 2.18.** During a process called photosynthesis, discussed in Chapter 8, green plants and algae convert carbon dioxide and water into carbohydrates and release oxygen back into the air. These carbohydrates are used as a source of energy for all organisms in the food web. Carbon dioxide is recycled when autotrophs and heterotrophs release it back into the air during cellular respiration. Carbon and oxygen recycle relatively quickly through living organisms.

Carbon enters a long-term cycle when organic matter is buried underground and converted to peat, coal, oil, or gas deposits. The carbon might remain as fossil fuel for millions of years. Carbon is released from fossil fuels when they are burned, which adds carbon dioxide to the atmosphere.

In addition to the removal of carbon from the short-term cycle by fossil fuels, carbon and oxygen can enter a long-term cycle in the form of calcium carbonate, as shown in **Figure 2.19.** Calcium carbonate is found in the shells of plankton and animals such as coral, clams, and oysters. These organisms, such as algae, fall to the bottom of the ocean floor, creating vast deposits of limestone rock. Carbon and oxygen remain trapped in these deposits until weathering and erosion release these elements to become part of the short-term cycle.

FOLDABLES Incorporate information from this section into your Foldable.

Figure 2.19 The white cliffs in Dover, England are composed almost entirely of calcium carbonate, or chalk. The calcium and oxygen found in these cliffs are in the long-term part of the cycle for calcium and oxygen.

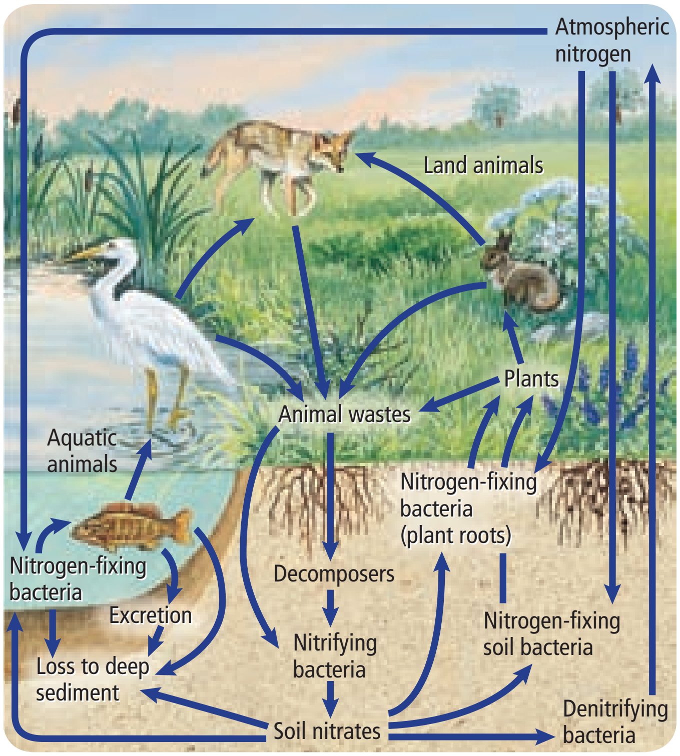


Figure 2.20 Nitrogen is used and reused as it is cycled continuously through the biosphere.

Concepts in Motion

Interactive Figure To see an animation of the nitrogen cycle, visit biologygmh.com.

CLICK HERE

The nitrogen cycle Nitrogen is an element found in proteins. The largest concentration of nitrogen is found in the atmosphere. Plants and animals cannot use nitrogen directly from the atmosphere. Nitrogen gas is captured from the air by species of bacteria that live in water, the soil, or grow on the roots of some plants. The process of capture and conversion of nitrogen into a form that is useable by plants is called **nitrogen fixation.** Some nitrogen also is fixed during electrical storms when the energy from lightning bolts changes nitrogen gas to nitrates. Nitrogen also is added to soil when chemical fertilizers are applied to lawns, crops, or other areas.

Nitrogen enters the food web when plants absorb nitrogen compounds from the soil and convert them into proteins, as illustrated in **Figure 2.20.** Consumers get nitrogen by eating plants or animals that contain nitrogen. They reuse the nitrogen and make their own proteins. Because the supply of nitrogen in a food web is dependent on the amount of nitrogen that is fixed, nitrogen often is a factor that limits the growth of producers.

Nitrogen is returned to the soil in several ways, also shown in **Figure 2.20.** When an animal urinates, nitrogen returns to the water or soil and is reused by plants. When organisms die, decomposers transform the nitrogen in proteins and other compounds into ammonia. Organisms in the soil convert ammonia into nitrogen compounds that can be used by plants. Finally, in a process called **denitrification,** some soil bacteria convert fixed nitrogen compounds back into nitrogen gas, which returns it to the atmosphere.

MiniLab 2.2

Test for Nitrates

How much nitrate is found in various water sources? One ion containing nitrogen found in water can be easily tested—nitrate. Nitrate is a common form of inorganic nitrogen that is used easily by plants.

Procedure

1. Read and complete the lab safety form.
2. Prepare a data table to record your observations.
3. Obtain the **water samples** from different sources that are provided by your teacher.
4. Using a **nitrate test kit,** test the amount of nitrate in each water sample.
5. Dispose of your samples as directed by your teacher.

Analysis

1. **Determine** Did the samples contain differing amounts of nitrate? Explain.
2. **Identify** What types of human activities might increase the amount of nitrate in the water?
3. **Infer** What problems could a high nitrate level cause considering that nitrates also increase the growth rate of algae in waterways?

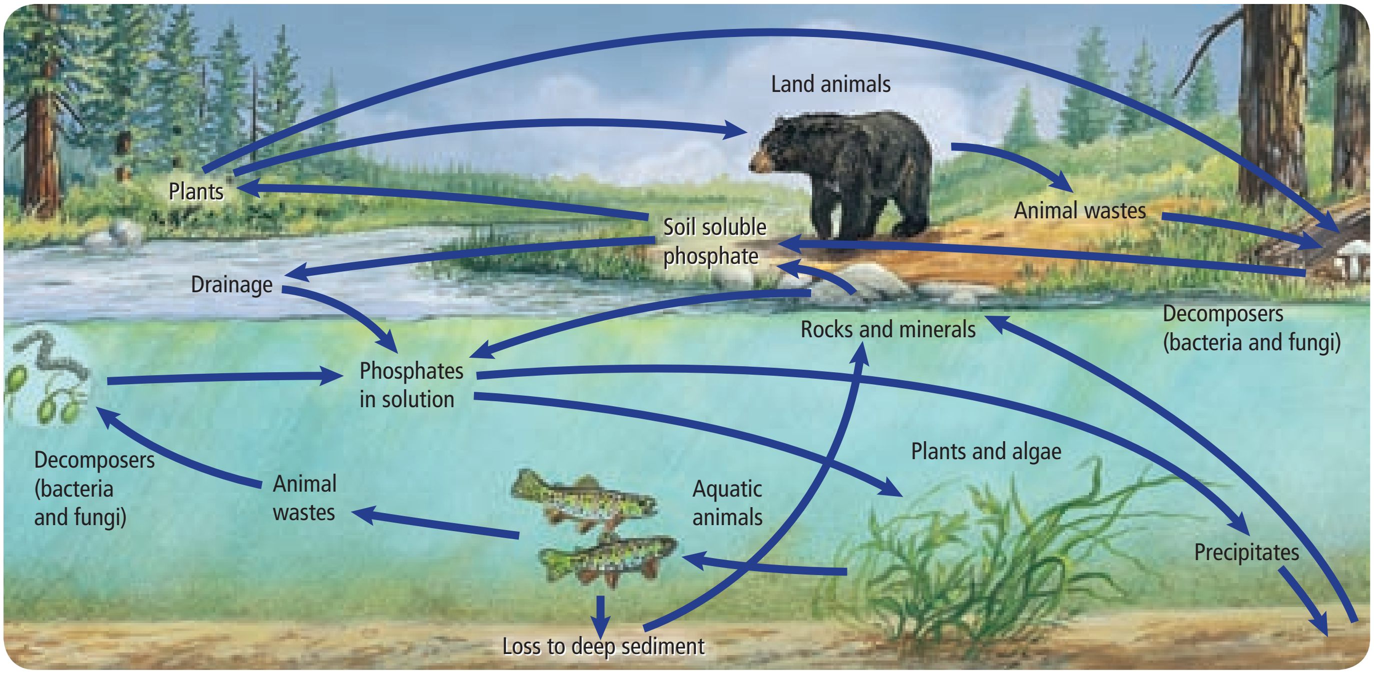


Figure 2.21 The phosphorus cycle has a short-term cycle and a long-term cycle.

Interactive Figure To see an animation of the phosphorus cycle, visit biologygmh.com.

CLICK HERE

The phosphorus cycle Phosphorus is an element that is essential for the growth and development of organisms. **Figure 2.21** illustrates the two cycles of phosphorus—a short-term and long-term cycle. In the short-term cycle, phosphorus as phosphates in solution, is cycled from the soil to producers and then from the producers to consumers. When organisms die or produce waste products, decomposers return the phosphorus to the soil where it can be used again. Phosphorus moves from the short-term cycle to the long-term cycle through precipitation and sedimentation to form rocks. In the long-term cycle, weathering or erosion of rocks that contain phosphorus slowly adds phosphorus to the cycle. Phosphorus, in the form of phosphates, may be present only in small amounts in soil and water. Therefore, phosphorus often is a factor that limits the growth of producers.

Section 2.3 Assessment

Section Summary

- Biogeochemical cycles include the exchange of important elements between the abiotic and biotic parts of an ecosystem.
- The carbon and oxygen cycles are closely intertwined.
- Nitrogen gas is limited in its ability to enter biotic portions of the environment.
- Phosphorus and carbon have short-term and long-term cycles.

Understand Main Ideas

1. MAIN Idea **List** four important biogeochemical processes that cycle nutrients.
2. **Compare and contrast** two of the cycles of matter.
3. **Explain** the importance of nutrients to an organism of your choice.
4. **Describe** how phosphorus moves through the biotic and abiotic parts of an ecosystem.

Think Scientifically

5. ***Design an Experiment*** Suppose a particular fertilizer contains nitrogen, phosphorus, and potassium. The numbers on the fertilizer's label represent the amounts of each element in the fertilizer. Design an experiment to test how much fertilizer should be added to a lawn for the best results.

Self-Check Quiz biologygmh.com

Biology & Society

To Dam or Not to Dam

The Glen Canyon area is a popular location for white-water rafting, fishing, hiking, and kayaking. The Glen Canyon area also is the location of a controversial dam, the Glen Canyon Dam. It was built between 1956 and 1963 in Arizona on the Colorado River. The dam holds and releases water from Lake Powell.

Economic benefits The Glen Canyon Dam provides electricity to many rural communities. It also provides water to California, New Mexico, Arizona, and Nevada. Lake Powell, which is one of the most visited tourist destinations of the southwest, provides jobs for many of the local residents. Millions of tourists visit Lake Powell each year for activities such as hiking, boating, fishing, and swimming.

The Glen Canyon Dam provides opportunities for recreation to millions of tourists every year. However, it also impacts the Colorado River ecosystem.

Impact on flora and fauna The construction of the dam has brought economic benefits to the area, but it also has negatively impacted the Colorado River ecosystem. The habitat of native fish has changed as a result of the dam. Three species of fish—the roundtail chub, the bonytail chub, and the Colorado squawfish—have become extinct.

The Lake Powell shoreline now is dominated by a non-native, semidesert scrub known as saltcedar or tamarisk. The saltcedar outcompetes native vegetation such as the sandbar willow, Gooding's willow, and fremont cottonwood. Saltcedar collects salt in its tissues over time. This salt eventually is released into the soil, making it unsuitable for many native plants.

Impact on temperature Before the dam was built, the water temperature of the Colorado River ranged from near freezing in the winter to a warm 29°C in the summer. Since the dam was built, the temperature of the water released downstream remains steady at 7–10°C. This temperature is fine for the nonnative trout that are bred for recreational activities; however, the native species do not fare as well.

The Bureau of Reclamation has proposed placing a temperature control device on the Glen Canyon Dam that would regulate the water temperature. Environmentalists suggest that this solution might not solve the problems for the native species because the native species need the fluctuating temperatures that were once part of the river system.

The Glen Canyon Dam has negatively impacted the ecosystem of the Colorado River area, but it has benefited the area economically. How do the costs weigh against the benefits? Biologists face real-world issues like these every day.

DEBATE in Biology

Collaborate Form a team to debate whether the recreational and economic opportunities outweigh the costs of damming the Colorado River. Conduct additional research at biologygmh.com prior to the debate.

CONTENTS

BIOLAB

Design Your Own

FIELD INVESTIGATION: EXPLORE HABITAT SIZE AND SPECIES DIVERSITY

Background: Ecologists know that a major key to maintaining not only individual species but also a robust diversity of species is preserving the proper habitat for those species.

Question: *What effect does increasing the size of a habitat have on the species diversity within that habitat?*

Materials

Choose materials that would be appropriate for the experiment you plan.

Safety Precautions

WARNING: ***Follow all safety rules regarding travel to and from the study site. Be alert on site and avoid contact, if possible, with stinging or biting animals and poisonous plants.***

Plan and Perform the Experiment

1. Read and complete the lab safety form.
2. Form a hypothesis that you can test to answer the above question.
3. Record your procedure and list the materials you will use to test your hypothesis.
4. Make sure your experiment allows for the collection of quantitative data, which is data that can be expressed in units of measure.
5. Design and construct appropriate data tables.
6. Make sure your teacher approves your plan before you proceed.
7. Carry out the procedure at an appropriate field site.

Analyze and Conclude

1. **Graph Data** Prepare a graph of your data and the combined class data if it is available.
2. **Analyze** Do any patterns emerge as you analyze your group and/or class data and graphs? Explain.

3. **Conclude** Based on your data, was your initial hypothesis correct?
4. **Error Analysis** Compare your observations and conclusions with your classmates. Did your observations and conclusions match? If not, what could explain the differences? How could you verify your results?
5. Did the populations and diversity change proportionally as the habitat was expanded? As the habitat expanded, did it become more or less suitable for supporting life?
6. **Think Critically** Would you expect the same results if you were to perform this experiment in other types of habitats? Explain.
7. **Think Critically** Would you expect the same results 10 years from now? 20 years from now? Explain your answer.

APPLY YOUR SKILL

Presentation Diagram and explain at least one food chain that might exist in the habitat you explored in this lab. To learn more about habitat size and species diversity, visit BioLabs at biologygmh.com.

David Young-Wolff/Photo Edit

CHAPTER 2

Study Guide

STUDY TO GO Download quizzes, key terms, and flash cards from biologygmh.com.

FOLDABLES **Summarize** the law of conservation of matter, and explain how it applies to the physical and chemical changes that take place in substances during natural cycles.

Vocabulary	Key Concepts
Section 2.1 Organisms and Their Relationships	
• abiotic factor (p. 35) • biological community (p. 36) • biome (p. 36) • biosphere (p. 34) • biotic factor (p. 35) • commensalism (p. 40) • ecology (p. 32) • ecosystem (p. 36) • habitat (p. 38) • mutualism (p. 39) • niche (p. 38) • parasitism (p. 40) • population (p. 36) • predation (p. 38) • symbiosis (p. 39)	MAIN Idea Biotic and abiotic factors interact in complex ways in communities and ecosystems. • Ecology is the branch of biology in which interrelationships between organisms and their environments are studied. • Levels of organization in ecological studies include individual, population, biological community, ecosystem, biome, and biosphere. • Abiotic and biotic factors shape an ecosystem and determine the communities that will be successful in it. • Symbiosis is the close relationship that exists when two or more species live together.
Section 2.2 Flow of Energy in an Ecosystem	
• autotroph (p. 41) • biomass (p. 44) • carnivore (p. 41) • detritivore (p. 42) • food chain (p. 43) • food web (p. 43) • herbivore (p. 41) • heterotroph (p. 41) • omnivore (p. 42) • trophic level (p. 42)	MAIN Idea Autotrophs capture energy, making it available for all members of a food web. • Autotrophs capture energy from the Sun or use energy from certain chemical substances to make food. • Heterotrophs include herbivores, carnivores, omnivores, and detritivores. • A trophic level is a step in a food chain or food web. • Food chains, food webs, and ecological pyramids are models used to show how energy moves through ecosystems.
Section 2.3 Cycling of Matter	
• biogeochemical cycle (p. 45) • denitrification (p. 48) • matter (p. 45) • nitrogen fixation (p. 48) • nutrient (p. 45)	MAIN Idea Essential nutrients are cycled through biogeochemical processes. • Biogeochemical cycles include the exchange of important elements between the abiotic and biotic parts of an ecosystem. • The carbon and oxygen cycles are closely intertwined. • Nitrogen gas is limited in its ability to enter biotic portions of the environment. • Phosphorus and carbon have short-term and long-term cycles.

Biology Online Vocabulary PuzzleMaker biologygmh.com

CHAPTER 2 Assessment

Section 2.1

Vocabulary Review

Replace each underlined word with the correct vocabulary term from the Study Guide page.

1. A <u>niche</u> is the place in which an organism lives.
2. The presence of interbreeding individuals in one place at a given time is called a <u>biological community</u>.
3. A group of biological communities that interact with the physical environment is <u>the biosphere</u>.

Understand Key Concepts

4. Which of these levels of organization includes all the other levels?
   A. community **C.** individual
   B. ecosystem **D.** population
5. Which would be an abiotic factor for a tree in the forest?
   A. a caterpillar eating its leaves
   B. wind blowing through its branches
   C. a bird nesting in its branches
   D. fungus growing on its roots

Use the photo below to answer questions 6 and 7.

6. The insect in the photo above is gathering pollen and nectar for food, but at the same time is aiding in the plant's reproduction. What does this relationship demonstrate?
   A. predation **C.** mutualism
   B. commensalism **D.** parasitism
7. What term best describes the bee's role of gathering pollen?
   A. niche **C.** parasite
   B. predator **D.** habitat

Use the illustration below to answer question 8.

8. Which type of heterotroph best describes this snake?
   A. herbivore **C.** omnivore
   B. carnivore **D.** detritivore

Constructed Response

9. **Short Answer** Explain the difference between a habitat and niche.
10. **Open Ended** Describe two abiotic factors that affect your environment.
11. **CAREERS IN BIOLOGY** Summarize why most ecologists do not study the biosphere level of organization.

Think Critically

12. **Identify** an example of a predator-prey relationship, a competitive relationship, and a symbiotic relationship in an ecosystem near where you live.
13. **Explain** why it is advantageous for organisms such as fungi and algae to form mutualistic relationships.

Section 2.2

Vocabulary Review

Explain how the terms in each set below are related.

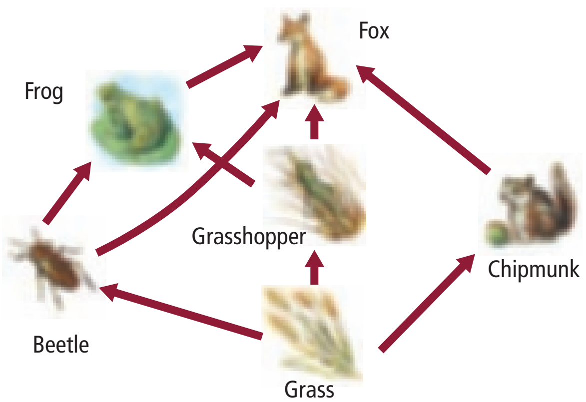
14. heterotroph, omnivore, carnivore
15. food chain, food web, trophic level
16. decomposer, heterotroph, carnivore
17. autotroph, food chain, heterotroph

Understand Key Concepts

18. How does energy first enter a pond ecosystem?
- **A.** through growth of algae
- **B.** through light from the Sun
- **C.** through decay of dead fish
- **D.** through runoff from fields

19. Which statement is true about energy in an ecosystem?
- **A.** Energy for most ecosystems originates from the Sun.
- **B.** Energy most often is released as light from an ecosystem.
- **C.** Energy flows from heterotrophs to autotrophs.
- **D.** Energy levels increase toward the top of the food chain.

Use the illustration below to answer questions 20 and 21.



20. What does the illustration represent?
- **A.** a food web
- **B.** a food chain
- **C.** an ecological pyramid
- **D.** a pyramid of energy

21. Which organism in the illustration is an autotroph?
- **A.** frog
- **B.** grasshopper
- **C.** fox
- **D.** grass

22. Which is a detritivore?
- **A.** cat
- **B.** mouse
- **C.** sunflower
- **D.** crayfish

Constructed Response

23. Open Ended Illustrate a three-step food chain that might occur in your community. Use specific organisms.

24. Short Answer Describe why food webs usually are better models for explaining energy flow than food chains.

25. Short Answer Determine approximately how much total energy is lost from a three-step food chain if 1000 calories enter at the autotroph level.

Think Critically

26. Apply Information Create a poster of a food web that might exist in an ecosystem that differs from your community. Include as many organisms as possible in the food web.

Section 2.3

Vocabulary Review

Each of the following sentences is false. Make each sentence true by replacing the italicized word with a vocabulary term from the Study Guide page.

27. Because nitrogen is required for growth, it is considered an essential *nitrate.*

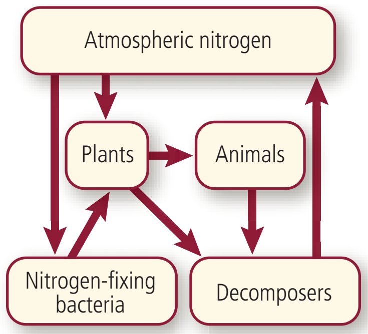
28. Converting nitrogen from a gas to a useable form by bacteria is *denitrification.*

29. The movement of chemicals on a global scale from abiotic through biotic parts of the environment is a *lithospheric process.*

Understand Key Concepts

30. What is the name of the process in which bacteria and lightning convert nitrogen into compounds that are useful to plants?
- **A.** ammonification
- **B.** denitrification
- **C.** nitrate cycling
- **D.** nitrogen fixation

Use the following diagram to answer question 31.



31. Where is the largest concentration of nitrogen found?
- **A.** animals
- **B.** atmosphere
- **C.** bacteria
- **D.** plants

32. What are the two major life processes that involve carbon and oxygen?
- **A.** coal formation and photosynthesis
- **B.** photosynthesis and respiration
- **C.** fuel combustion and open burning
- **D.** death and decay

33. Which process locks phosphorus in a long-term cycle?
- **A.** organic materials buried at the bottom of oceans
- **B.** phosphates released into the soil
- **C.** animals and plants eliminating wastes
- **D.** rain eroding mountains

Constructed Response

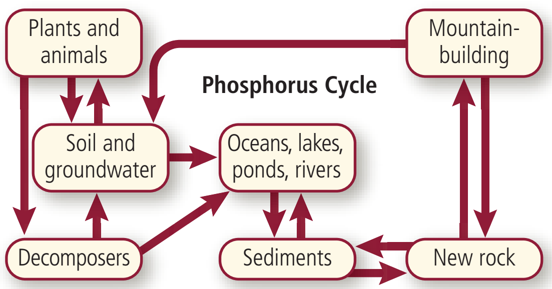
34. Short Answer Clarify what is meant by the following statement: Grass is just as important as mice in the diet of a carnivore such as a fox.

35. Short Answer The law of conservation of matter states that matter cannot be created or destroyed. How does this law relate to the cycling of carbon in an ecosystem?

36. Short Answer Explain the role of decomposers in the nitrogen cycle.

Think Critically

Use the illustration below to answer question 37 and 38.



37. Interpret Scientific Illustrations Predict the effect of additional mountain building in the Rocky Mountains on the levels of phosphorus in the surrounding valleys.

38. Explain how decomposers supply phosphorus to soil, groundwater, oceans, lakes, ponds, and rivers.

Additional Assessment

39. WRITING in Biology Write a poem that includes vocabulary terms and concepts from the chapter.

DBQ Document-Based Questions

The following information pertains to an ancient sand dune in Florida that is now landlocked—Lake Wales Ridge. Read the passage and answer the following questions.

Data obtained from: Mohlenbrock, R. H. 2004–2005. Florida high. *Natural History* 113: 46–47.

The federally listed animals that live on the ridge are the blue-tailed mole skink, the Florida scrub jay, and the sand skink (which seems to "swim" through loose sand of the scrub). Other animals on the ridge are the eastern indigo snake (which can grow to more than eight feet long, making it the longest nonvenomous snake species in North America), the Florida black bear, the Florida gopher frog, the Florida mouse, the Florida pine snake, the Florida sandhill crane, the Florida scrub lizard, the gopher tortoise, Sherman's fox squirrel, and the short-tailed snake.

The gopher tortoise is particularly important because its burrows, sometimes as long as thirty feet, serve as homes for several of the rare species as well as many other more common organisms. The burrows also provide temporary havens when fires sweep through the area, or when temperatures reach high or low extremes.

40. Construct a simple food web using at least five of the organisms listed.

41. Explain how the burrows are used during fires and why they are effective.

Cumulative Review

42. Distinguish between science and pseudoscience. **(Chapter 1)**

43. Describe conditions under which a controlled experiment occurs. **(Chapter 1)**

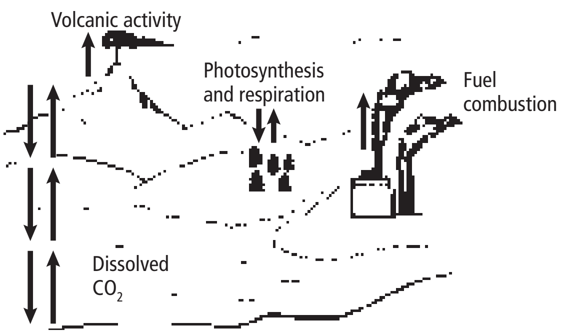
Standardized Test Practice

Cumulative

Multiple Choice

1. Which would be considered an ecosystem?
   - **A.** bacteria living in a deep ocean vent
   - **B.** biotic factors in a forest
   - **C.** living and nonliving things in a pond
   - **D.** populations of zebras and lions

Use the illustration below to answer questions 2 and 3.



2. Which part of the diagram above relates to carbon leaving a long-term cycle?
   - **A.** Dissolved CO_2
   - **B.** Fuel combustion
   - **C.** Photosynthesis and respiration
   - **D.** Volcanic activity

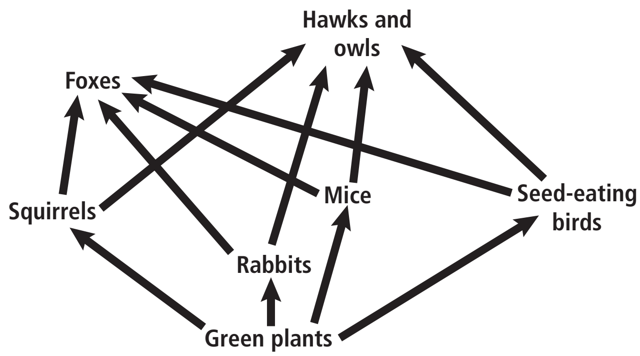
3. Which part of the diagram above relates to carbon moving from an abiotic to a biotic part of the ecosystem?
   - **A.** Dissolved CO_2
   - **B.** Fuel combustion
   - **C.** Photosynthesis and respiration
   - **D.** Volcanic activity

4. Which is a scientific explanation of a natural phenomenon supported by many observations and experiments?
   - **A.** factor
   - **B.** hypothesis
   - **C.** result
   - **D.** theory

5. The mole is the SI unit for which quantity?
   - **A.** number of particles in a substance
   - **B.** compounds that make up a substance
   - **C.** number of elements in a substance
   - **D.** total mass of a substance

6. Suppose two leaf-eating species of animals live in a habitat where there is a severe drought, and many plants die as a result of the drought. Which term describes the kind of relationship the two species probably will have?
   - **A.** commensalism
   - **B.** competition
   - **C.** mutualism
   - **D.** predation

Use the illustration below to answer questions 7–9.



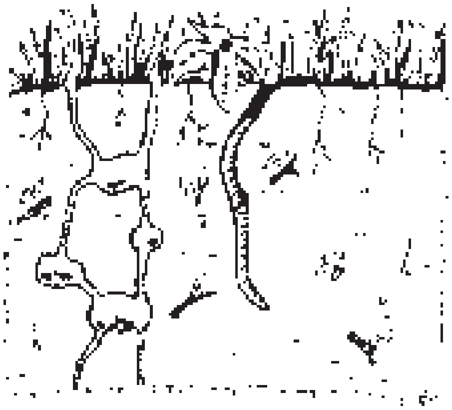
7. Which part of the food web above contains the greatest biomass?
   - **A.** foxes
   - **B.** green plants
   - **C.** mice
   - **D.** rabbits

8. Which part of the food web above contains the least biomass?
   - **A.** foxes
   - **B.** green plants
   - **C.** mice
   - **D.** rabbits

9. What happens to the energy that the fox uses for maintaining its body temperature?
   - **A.** It is taken up by decomposers that consume the fox.
   - **B.** It moves into the surrounding environment.
   - **C.** It stays in the fox through the metabolism of food.
   - **D.** It travels to the next trophic level when the fox is eaten.

Short Answer

Use the illustration below to answer questions 10 and 11.



10. What are two biotic factors and two abiotic factors that affect a worm found in a situation similar to what is shown in the diagram?

11. Explain the portions of the following biogeochemical cycles that are related to the diagram above.
A. Nitrogen cycle
B. Oxygen cycle
C. Carbon cycle

12. Distinguish between the everyday use of the term *theory* and its true scientific meaning.

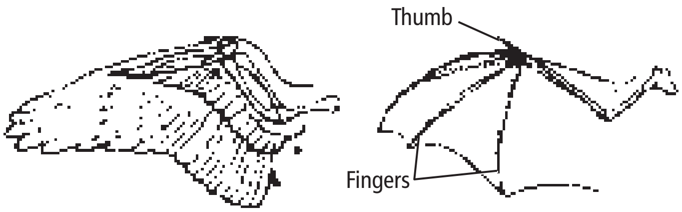
13. Evaluate how scientific knowledge changes and how the amount of scientific knowledge grows. Suggest a reason why it probably will continue to grow.

14. Describe how a forest ecosystem might be different without the presence of decomposers and detritivores.

15. Suppose that some unknown organisms are discovered in the deep underground of Earth. Give two examples of questions that biologists might try to answer by researching these organisms.

Extended Response

Use this drawing to answer questions 16 and 17.



16. Someone tells you that bats and birds are closely related because they both have wings. Evaluate how this diagram could be used to critique the idea that bats and birds are not closely related.

17. Suppose you form a hypothesis that bats and birds are not closely related and you want to confirm this by comparing the way bats and birds fly. Design an experiment to test this hypothesis.

Essay Question

Various substances or elements on Earth move through long-term and short-term biogeochemical cycles as they become part of different aspects of the biosphere. The amount of a substance that is involved in a long-term cycle has an effect on the availability of that substance for use by humans and other organisms on Earth.

Using the information in the paragraph above, answer the following question in essay format.

18. Choose a substance or element that you know is involved in both long-term and short-term biogeochemical cycles. In a well-organized essay, describe how it moves through both types of cycles, and how these cycles affect its availability to humans and other organisms.

NEED EXTRA HELP?																		
If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Review Section . . .	2.2	2.3	2.3, 2.1	1.2	1.2	2.1	2.2	2.2	2.2	2.1	2.3	1.2	1.2	2.2	1.3	1.2	1.3	2.1