Chapter 22

Ecosystems and Biomes

The BIG Idea

Cycles of Matter and Energy

How do matter and energy flow through ecosystems?

Chapter Preview

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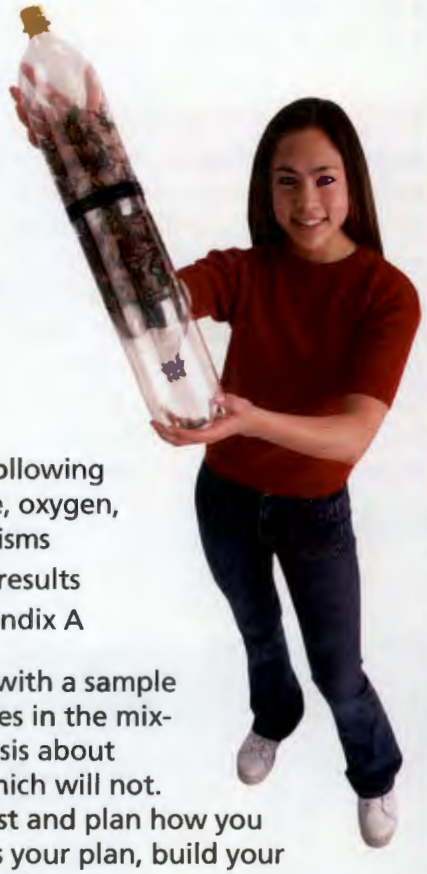
This macaque adds to the rich diversity of organisms in the tropical rain forest. ▶

Lab zone™ Chapter **Project**

Breaking It Down

Nothing in an ecosystem is wasted. Even when living things die, organisms such as mushrooms recycle them. This natural process of breakdown is called decomposition. When fallen leaves and other waste products decompose, a fluffy, brown mixture called compost is formed. You can observe decomposition firsthand in this chapter project by building a compost chamber.



Your Goal To design and conduct an experiment to learn more about the process of decomposition

To complete this project, you must

- build two compost chambers
- investigate the effect of one of the following variables on decomposition: moisture, oxygen, temperature, or activity of soil organisms
- analyze your data and present your results
- follow the safety guidelines in Appendix A

Plan It! Your teacher will provide you with a sample of compost material. Observe the wastes in the mixture with a hand lens. Write a hypothesis about which kinds of waste will decay and which will not. Next, decide which variable you will test and plan how you will test it. Once your teacher approves your plan, build your compost chambers and begin your experiment.

Section 1

Energy Flow in Ecosystems

Reading Preview

Key Concepts

- What energy roles do organisms play in an ecosystem?
- How does energy move through an ecosystem?
- How much energy is available at each level of an energy pyramid?

Key Terms

- producer • consumer
- herbivore • carnivore
- omnivore • scavenger
- decomposer • food chain
- food web • energy pyramid

Target Reading Skill

Building Vocabulary A definition states the meaning of a word or phrase by telling about its most important feature or function. After you read the section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a definition of each Key Term in your own words.

Lab zone **Discover Activity**

Where Did Your Dinner Come From?

1. Across the top of a sheet of paper, list the different types of foods you ate for dinner last night.
2. Under each item, write the name of the plant, animal, or other organism that was the source of that food. Some foods have more than one source. For example, macaroni and cheese contains flour (which is made from a plant such as wheat) and cheese (which comes from an animal).

Think It Over

Classifying How many of your food sources were plants? How many were animals?

Do you play an instrument in your school band? If so, you know that each instrument has a role in a piece of music. For instance, the flute may provide the melody while the drum provides the beat.

Just like the instruments in a band, each organism has a role in the movement of energy through its ecosystem. A bluebird's role, for example, is different from that of the giant oak tree where it is perched. But all parts of the ecosystem, like all parts of a band, are necessary for the ecosystem to work.

Energy Roles

An organism's energy role is determined by how it obtains energy and how it interacts with other organisms. **Each of the organisms in an ecosystem fills the energy role of producer, consumer, or decomposer.**

Producers Energy enters most ecosystems as sunlight. Some organisms, such as plants, algae, and some bacteria, capture the energy of sunlight and store it as food energy. These organisms use the sun's energy to turn water and carbon dioxide into food molecules in a process called photosynthesis.

An organism that can make its own food is a **producer.** Producers are the source of all the food in an ecosystem. In a few ecosystems, producers obtain energy from a source other than sunlight. One such ecosystem is found in rocks deep beneath the ground. How is energy brought into this ecosystem? Certain bacteria in this ecosystem produce their own food using the energy in a gas, hydrogen sulfide, that is found in their environment.

Consumers Some members of an ecosystem cannot make their own food. An organism that obtains energy by feeding on other organisms is a **consumer.**

Consumers are classified by what they eat. Consumers that eat only plants are **herbivores.** Familiar herbivores are caterpillars and deer. Consumers that eat only animals are **carnivores.** Lions and spiders are some examples of carnivores. Consumers that eat both plants and animals are **omnivores.** Crows, bears, and most humans are omnivores.

Some carnivores are scavengers. A **scavenger** is a carnivore that feeds on the bodies of dead organisms. Scavengers include catfish and vultures.

Decomposers If an ecosystem had only producers and consumers, the raw materials of life would stay locked up in wastes and the bodies of dead organisms. Luckily, there are organisms in ecosystems that prevent this problem. **Decomposers** break down wastes and dead organisms and return the raw materials to the ecosystem.

You can think of decomposers as nature's recyclers. While obtaining energy for their own needs, decomposers return simple molecules to the environment. These molecules can be used again by other organisms. Mushrooms and bacteria are common decomposers.

Reading Checkpoint **What do herbivores and carnivores have in common?**

FIGURE 1
Energy Roles
Each organism in an ecosystem fills a specific energy role. Producers, such as oak trees, make their own food. Consumers, such as luna moth larvae and eastern bluebirds, obtain energy by feeding on other organisms. **Classifying** *What role do decomposers play in ecosystems?*

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For: Links on food chains and food webs
Visit: www.SciLinks.org
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Food Chains and Food Webs

As you have read, energy enters most ecosystems as sunlight and is converted into food molecules by producers. This energy is transferred to each organism that eats a producer, and then to other organisms that feed on these consumers. **The movement of energy through an ecosystem can be shown in diagrams called food chains and food webs.**

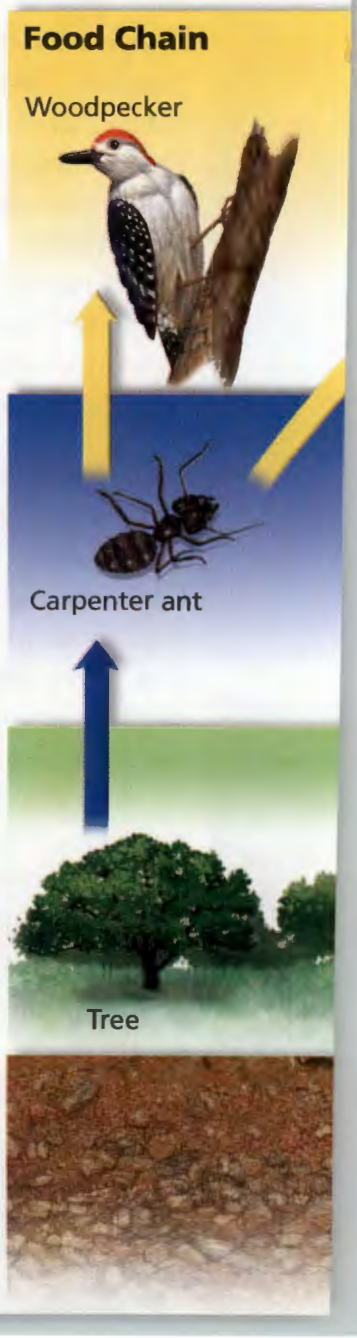
Food Chains A **food chain** is a series of events in which one organism eats another and obtains energy. You can follow one food chain in Figure 2. The first organism in a food chain is always a producer, such as the tree. The second organism feeds on the producer and is called a first-level consumer. The termite is a first-level consumer. Next, a second-level consumer eats the first-level consumer. The second-level consumer in this example is the woodpecker.

Food Webs A food chain shows only one possible path along which energy can move through an ecosystem. But just as you do not eat the same thing every day, neither do most other organisms. Most producers and consumers are part of many food chains. A more realistic way to show the flow of energy through an ecosystem is a food web. As shown in Figure 2, a **food web** consists of the many overlapping food chains in an ecosystem.

In Figure 2, you can trace the many food chains in a woodland ecosystem. Note that an organism may play more than one role in an ecosystem. For example, an omnivore such as the mouse is a first-level consumer when it eats grass. But when the mouse eats a grasshopper, it is a second-level consumer.

Just as food chains overlap and connect, food webs interconnect as well. While a gull might eat a fish at the ocean, it might also eat a mouse at a landfill. The gull, then, is part of two food webs—an ocean food web and a land food web. All the world's food webs interconnect in what can be thought of as a global food web.

Reading Checkpoint **What energy role is filled by the first organism in a food chain?**



Lab zone Try This Activity

Weaving a Food Web

This activity shows how the organisms in a food web are interconnected.

1. Your teacher will assign you a role in the food web.
2. Hold one end of each of several pieces of yarn in your hand. Give the other ends of your yarn to the other organisms to which your organism is linked.
3. Your teacher will now eliminate an organism. All the organisms connected to the missing organism should drop the yarn that connects them.

Making Models How many organisms were affected by the removal of just one organism? What does this activity show about the importance of each organism in a food web?

FIGURE 2

A Food Web

A food web consists of many interconnected food chains. Trace the path of energy through the producers, consumers, and decomposers. **Interpreting Diagrams** *Which organisms in the food web are acting as herbivores? Which are carnivores?*

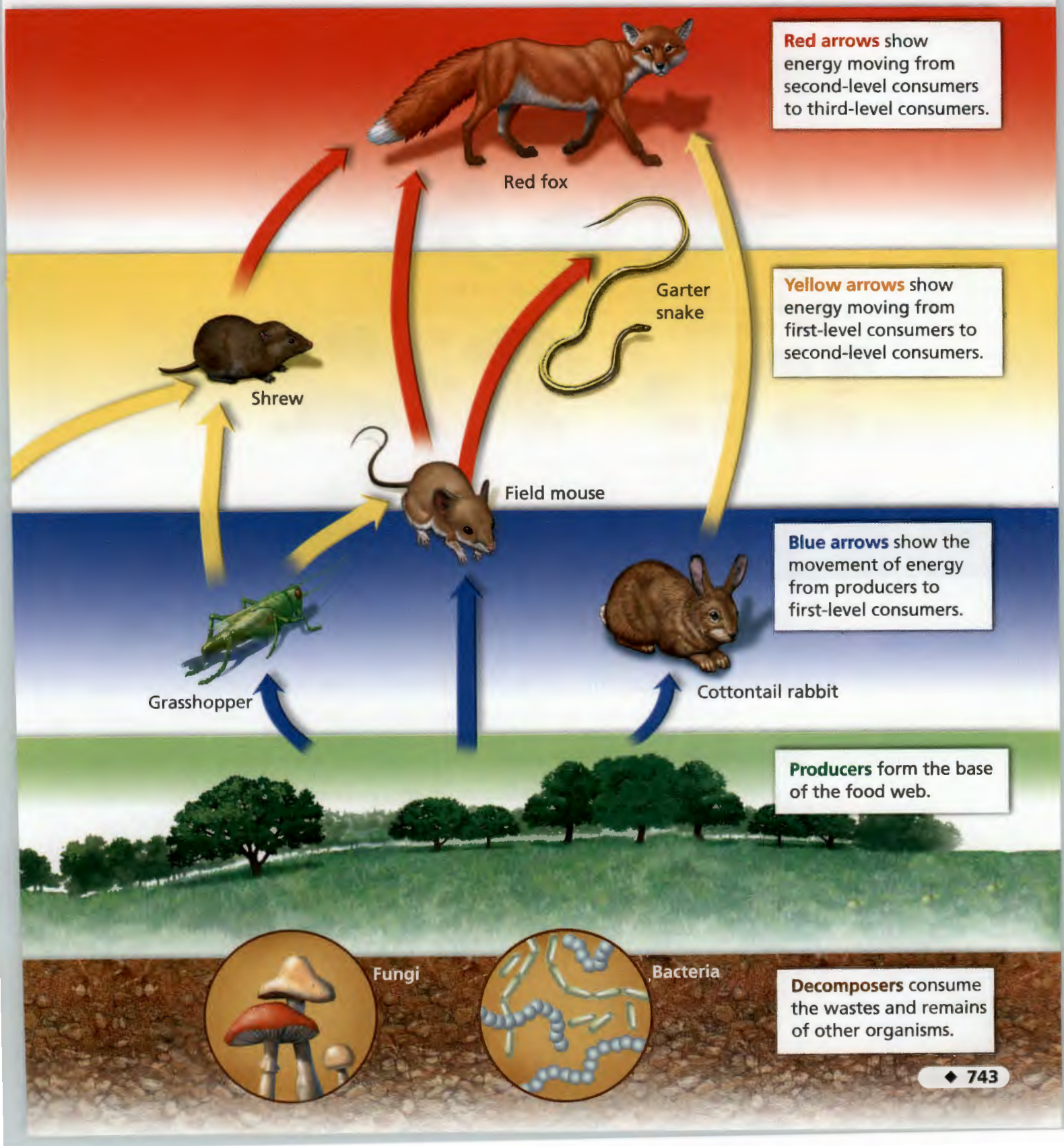
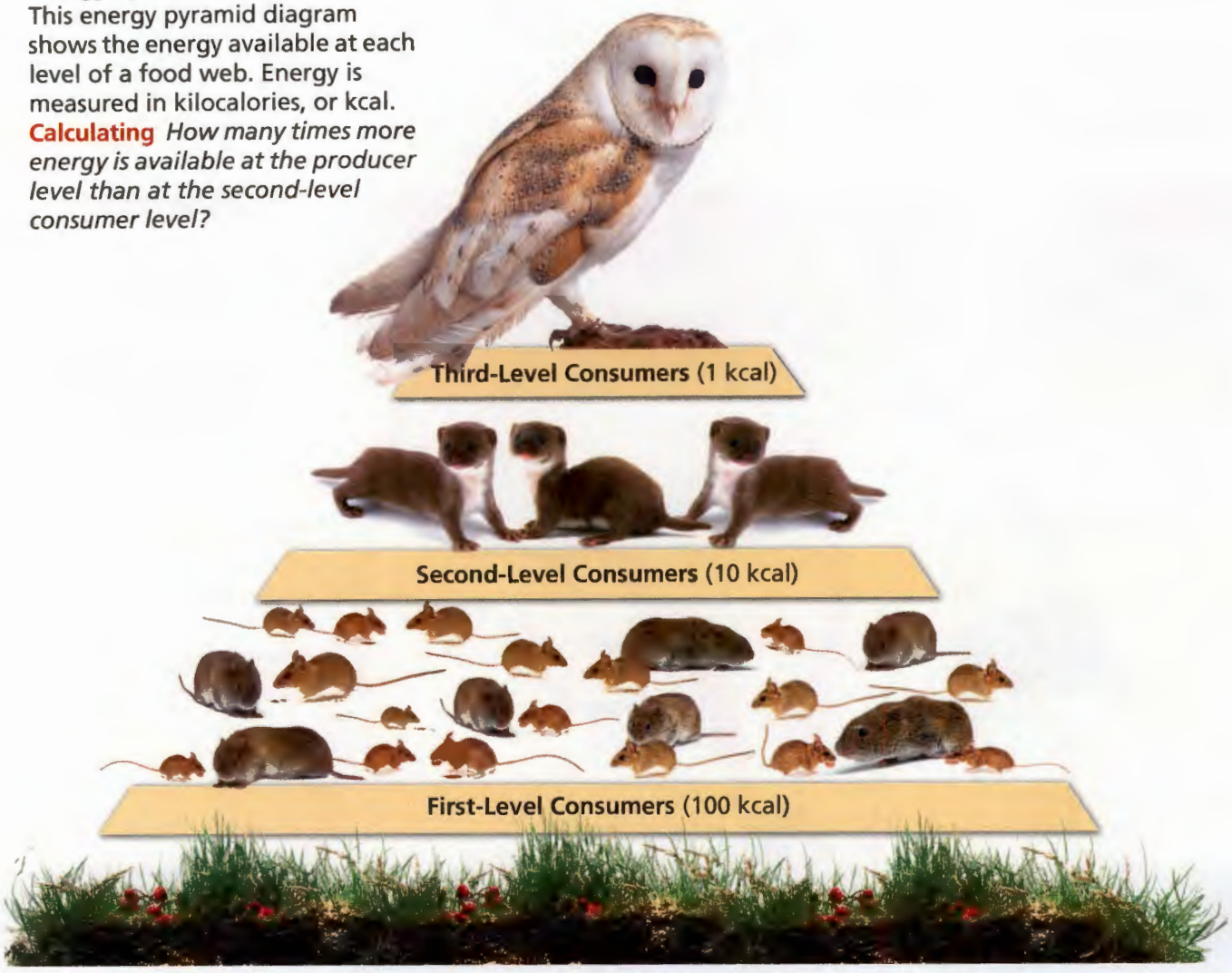


FIGURE 3
Energy Pyramid
This energy pyramid diagram shows the energy available at each level of a food web. Energy is measured in kilocalories, or kcal.
Calculating *How many times more energy is available at the producer level than at the second-level consumer level?*



Energy Pyramids

When an organism in an ecosystem eats, it obtains energy. The organism uses some of this energy to move, grow, reproduce, and carry out other life activities. This means that only some of the energy it obtains will be available to the next organism in the food web.

A diagram called an **energy pyramid** shows the amount of energy that moves from one feeding level to another in a food web. You can see an energy pyramid in Figure 3. **The most energy is available at the producer level of the pyramid. As you move up the pyramid, each level has less energy available than the level below.** An energy pyramid gets its name from the shape of the diagram—wider at the base and narrower at the top.

In general, only about 10 percent of the energy at one level of a food web is transferred to the next higher level. The other 90 percent of the energy is used for the organism's life processes or is lost to the environment as heat. Since about 90 percent of the energy is lost at each step, there is not enough energy to support many feeding levels in an ecosystem.

The organisms at higher feeding levels of an energy pyramid do not necessarily require less energy to live than do the organisms at lower levels. Since so much energy is lost at each level, the amount of energy available at the producer level limits the number of consumers that the ecosystem is able to support. As a result, there are usually few organisms at the highest level in a food web.

Reading Checkpoint **Why is the pyramid shape useful for showing the energy available at each of the levels of a food web?**

FIGURE 4
Energy Flow
This barn owl will soon use the energy contained in the rat to carry out its own life processes.

Section 1 Assessment

Target Reading Skill **Building Vocabulary** Use your definitions to help answer the questions below.

Reviewing Key Concepts

1. **a.** **Identifying** Name the three energy roles that organisms fill in an ecosystem.
   b. **Explaining** How do organisms in each of the three energy roles obtain energy?
   c. **Classifying** Identify the energy roles of the following organisms in a pond ecosystem: tadpole, algae, heron.
2. **a.** **Defining** What is a food chain? What is a food web?
   b. **Comparing and Contrasting** Why is a food web a more realistic way of portraying an ecosystem than is a food chain?
3. **a.** **Reviewing** What does an energy pyramid show?
   b. **Describing** How does the amount of energy available at one level of an energy pyramid compare to the amount of energy available at the next level up?
   c. **Relating Cause and Effect** Why are there usually few organisms at the top of an energy pyramid?

Lab zone At-Home Activity

Energy-Role Walk Take a short walk outdoors with a family member to look for producers, consumers, and decomposers. Create a list of the organisms and their energy roles. For each consumer, try to classify it further according to what it eats and its level. Then explain to your family member how energy flows in ecosystems.

Cycles of Matter

Reading Preview

Key Concepts

- What processes are involved in the water cycle?
- How are carbon and oxygen recycled in ecosystems?
- What is the nitrogen cycle?

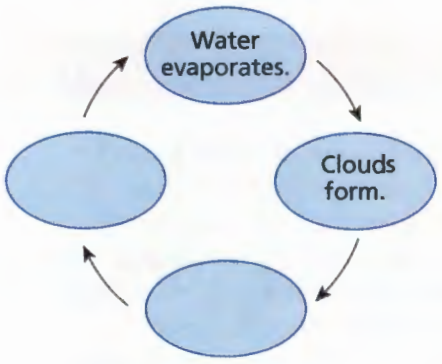
Key Terms

- water cycle
- evaporation
- condensation
- precipitation
- nitrogen fixation

Target Reading Skill

Sequencing A sequence is the order in which a series of events occurs. As you read, make a cycle diagram that shows the water cycle. Write each event of the water cycle in a separate oval.

The Water Cycle



Lab zone Discover Activity

Are You Part of a Cycle?

1. Hold a small mirror a few centimeters from your mouth.
2. Exhale onto the mirror.
3. Observe the surface of the mirror.

Think It Over

Inferring What is the substance that forms on the mirror? Where did this substance come from?

A pile of crumpled cars is ready for loading into a giant compactor. The aluminum and copper pieces have already been removed so that they can be recycled, or used again. Now the steel will be reclaimed at a recycling plant. Earth has a limited supply of aluminum, copper, and the iron used in steel. Recycling old cars is one way to ensure a steady supply of these materials.

Like the supply of metal for building cars, the supply of matter in an ecosystem is limited. Matter in an ecosystem includes water, carbon, oxygen, nitrogen, and many other substances. If matter could not be recycled, ecosystems would quickly run out of the raw materials necessary for life. In this section, you will learn about some cycles of matter: the water cycle, the carbon and oxygen cycles, and the nitrogen cycle.

To understand how these substances cycle over and over through an ecosystem, you need to know a few basic terms that describe the structure of matter. Matter is made up of tiny particles called atoms. Two or more atoms that are joined and act as a unit make up a molecule. For example, a water molecule consists of two hydrogen atoms and one oxygen atom.

The Water Cycle

Water is essential for life. To ensure a steady supply, Earth's water must be recycled. The **water cycle** is the continuous process by which water moves from Earth's surface to the atmosphere and back. **The processes of evaporation, condensation, and precipitation make up the water cycle.** As you read about these processes, follow the cycle in Figure 5.

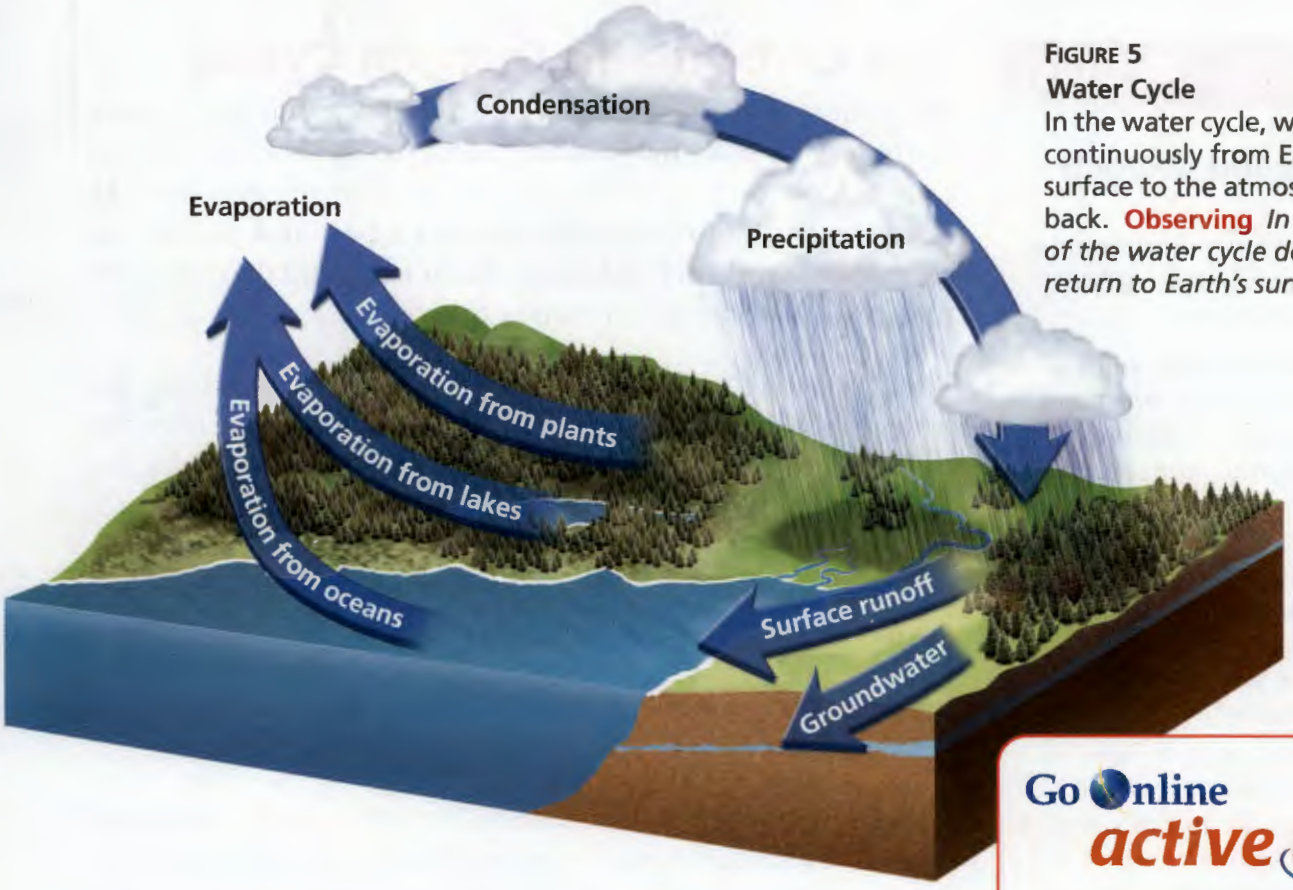


FIGURE 5
Water Cycle
In the water cycle, water moves continuously from Earth's surface to the atmosphere and back. **Observing** *In which step of the water cycle does water return to Earth's surface?*

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Evaporation The process by which molecules of liquid water absorb energy and change to a gas is called **evaporation.** In the water cycle, liquid water evaporates from oceans, lakes, and other surfaces and forms water vapor, a gas, in the atmosphere. The energy for evaporation comes from the heat of the sun.

Living things also give off water. For example, plants release water vapor from their leaves. You release liquid water in your wastes and water vapor when you exhale.

Condensation As the water vapor rises higher in the atmosphere, it cools down. The cooled vapor then turns back into tiny drops of liquid water. The process by which a gas changes to a liquid is called **condensation.** The water droplets collect around particles of dust, eventually forming clouds.

Precipitation As more water vapor condenses, the drops of water in the cloud grow larger. Eventually the heavy drops fall back to Earth as **precipitation**—rain, snow, sleet, or hail. Most precipitation falls back into oceans or lakes. The precipitation that falls on land may soak into the soil and become groundwater. Or the precipitation may run off the land, eventually flowing back into a river or ocean.

Reading Checkpoint **What process causes water from the surface of the ocean to enter the atmosphere as water vapor?**

Lab zone Skills Activity

Developing Hypotheses

You've decided to have cocoa at a friend's house on a cold, rainy day. As your friend boils some water, you notice that the inside of a window near the stove is covered with water droplets. Your friend thinks the window is leaking. Using what you know about the water cycle, can you propose another explanation for the water droplets?

Lab zone Try This Activity

Carbon and Oxygen Blues

This activity explores the role of producers in the carbon and oxygen cycles.

1. Your teacher will provide you with two plastic cups containing bromthymol blue solution. Bromthymol blue solution appears blue in the absence of carbon dioxide and appears yellow in the presence of carbon dioxide. Note the color of the solution.
2. Place two sprigs of an *Elodea* plant into one of the cups. Do not put any *Elodea* into the second cup. Cover both cups with plastic wrap. Wash your hands.
3. Place the cups where they will not be disturbed. Observe the two cups over the next few days. Note any color changes.

Inferring What do your observations indicate about the role of producers in the carbon and oxygen cycles?

The Carbon and Oxygen Cycles

Two other substances necessary for life are carbon and oxygen. Carbon is an essential building block in the bodies of living things. Most organisms use oxygen for their life processes. **In ecosystems, the processes by which carbon and oxygen are recycled are linked. Producers, consumers, and decomposers play roles in recycling carbon and oxygen.**

The Carbon Cycle Producers take in carbon dioxide gas from the air during photosynthesis. They use carbon from the carbon dioxide to make food molecules—carbon-containing molecules such as sugars and starches. When consumers eat producers, they take in the carbon-containing food molecules. When consumers break down these food molecules to obtain energy, they release carbon dioxide and water as waste products. When producers and consumers die, decomposers break down their remains and return carbon compounds to the soil. Some decomposers also release carbon dioxide as a waste product.

The Oxygen Cycle Like carbon, oxygen cycles through ecosystems. Producers release oxygen as a result of photosynthesis. Most organisms take in oxygen from the air or water and use it to carry out their life processes.

Human Impact Human activities also affect the levels of carbon and oxygen in the atmosphere. When humans burn oil and other fuels, carbon dioxide is released into the atmosphere. When humans clear forests for lumber, fuel, and farmland, carbon dioxide levels also rise. As you know, producers take in carbon dioxide during photosynthesis. When trees are removed from the ecosystem, there are fewer producers to absorb carbon dioxide. There is a greater effect if trees are burned down to clear a forest. If trees are burned down to clear a forest, additional carbon dioxide is released in the burning process.

Reading Checkpoint **What role do producers play in the carbon and oxygen cycles?**

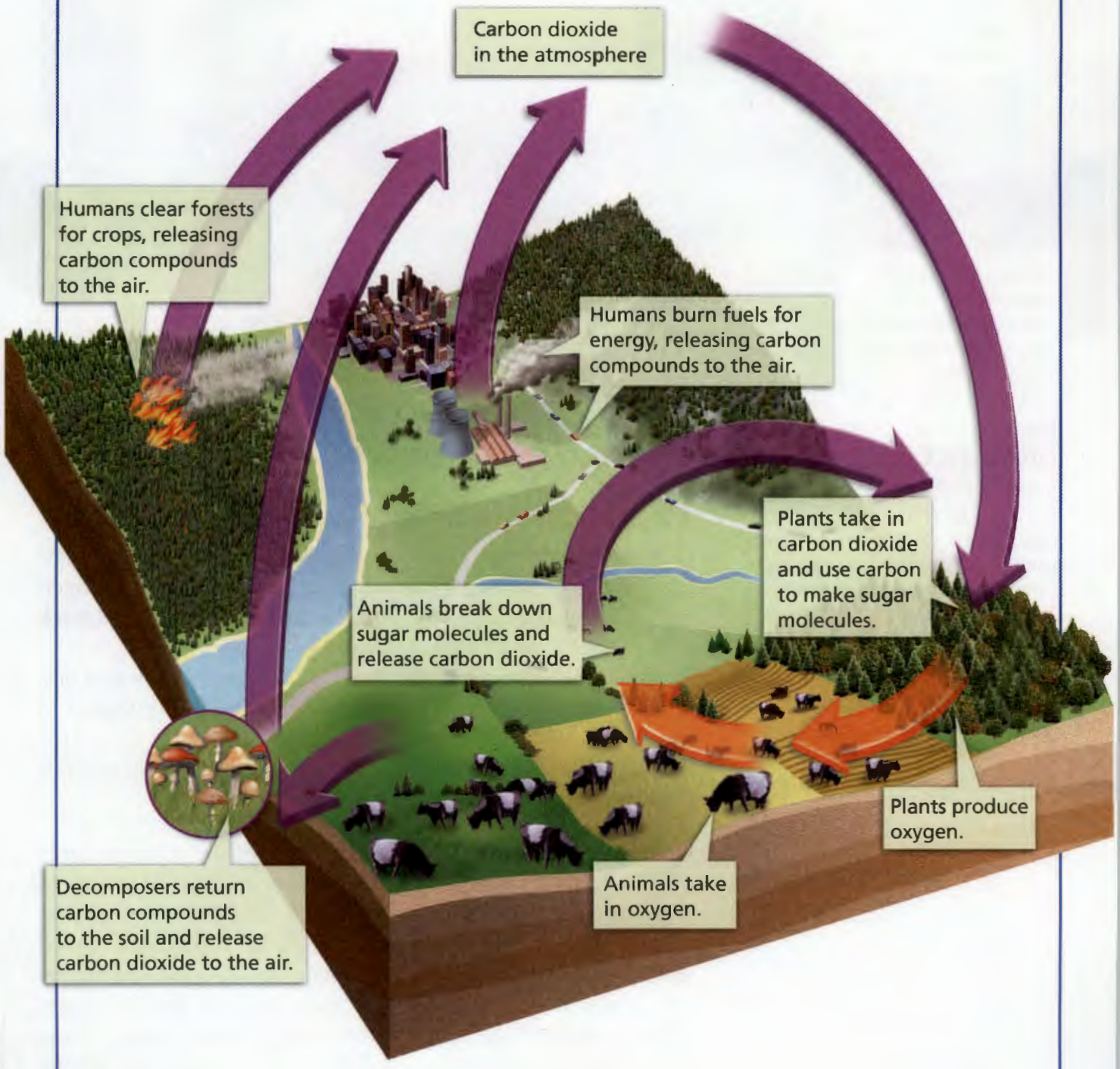
FIGURE 6
Rising Carbon Dioxide Levels
When forests burn, large amounts of carbon dioxide are released into the air. In addition, there are fewer trees available to absorb carbon dioxide from the air.

FIGURE 7

Carbon and Oxygen Cycles

This scene shows how the carbon and oxygen cycles are linked. Producers, consumers, and decomposers all play a role in recycling these two substances.

Interpreting Diagrams *How do human activities affect the carbon and oxygen cycles?*



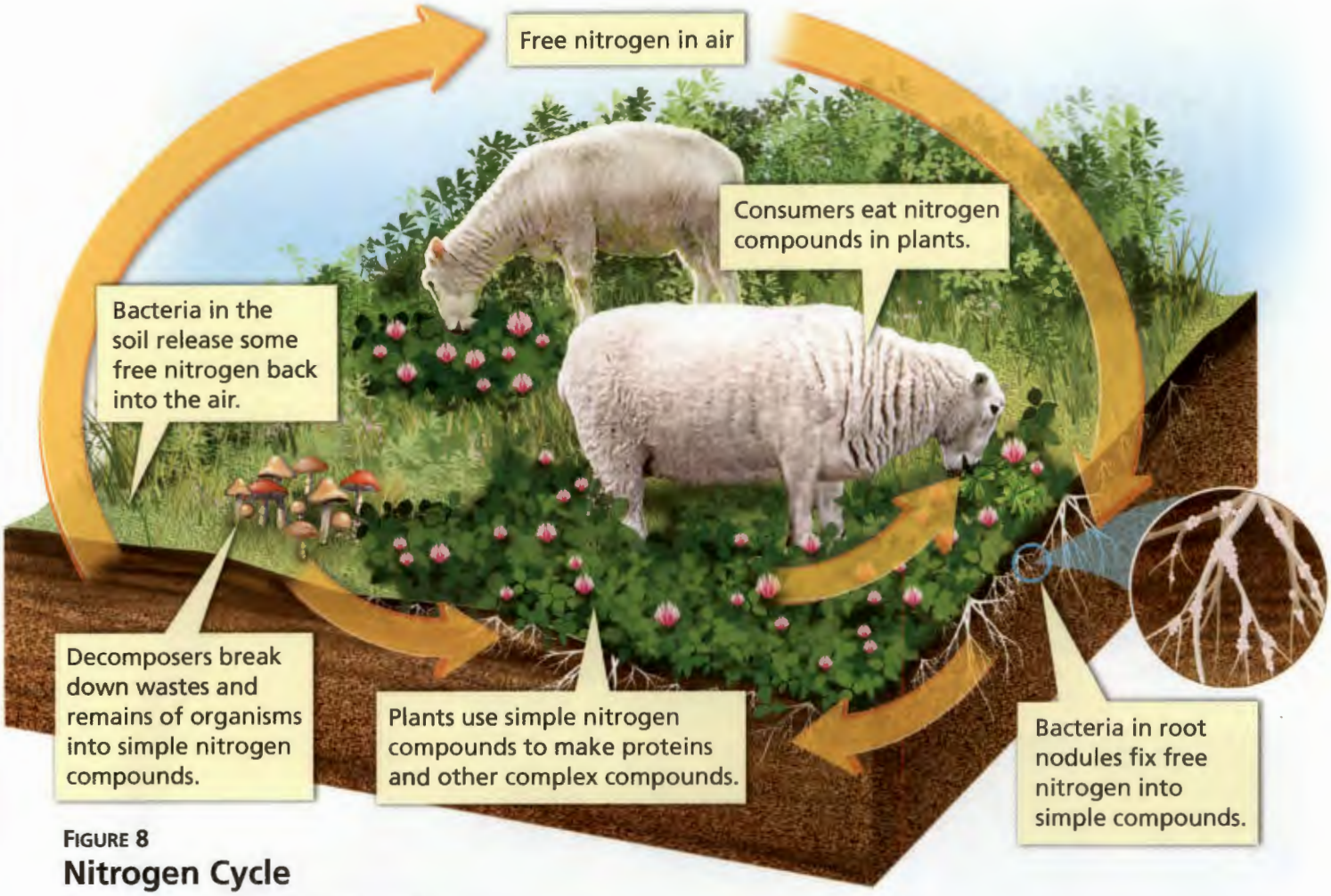


FIGURE 8
Nitrogen Cycle
In the nitrogen cycle, free nitrogen from the air is fixed into compounds. Consumers can then use these nitrogen compounds in carrying out their life processes. **Relating Cause and Effect** *How does nitrogen get returned to the environment?*

The Nitrogen Cycle

Like carbon, nitrogen is a necessary building block in the matter that makes up living things. **In the nitrogen cycle, nitrogen moves from the air to the soil, into living things, and back into the air.** You can follow this process in Figure 8.

Since the air around you is about 78 percent nitrogen gas, you might think that it would be easy for living things to obtain nitrogen. However, most organisms cannot use nitrogen gas. Nitrogen gas is called "free" nitrogen because it is not combined with other kinds of atoms.

Nitrogen Fixation Most organisms can use nitrogen only once it has been "fixed," or combined with other elements to form nitrogen-containing compounds. The process of changing free nitrogen into a usable form of nitrogen is called **nitrogen fixation.** Most nitrogen fixation is performed by certain kinds of bacteria. Some of these bacteria live in bumps called nodules (NAHJ oolz) on the roots of certain plants. These plants, known as legumes, include clover, beans, peas, alfalfa, and peanuts.

The relationship between the bacteria and the legumes is an example of mutualism. Both the bacteria and the plant benefit from this relationship: The bacteria feed on the plant's sugars, and the plant is supplied with nitrogen in a usable form.

Return of Nitrogen to the Environment

Once nitrogen has been fixed, producers can use it to build proteins and other complex compounds. Decomposers, in turn, break down these complex compounds in animal wastes and the bodies of dead organisms. Decomposition returns simple nitrogen compounds to the soil. Nitrogen can cycle from the soil to producers and then to consumers many times. At some point, however, bacteria break down the nitrogen compounds completely. These bacteria then release free nitrogen back into the air. The cycle continues from there.

Reading Checkpoint **Where do some nitrogen-fixing bacteria live?**

FIGURE 9
Growth in Nitrogen-Poor Soil
Pitcher plants can grow in nitrogen-poor soil because they have another way of obtaining nitrogen. Insects become trapped in the plant's tube-shaped leaves. The plant then digests the insects and uses their nitrogen compounds for its functions.

Section 2 Assessment

Target Reading Skill **Sequencing** Refer to your cycle diagram about the water cycle as you answer Question 1.

Reviewing Key Concepts

1. a. **Defining** Name and define the three major processes that occur during the water cycle.
   b. **Making Generalizations** Defend this statement: The sun is the driving force behind the water cycle.
2. a. **Reviewing** Which two substances are linked in one recycling process?
   b. **Comparing and Contrasting** What role do producers play in the carbon and oxygen cycles? What role do consumers play in these cycles?
   c. **Developing Hypotheses** How might the death of all the producers in a community affect the carbon and oxygen cycles?
3. a. **Reviewing** Why do organisms need nitrogen?
   b. **Sequencing** Outline the major steps in the nitrogen cycle.
   c. **Predicting** What might happen in a community if all the nitrogen-fixing bacteria died?

Writing in Science

Comic Strip Choose one of the cycles discussed in this section. Then draw a comic strip with five panels that depicts the important events in the cycle. Remember that the last panel must end with the same event that begins the first panel.

Section 3

Biogeography

Reading Preview

Key Concepts

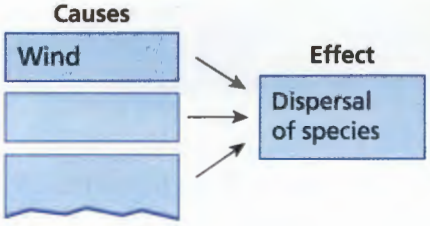
- How has the movement of the continents affected the distribution of species?
- What are three ways that dispersal of organisms occurs?
- What factors can limit the dispersal of a species?

Key Terms

- biogeography
- continental drift
- dispersal
- exotic species
- climate

Target Reading Skill

Relating Cause and Effect As you read, identify three causes of dispersal. Write the information in a graphic organizer like the one below.



Lab zone **Discover Activity**

How Can You Move a Seed?

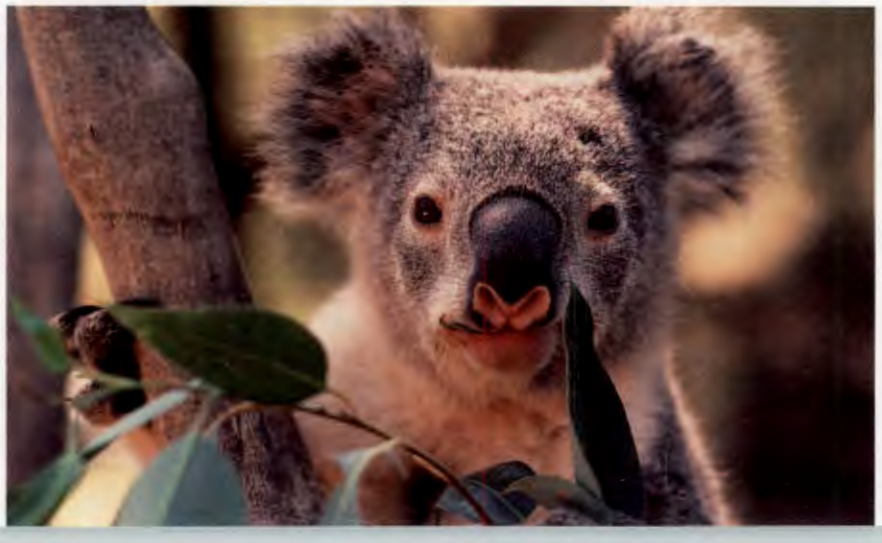
1. Place a few corn kernels at one end of a shallow pan.
2. Make a list of ways you could move the kernels to the other side of the pan. You may use any of the simple materials your teacher has provided.
3. Now try each method. Record whether each was successful in moving the kernels across the pan.

Think It Over

Predicting How might seeds be moved from place to place?

Imagine how European explorers must have felt when they saw Australia for the first time. Instead of familiar grazing animals such as horses and deer, they saw animals that looked like giant rabbits with long tails. Peering into eucalyptus trees, the explorers saw bearlike koalas. And who could have dreamed up an egg-laying animal with a beaver's tail, a duck's bill, and thick fur? You can see why people who heard the first descriptions of the platypus accused the explorers of lying!

As the explorers had learned, different species live in different parts of the world. The study of where organisms live is called **biogeography.** The word *biogeography* is made up of three Greek word roots: *bio,* meaning "life"; *geo,* meaning "Earth"; and *graphy*, meaning "description of." Together, these root words tell what biogeographers do—they describe where living things are found on Earth.



Koala in a eucalyptus tree in Australia ▶

FIGURE 10
Continental Drift
The movement of the continents is one factor affecting the distribution of organisms. **Interpreting Maps** *How has Australia's location changed?*

225 Million Years Ago

180–200 Million Years Ago

135 Million Years Ago

Earth Today

Continental Drift

In addition to studying where species live, biogeographers also try to understand what led to the worldwide distribution of species that exists today. **One factor that has affected how species are distributed is the motion of Earth's continents.** The continents are parts of huge blocks of solid rock, called plates, that make up Earth's surface. Scientists have found that the plates have been moving very slowly for millions of years. As the plates move, the continents move with them in a process called **continental drift.**

Figure 10 shows how much the continents have moved over time. About 225 million years ago, all of today's continents were part of one large landmass now called Pangaea. But after millions of years of slow drifting, they have moved to their present locations.

Continental drift has had a great impact on the distribution of species. Consider Australia, for example. Millions of years ago Australia drifted away from the other landmasses. Organisms from other parts of the world could not reach the isolated island. Kangaroos, koalas, and other unique species flourished in this isolation.

Reading Checkpoint **What was Pangaea?**

Means of Dispersal

The movement of organisms from one place to another is called **dispersal.** Organisms may be dispersed in several different ways. **Dispersal can be caused by wind, water, or living things, including humans.**

Wind and Water Many animals move into new areas on their own. But plants and small organisms need assistance to move from place to place. Wind can disperse seeds, the spores of fungi, tiny spiders, and other small, light organisms. Similarly, water transports objects that float, such as coconuts and leaves. Small animals may get a free ride to a new home on top of these floating rafts.

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FIGURE 11
Means of Dispersal
Berry seeds can be dispersed by animals, such as cedar waxwings (top left), that eat berries and leave seeds in their wastes. The spores of puffball mushrooms (top center) and the seeds of milkweed plants (top right) are usually dispersed by wind.
Inferring *What are two ways that seeds disperse?*

Other Living Things Organisms may also be dispersed by other living things. For example, a bird may eat berries in one area and deposit the seeds elsewhere in its wastes. And if your dog or cat has ever come home covered with sticky plant burs, you know another way seeds can get around.

Humans are also important to the dispersal of organisms. As people move around the world, they take organisms with them. Sometimes this dispersal is intentional, as when Europeans who explored Central and South America in the 1500s took corn and tomato plants back to Europe. Sometimes it is unintentional, as when insects are carried from one location to another by an airplane passenger. An organism that is carried into a new location by people is referred to as an **exotic species.**

Reading Checkpoint **What are two ways that an animal can disperse a species?**

Limits to Dispersal

With all these means of dispersal, you might expect to find the same species everywhere in the world. Of course, that's not so. **Three factors that limit dispersal of a species are physical barriers, competition, and climate.**

Physical Barriers Barriers such as water, mountains, and deserts are hard to cross. These features can limit the movement of organisms. For example, once Australia became separated from the other continents, the ocean acted as a barrier to dispersal. Organisms could not easily move to or from Australia.

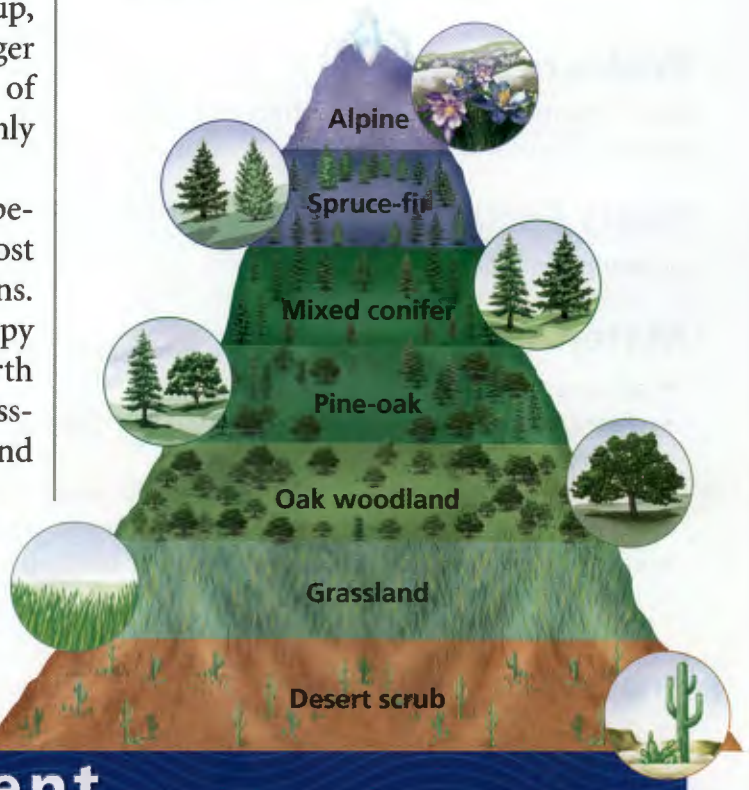
Competition When an organism enters a new area, it must compete for resources with the species already there. To survive, the organism must find a unique niche. Existing species may outcompete the new species. In this case, competition is a barrier to dispersal. Sometimes, however, new species outcompete the existing species. The existing species may be displaced.

Climate The typical weather pattern in an area over a long period of time is the area's **climate.** Climate differences can limit dispersal. For example, conditions at the top of the mountain shown in Figure 12 are very different from those at the base. The base of the mountain is warm and dry. Low shrubs and cactuses grow there. Higher up, the climate becomes cooler and wetter, and larger trees such as oaks and firs grow. Near the top of the mountain, it is very cold and windy. Only short plants can grow in this area.

Places with similar climates tend to have species that occupy similar niches. For example, most continents have a large area of flat, grassy plains. So these continents have organisms that occupy the niche of "large, grazing mammal." In North America, the large, grazing mammals of the grasslands are bison. In Africa, they are wildebeests and antelopes. And in Australia, they are kangaroos.

Reading Checkpoint **How does the climate at the base of a mountain differ from the climate at the top?**

FIGURE 12
Climate Differences and Dispersal
The climate changes dramatically as you move up a tall mountain. Climate determines the distribution of species on different parts of the mountain.



Section 3 Assessment

Target Reading Skill

Relating Cause and Effect Refer to your graphic organizer about means of dispersal to help you answer Question 2 below.

Reviewing Key Concepts

1. a. **Defining** What is continental drift?
   b. **Explaining** How has continental drift affected the dispersal of organisms?
   c. **Relating Cause and Effect** How can continental drift explain why unique species are often found on islands?
2. a. **Listing** What are three ways in which organisms can be dispersed?
   b. **Explaining** What role do humans play in the dispersal of species?
   c. **Predicting** Do you think the role of humans in the dispersal of species will increase or decrease in the next 50 years? Defend your answer.
3. a. **Identifying** What are three factors that can limit the dispersal of a species?
   b. **Applying Concepts** Suppose that a new species of insect were introduced to your area. How might competition limit its dispersal?

Lab zone At-Home Activity

Sock Walk Take an adult family member on a "sock walk" to learn about seed dispersal. Each person should wear a thick white sock over one shoe. Take a short walk through woods, a field, or a park. Back home, observe how many seeds you collected. Then plant the socks in pans of soil. Place the pans in a sunny spot and water them regularly. How many species did you successfully disperse?

Lab zone Skills Lab

Biomes in Miniature

Problem

What abiotic factors create different biomes around the world?

Skills Focus

observing, making models

Materials

- scissors
- clear plastic wrap
- index card
- lamp
- tape
- empty, clean cardboard milk carton
- stapler
- about 30 rye grass seeds
- 10 impatiens seeds
- 5 lima bean seeds
- sandy soil or potting soil

Procedure

1. Your teacher will assign your group a biome. You will also observe the other groups' model biomes. Based on the chart below, predict how well you think each of the three kinds of seeds will grow in each set of conditions. Record these predictions in your notebook. Then copy the data table on the facing page four times, once for each biome.
2. Staple the spout of the milk carton closed. Completely cut away one of the four sides of the carton. Poke a few holes in the opposite side for drainage, and then place that side down.
3. Fill the carton to 3 centimeters from the top with the type of soil given in the table. Divide the surface of the soil into three sections by making two lines in it with a pencil.
4. In the section near the spout, plant the impatiens seeds. In the middle section, plant the lima bean seeds. In the third section, scatter the rye grass seeds on the surface.
5. Water all the seeds well. Then cover the open part of the carton with plastic wrap.
6. On an index card, write the name of your biome, the names of the three types of seeds in the order you planted them, and the names of your group members. Tape the card to the carton. Put the carton in a warm place where it will not be disturbed.
7. Once the seeds sprout, provide your biome with light and water as specified in the chart. Keep the carton covered with plastic wrap except when you add water.
8. Observe all the model biomes daily for at least one week. Record your observations.

Growing Conditions			
Biome	**Soil Type**	**Hours of Light per Day**	**Watering Instructions**
Forest	Potting soil	1–2 hours of direct light	Let the surface dry; then add water.
Desert	Sandy soil	5–6 hours of direct light	Let the soil dry to a depth of 2.5 cm below the surface.
Grassland	Potting soil	5–6 hours of direct light	Let the surface dry; then add water.
Rain forest	Potting soil	No direct light; indirect light for 5–6 hours	Keep the surface of the soil moist.

Data Table			
Name of Biome: _____			
Day	Impatiens	Lima Beans	Rye Grass
1			
2			
3			
4			
5			
6			
7			

Analyze and Conclude

1. **Observing** In which model biome did each type of seed grow best? In which model biome did each type of seed grow least well?
2. **Making Models** In this experiment, how did you model the following abiotic factors: sunlight, water, and temperature?
3. **Inferring** How was each type of seed affected by the soil type, amount of light, and availability of water?
4. **Classifying** Why do you think that ecologists who study biomes often focus on identifying the key abiotic factors and typical plants in an area?
5. **Communicating** Write a paragraph explaining how your miniature biomes modeled real-life biomes. Which features of real-life biomes were you able to model well? Which features of real-life biomes were more difficult to model?

Design an Experiment

Write a plan for setting up a model rain forest or desert terrarium. Include typical plants found in that biome. *Obtain your teacher's approval before carrying out your investigation.*

Section 4

Biomes and Aquatic Ecosystems

Reading Preview

Key Concepts

- What are the six major biomes found on Earth?
- What factors determine the type of biome found in an area?
- What do freshwater and marine ecosystems include?

Key Terms

- biome • canopy • understory
- desert • grassland • savanna
- deciduous tree
- coniferous tree • tundra
- permafrost • estuary
- intertidal zone • neritic zone

Target Reading Skill

Comparing and Contrasting As you read, compare the biomes by completing a table like this one.

Characteristic	Tropical Rain Forest	Tundra
Temperature	Warm all year	
Precipitation		
Typical Organisms		

Discovery CHANNEL SCHOOL

Ecosystems and Biomes

Video Preview
▶ Video Field Trip
Video Assessment

Lab zone **Discover Activity**

How Much Rain Is That?

The table shows the typical amount of precipitation that falls each year in four locations. With your classmates, you will create a full-sized bar graph on a wall to represent these amounts.

Location	Precipitation (cm)
Mojave Desert	15
Illinois Prairie	70
Great Smoky Mountains	180
Costa Rican Rain Forest	350

1. Using a meter stick, measure a strip of adding-machine paper 15 centimeters long. Label this strip "Mojave Desert."
2. Repeat Step 1 for the other locations. Label each strip.
3. Follow your teacher's instructions on hanging your strips.

Think It Over

Developing Hypotheses What effect might the amount of precipitation have on the types of species that live in a location?

Congratulations! You and your classmates have been selected to take part in an around-the-world scientific expedition. On this expedition you will collect data on the climate and typical organisms of each of Earth's biomes. A **biome** is a group of land ecosystems with similar climates and organisms.

The ecologists leading your expedition have agreed to focus on six major biomes. **The six major biomes that most ecologists study are the rain forest, desert, grassland, deciduous forest, boreal forest, and tundra.**

Be sure to pack a variety of clothing for your expedition. You will visit places ranging from steamy tropical jungles to frozen Arctic plains. **It is mostly the climate—temperature and precipitation—in an area that determines its biome.** This is because climate limits the species of plants that can grow in an area. In turn, the species of plants determine the kinds of animals that live there.

Hurry up and pack—it's almost time to go!

Rain Forest Biomes

The first stop on your expedition is a rain forest. This biome is living up to its name—it's pouring! Fortunately, you remembered to pack a raincoat. After just a short shower, however, the sun reappears. Surprisingly, though, very little sunlight reaches you through the thick leaves above.

Plants are everywhere in the rain forest. Some plants, such as the ferns, flowers, and vines hanging from tree limbs, even grow on other plants! And animals are flying, creeping, and slithering all around you.

Temperate Rain Forests When you hear the term *rain forest,* you probably think of a warm, humid, "jungle" in the tropics. But there is another type of rain forest. The northwestern coast of the United States receives more than 300 centimeters of rain a year. Huge trees grow there, including cedars, redwoods, and Douglas firs. However, it is difficult to classify this region. Many ecologists refer to this ecosystem as a temperate rain forest. The term *temperate* means having moderate temperatures.

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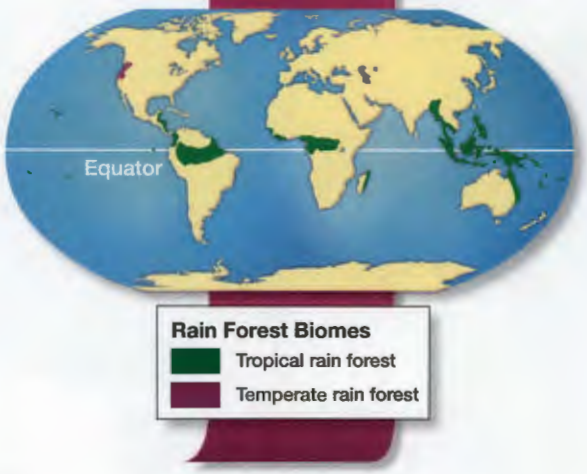
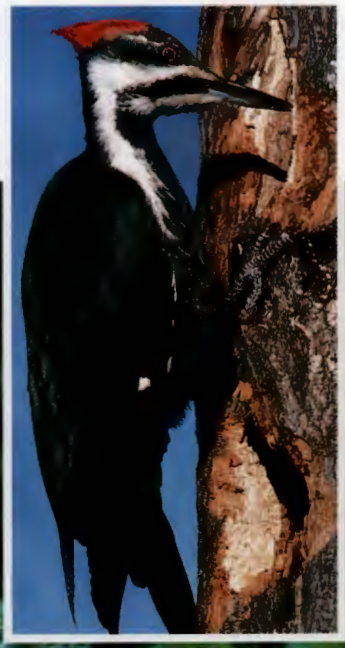


FIGURE 13 Temperate Rain Forest
Temperate rain forests receive a great deal of rain and have moderate temperatures. Mule deer are commonly found in the Olympic Rain Forest in Washington State. **Interpreting Maps** *Where is one temperate rain forest located?*

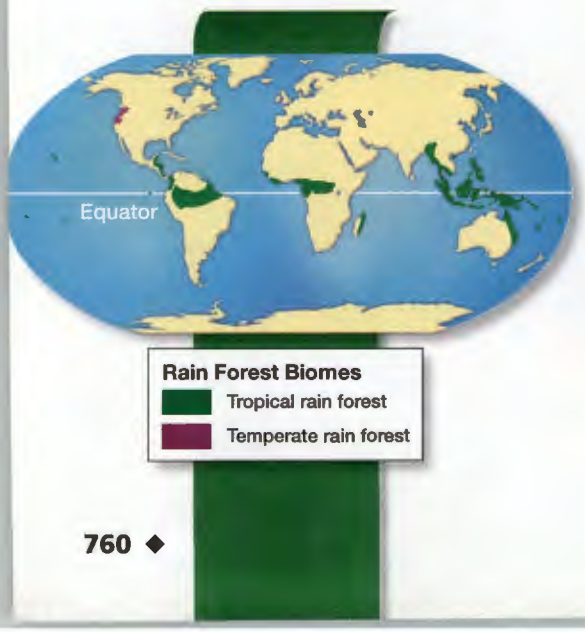


◀ Pileated woodpecker

◀ Orangutan

▲ Bromeliad

FIGURE 14
Tropical Rain Forest
Tropical rain forests are wet, warm biomes that contain an amazing variety of plants and other organisms. In the large photo, a river winds through the lush Indonesian rain forest.



Tropical Rain Forests As you can see on the map, tropical rain forests are found in regions close to the equator. The climate is warm and humid all year long, and there is a lot of rain. Because of these climate conditions, an astounding variety of plants grow in tropical rain forests. In fact, scientists studying a 100-square-meter area of one rain forest identified 300 different kinds of trees!

Trees in the rain forest form several distinct layers. The tall trees form a leafy roof called the **canopy.** A few giant trees poke out above the canopy. Below the canopy, a second layer of shorter trees and vines form an **understory.** Understory plants grow well in the shade formed by the canopy. The forest floor is nearly dark, so only a few plants live there.

The abundant plant life in tropical rain forests provides habitats for many species of animals. Ecologists estimate that millions of species of insects live in tropical rain forests. These insects serve as a source of food for many reptiles, birds, and mammals. Many of these animals are, in turn, food sources for other animals. Although tropical rain forests cover only a small part of the planet, they probably contain more species of plants and animals than all the other biomes combined.

Reading Checkpoint **What is the climate of the tropical rain forest?**

Desert Biomes

The next stop on your expedition is a desert. It couldn't be more different from the tropical rain forest you just left. You step off the bus into the searing summer heat. At midday, it is too hot to walk outside in the desert.

A **desert** is an area that receives less than 25 centimeters of rain per year. The amount of evaporation in a desert is greater than the amount of precipitation. Some of the driest deserts may not receive any precipitation in a year! Deserts often undergo large shifts in temperature during the course of a day. A scorching hot desert like the Namib Desert in Africa cools rapidly each night when the sun goes down. Other deserts, such as the Gobi in central Asia, are cooler, and even experience freezing temperatures in the winter.

Organisms that live in the desert must be adapted to the lack of rain and extreme temperatures. For example, the stem of a saguaro cactus has folds that work like the pleats in an accordion. The stem expands to store water when it is raining. Gila monsters can spend weeks at a time in their cool underground burrows. Many other desert animals are most active at night when the temperatures are cooler.

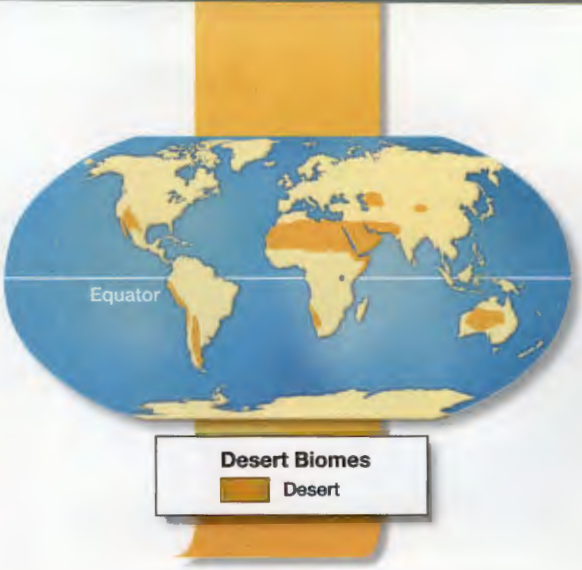


FIGURE 15
Desert
The Mojave Desert in the southwestern United States is a typical hot desert.
Making Generalizations *Describe the climate conditions of a typical desert.*

Lab zone Try This Activity

Desert Survival

Use a hand lens to carefully observe a small potted cactus. **CAUTION:** *Be careful of the spines.* With a pair of scissors, carefully snip a small piece from the tip of the cactus. Observe the inside of the plant. Note any characteristics that seem different from those of other plants.

Observing How is the inside of the cactus different from the outside? Suggest how the features you observe might be adaptations to its desert habitat.

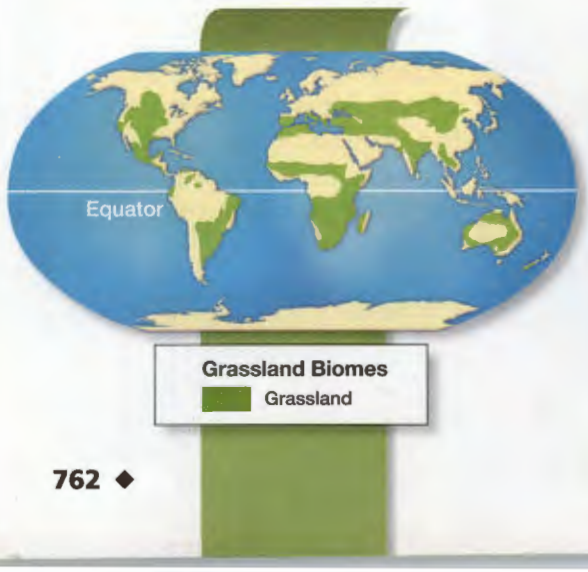
FIGURE 16
Savanna
Migrating wildebeest make their way across a vast Kenyan savanna. A savanna is one type of grassland biome—an area populated mostly by grasses and other non-woody plants.

Grassland Biomes

The next stop on the expedition is a grassy plain called a prairie. Temperatures here are more comfortable than they were in the desert. The breeze carries the scent of soil warmed by the sun. This rich soil supports grasses as tall as you. Startled by your approach, sparrows dart into hiding places among the waving grass stems.

Although this prairie receives more rain than a desert, it does not get enough rain for trees to grow. Ecologists classify prairies, which are generally found in the middle latitudes, as grasslands. A **grassland** is an area that is populated mostly by grasses and other non-woody plants. Most grasslands receive 25 to 75 centimeters of rain each year. Fires and droughts are common in this biome. Grasslands that are located closer to the equator than prairies are known as savannas. A **savanna** receives as much as 120 centimeters of rain each year. Scattered shrubs and small trees grow on savannas along with grass.

Grasslands are home to many of the largest animals on Earth—herbivores such as elephants, bison, antelopes, zebras, rhinoceroses, giraffes, and kangaroos. Grazing by these large herbivores helps to maintain the grasslands. They keep young trees and bushes from sprouting and competing with the grass for water and sunlight.



Reading Checkpoint **What type of grassland usually receives more rainfall, a prairie or a savanna?**

Deciduous Forest Biomes

Your trip to the next biome takes you to another forest. It is now late summer. Cool mornings here give way to warm days. Several members of the expedition are busy recording the numerous plant species. Others are looking through their binoculars, trying to identify the songbirds. You step carefully to avoid a small salamander.

You are now visiting a deciduous forest biome. Many of the trees in this forest are **deciduous trees** (dee SIJ oo us), trees that shed their leaves and grow new ones each year. Oaks and maples are examples of deciduous trees. Deciduous forests receive enough rain to support the growth of trees and other plants, at least 50 centimeters per year. Temperatures in the deciduous forest vary greatly during the year. The growing season usually lasts five to six months.

The variety of plants in a deciduous forest creates many different habitats. Different species of birds live in different parts of the forest, eating the insects and fruits in their specific areas. Mammals such as chipmunks and skunks live in deciduous forests. In a North American deciduous forest you might also see wood thrushes, white-tailed deer, and black bears.

If you were to return to this biome in the winter, you would not see much wildlife. Many of the bird species migrate to warmer areas. Some of the mammals hibernate, or enter a state of greatly reduced body activity similar to sleep. Animals that hibernate rely on fat stored in their bodies during the winter months.

Reading Checkpoint **What are deciduous trees?**

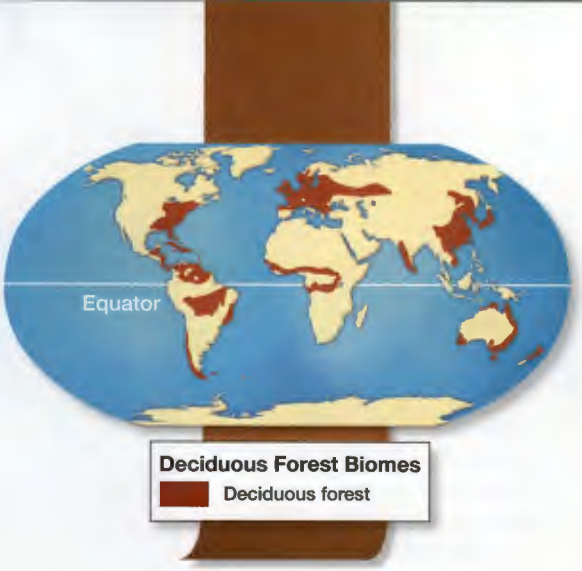


FIGURE 17
Deciduous Forest
This forest is a beautiful example of a deciduous forest in autumn. Most of the trees in a deciduous forest have leaves that change color and drop each autumn.
Comparing and Contrasting *How do deciduous forests differ from rain forests?*

▼ Southern flying squirrel

▼ Red fox

FIGURE 18
Boreal Forest
This boreal forest in Alaska's Denali National Park is home to coniferous trees and animals such as moose. The boreal forest is often called the "spruce-moose" forest.

Boreal Forest Biomes

Now the expedition heads north into a colder climate. The expedition leaders claim they can identify the next biome, a boreal forest, by its smell. When you arrive, you catch a whiff of the spruce and fir trees that blanket the hillsides. Feeling the chilly early fall air, you pull a jacket and hat out of your bag.

Boreal Forest Plants Most of the trees in the boreal forest are **coniferous trees** (koh NIF ur us), trees that produce their seeds in cones and have leaves shaped like needles. The boreal forest is sometimes referred to by its Russian name, the *taiga* (TY guh). Winters in these forests are very cold. The snow can reach heights well over your head! Even so, the summers are rainy and warm enough to melt all the snow.

Tree species in the boreal forest are well-adapted to the cold climate. Since water is frozen for much of the year, trees in the boreal forest must have adaptations that prevent water loss. Fir, spruce, hemlock, and other coniferous trees all have thick, waxy needles that prevent water from evaporating.

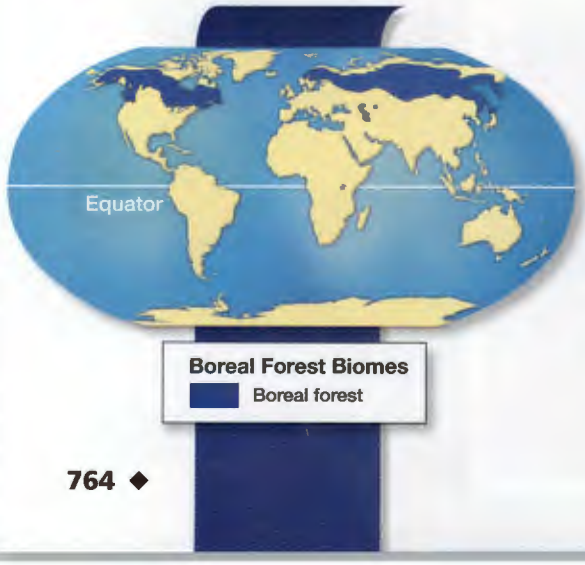
Boreal Forest Animals Many of the animals of the boreal forest eat the seeds produced by the coniferous trees. These animals include red squirrels, insects, and birds such as finches and chickadees. Some herbivores, such as snowshoe hares, moose, and beavers, eat tree bark and new shoots. The variety of herbivores in the boreal forest supports many large predators, including wolves, bears, great horned owls, and lynxes.

Reading Checkpoint **How are needles an advantage to trees in the boreal forest?**

Lab zone Skills Activity

Inferring

Observe the map that shows the locations of boreal forests. Where are most boreal forests located? Why are there no boreal forests in the Southern Hemisphere?



Tundra Biomes

As you arrive at your next stop, the driving wind gives you an immediate feel for this biome. The **tundra** is an extremely cold and dry biome. Expecting deep snow, many are surprised to learn that the tundra may receive no more precipitation than a desert.

Most of the soil in the tundra is frozen all year. This frozen soil is called **permafrost.** During the short summer, the top layer of soil thaws, but the underlying soil remains frozen. Because rainwater cannot soak into the permafrost, there are many shallow ponds and marshy areas on the tundra in the summer.

Tundra Plants Plants of the tundra include mosses, grasses, shrubs, and dwarf forms of a few trees, such as willows. Most of the plant growth takes place during the long days of the short summer season. North of the Arctic Circle, the sun does not set during midsummer.

Tundra Animals In summer, the animals you might remember most are insects. Insect-eating birds take advantage of the plentiful food and long days by eating as much as they can. But when winter approaches, these birds migrate south. Mammals of the tundra include caribou, foxes, wolves, and Arctic hares. The mammals that remain on the tundra during the winter grow thick fur coats. What can these animals find to eat on the tundra in winter? The caribou scrape snow away to find lichens. Wolves follow the caribou and look for weak members of the herd to prey upon.

Reading Checkpoint **What is permafrost?**

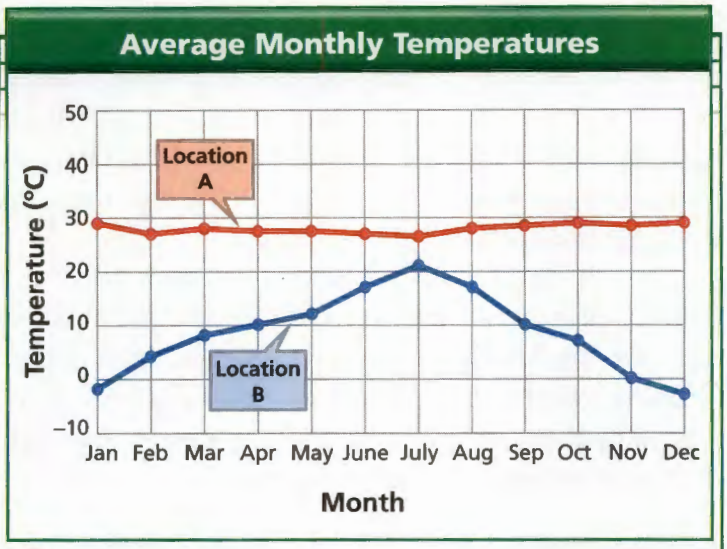
FIGURE 19
Tundra
Although it is frozen and seemingly barren in winter, the tundra in Alaska explodes with color in autumn.
Relating Cause and Effect *Why are there no tall trees on the tundra?*

Musk ox ▲

Math Analyzing Data

Biome Climates

An ecologist collected climate data from two locations. The graph shows the monthly average temperatures in the two locations. The total yearly precipitation in Location A is 250 cm. In Location B, the total yearly precipitation is 14 cm.



1. **Reading Graphs** What variable is plotted on the horizontal axis? On the vertical axis?
2. **Interpreting Data** Look over the graph. How would you describe the temperature over the course of a year in Location A? In Location B?
3. **Drawing Conclusions** Given the precipitation and temperature data for these locations, in which biome would you expect each to be located? Explain your answers.
4. **Predicting** What would you expect a temperature graph for your biome to look like? Draw a temperature graph for the biome in which you live.

Mountains and Ice

Some areas of land are not part of any major biome. These areas include mountain ranges and land that is covered with thick sheets of ice.

You read in Section 3 that the climate of a mountain changes from its base to its summit. If you were to hike all the way up a tall mountain, you would pass through a series of biomes. At the base, you might find grasslands. As you climbed, you might pass through deciduous forest and then boreal forest. As you neared the top, your surroundings would resemble the treeless tundra.

Other places are covered year-round with thick ice sheets. Most of the island of Greenland and the continent of Antarctica fall into this category. Organisms that are adapted to life on ice include emperor penguins, polar bears, and leopard seals.

Reading Checkpoint **What are two landmasses that are covered year-round with ice?**

FIGURE 20
Mountains
Pikas, such as this one, live in rocky mountain habitats. They spend much of their time in the summer gathering and storing plants for food. This behavior helps pikas survive through the long harsh winter.

Freshwater Ecosystems

On this part of the expedition, you will explore Earth's waters. Most of Earth's surface is covered with water, but only a tiny fraction is fresh water. **Freshwater ecosystems include streams, rivers, ponds, and lakes.** These ecosystems provide habitats for an amazing variety of organisms, from microscopic algae to huge bears.

Streams and Rivers Your first stop is a mountain stream. Where the stream begins, the cold, clear water flows rapidly. Animals that live here are adapted to the strong current. For example, insects and other small animals have hooks or suckers that help them cling to rocks. Trout have streamlined bodies that allow them to swim despite the rushing water. Few plants or algae can grow in this fast-moving water. Instead, first-level consumers rely on leaves and seeds that fall into the stream.

As the stream flows along, other streams join it. The current slows, and the water becomes cloudy with soil. The slower-moving water is warmer and contains less oxygen. This larger stream might now be called a river. Different organisms are adapted to life in a river. Plants take root among the pebbles on the river bottom. These producers provide food for young insects and homes for frogs and their tadpoles. These consumers, in turn, provide food for many larger consumers.

Ponds and Lakes Your next stop is a pond. Ponds and lakes are bodies of standing, or still, fresh water. Lakes are generally larger and deeper than ponds. Ponds are often shallow enough that sunlight can reach the bottom even in the center of the pond, allowing plants to grow there. In large ponds and most lakes, however, algae floating at the surface are the major producers.

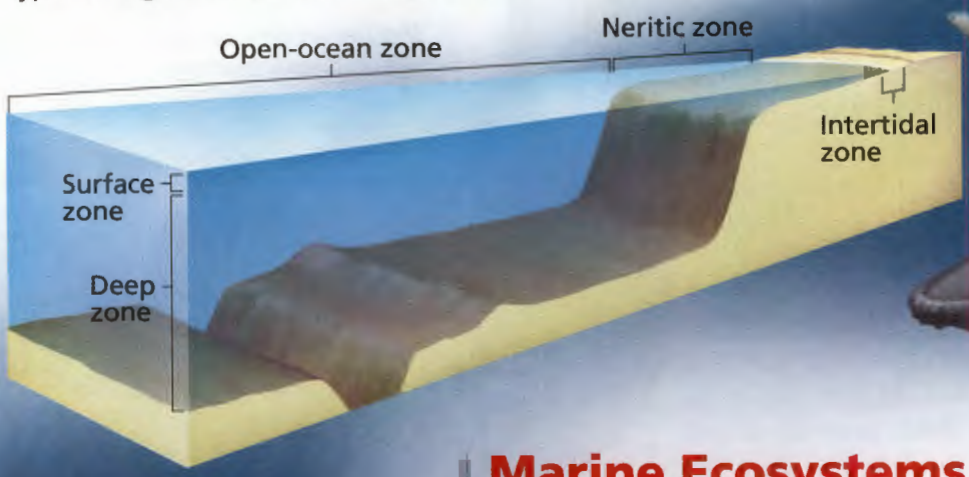
Many animals are adapted for life in the still water. Along the shore of the pond, you observe dragonflies, turtles, snails, and frogs. Sunfish live in the open water, feeding on insects and algae from the surface. Scavengers such as catfish live near the pond bottom. Bacteria and other decomposers also feed on the remains of other organisms.

FIGURE 21
A Pond Ecosystem
Ponds and lakes are freshwater ecosystems characterized by still water. Pickerelweed and herons are typical pond organisms.
Interpreting Photographs *How is the heron well-suited to its aquatic environment?*

FIGURE 22

Marine Ecosystems

The ocean is home to a number of different ecosystems. Factors such as water temperature and the amount of sunlight determine what types of organisms can live in each zone.



Marine Ecosystems

Now you head to the coast to explore some marine ecosystems. On your way, you'll pass through an estuary. An **estuary** (ES choo ehr ee), is found where the fresh water of a river meets the salt water of the ocean. Algae and plants such as marsh grasses provide food and shelter for numerous animals, including crabs, worms, clams, and fish. Many animals use the calm waters of estuaries for breeding grounds. **Marine ecosystems include estuaries, intertidal zones, neritic zones, and the open ocean.**

Intertidal Zone Next, you walk along the rocky shoreline. Here, between the highest high-tide line and the lowest low-tide line, is the **intertidal zone.** Organisms here must be able to survive pounding waves and sudden changes in water levels and temperature that occur with high and low tides. Animals such as barnacles and sea stars cling to the rocks. Others, such as clams and crabs, burrow in the sand.

Neritic Zone Now you set out to sea. The edge of a continent extends into the ocean for a short distance, like a shelf. Below the low-tide line is a region of shallow water called the **neritic zone** (nuh RIT ik), which extends over the continental shelf.

Because sunlight passes through the shallow water of the neritic zone, photosynthesis can occur. As a result, this zone is particularly rich in living things. Many large schools of fish, such as sardines, feed on algae. In warm ocean waters, coral reefs may form. Coral reefs provide living homes to a wide variety of other organisms.

The Open Ocean Out in the open ocean, light penetrates only a few hundred meters deep. Algae carry out photosynthesis in this region of the open ocean, known as the surface zone. Many marine animals depend on the algae for food.

The deep zone is located below the surface zone. The deep zone is almost totally dark. Most animals in this zone feed on the remains of organisms that sink down from the surface zone. The deepest parts of the deep zone are home to bizarre-looking animals, such as giant squid whose eyes glow in the dark.

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Section 4 Assessment

Target Reading Skill **Comparing and Contrasting** Use the information in your table about biomes to help you answer Question 1.

Reviewing Key Concepts

1. a. **Listing** What are the six major biomes?
   b. **Comparing and Contrasting** How are the three forest biomes alike? How are they different?
   c. **Inferring** A plain is dry, bitterly cold, and contains a few, short plants scattered about. What biome might this describe?
2. a. **Reviewing** What two factors are most important in determining an area's biome?
   b. **Relating Cause and Effect** If deserts and tundras receive similar amounts of rainfall, why are these two biomes so different?
   c. **Applying Concepts** Why would hiking up a tall mountain be a good way to observe how climate determines an area's biome?
3. a. **Reviewing** What are some freshwater ecosystems? What are some marine ecosystems?
   b. **Explaining** Why is sunlight an important abiotic factor in all aquatic ecosystems?

Writing in Science

Firsthand Account Choose one of the biomes and write a journal entry detailing the observations you made during your expedition. Describe sights, sounds, and smells you experienced as well as specific details about the organisms you observed.

Lab zone Skills Lab

Change in a Tiny Community

Problem

How does a pond community change over time?

Skills Focus

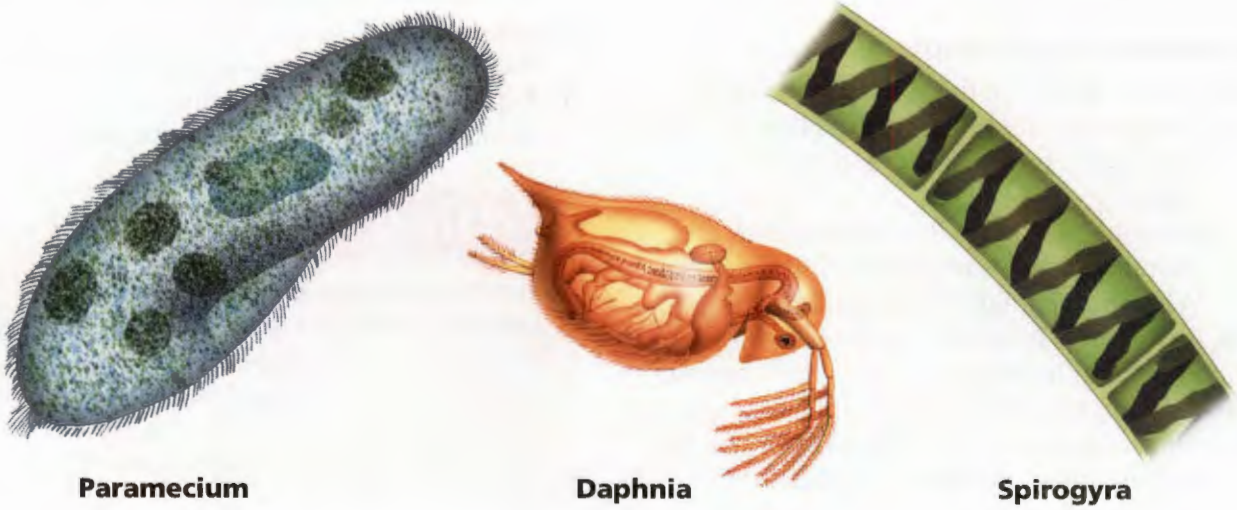
observing, classifying

Materials

- hay solution
- pond water
- small baby-food jar
- wax pencil
- plastic dropper
- microscope slide
- coverslip
- microscope

Procedure

1. Use a wax pencil to label a small jar with your name.
2. Fill the jar about three-fourths full with hay solution. Add pond water until the jar is nearly full. Examine the mixture, and record your observations in your notebook.
3. Place the jar in a safe location out of direct sunlight where it will remain undisturbed. Always wash your hands thoroughly with soap after handling the jar or its contents.
4. After two days, examine the contents of the jar, and record your observations.
5. Use a plastic dropper to collect a few drops from the surface of the solution in the jar. Make a slide following the procedures in the box at the right. **CAUTION:** *Slides and coverslips are fragile, and their edges are sharp. Handle them carefully.*
6. Examine the slide under a microscope, using both low and high power and following the procedures in the box at the right. Draw each type of organism you observe. Estimate the number of each type in your sample. The illustration below shows some of the organisms you might see.
7. Repeat Steps 5 and 6 with a drop of solution taken from the side of the jar beneath the surface.
8. Repeat Steps 5 and 6 with a drop of solution taken from the bottom of the jar. When you are finished, follow your teacher's directions about cleaning up.
9. After 3 days, repeat Steps 5 through 8.
10. After 3 more days, repeat Steps 5 through 8 again. Then follow your teacher's directions for returning the solution.



Paramecium **Daphnia** **Spirogyra**

Making and Viewing a Slide

A. Place one drop of the solution to be examined in the middle of a microscope slide. Place one edge of a coverslip at the edge of the drop, as shown in the photo. Gently lower the coverslip over the drop. Try not to trap any air bubbles.

B. Place the slide on the stage of a microscope so the drop is over the opening in the stage. Adjust the stage clips to hold the slide.

C. Look from the side of the microscope, and use the coarse adjustment knob to move the low-power objective close to, but not touching, the coverslip.

D. Look through the eyepiece, and use the coarse adjustment knob to raise the body tube and bring the slide into view. Use the fine adjustment knob to bring the slide into focus.

E. To view the slide under high power, look from the side of the microscope, and revolve the nosepiece until the high-power objective clicks into place just over, but not touching, the slide.

F. While you are looking through the eyepiece, use the fine adjustment knob to bring the slide into focus.

Analyze and Conclude

1. **Classifying** Identify as many of the organisms you observed as possible. Use the diagrams on the facing page and any other resources your teacher provides.
2. **Observing** How did the community change over the period of time that you made your observations?
3. **Inferring** What biotic and abiotic factors may have influenced the changes in this community? Explain.
4. **Developing Hypotheses** Where did the organisms you observed in the jar come from?
5. **Communicating** Based on what you have observed in this lab, write a paragraph that explains why ecosystems change gradually over time. Be sure to discuss the important factors that lead to changes in ecosystems.

Design an Experiment

Write a hypothesis about what would happen if you changed one biotic or abiotic factor in this activity. Design a plan to test your hypothesis. *Obtain your teacher's permission before carrying out your investigation.*

Chapter 22

Study Guide

The BIG Idea **Cycles of Matter and Energy** In ecosystems, matter cycles between organisms and the environment. Energy from sunlight is not recycled, but moves through organisms in food chains.

1 Energy Flow in Ecosystems

Key Concepts

- Each organism in an ecosystem fills the energy role of producer, consumer, or decomposer.
- The movement of energy through an ecosystem can be shown in diagrams called food chains and food webs.
- As you move up an energy pyramid, each level has less energy available than the level below.

Key Terms

producer
consumer
herbivore
carnivore
omnivore
scavenger
decomposer
food chain
food web
energy pyramid

2 Cycles of Matter

Key Concepts

- The processes of evaporation, condensation, and precipitation make up the water cycle.
- In ecosystems, the processes by which carbon and oxygen are recycled are linked. Producers, consumers, and decomposers play roles in recycling carbon and oxygen.
- Nitrogen cycles from the air to the soil, into living things, and back into the air.

Key Terms

water cycle
evaporation
condensation
precipitation
nitrogen fixation

3 Biogeography

Key Concepts

- One factor that has affected how species are distributed is the motion of Earth's continents.
- Dispersal can be caused by wind, water, or living things, including humans.
- Three factors that limit dispersal of a species are physical barriers, competition, and climate.

Key Terms

biogeography
continental drift
dispersal
exotic species
climate

4 Biomes and Aquatic Ecosystems

Key Concepts

- The six major biomes that most ecologists study are the rain forest, desert, grassland, deciduous forest, boreal forest, and tundra.
- It is mostly the temperature and precipitation in an area that determines its biome.
- Freshwater ecosystems include streams, rivers, ponds, and lakes.
- Marine ecosystems include estuaries, intertidal zones, neritic zones, and the open ocean.

Key Terms

biome
canopy
understory
desert
grassland
savanna
deciduous tree
coniferous tree
tundra
permafrost
estuary
intertidal zone
neritic zone

Review and Assessment

Go Online
PHSchool.com
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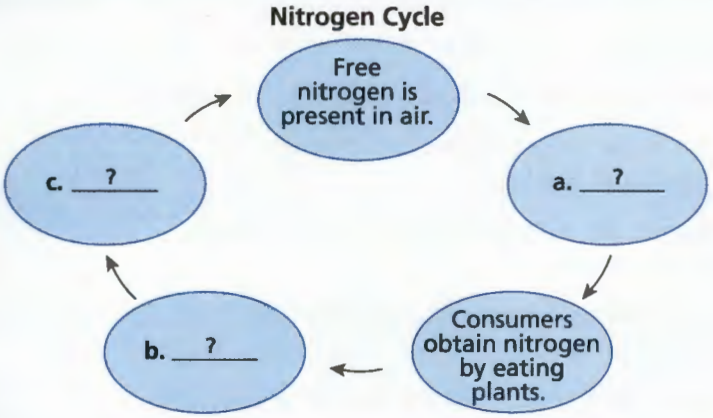
Organizing Information

Sequencing Copy the cycle diagram about the nitrogen cycle onto a separate sheet of paper. Then complete it. (For more on Sequencing, see the Skills Handbook.)



Reviewing Key Terms

Choose the letter of the best answer.

1. Which of the following organisms are typical decomposers?
   a. grasses and ferns
   b. mushrooms and bacteria
   c. mice and deer
   d. lions and snakes
2. A diagram that shows how much energy is available at each feeding level in an ecosystem is a(n)
   a. food chain. **b.** food web.
   c. water cycle. **d.** energy pyramid.
3. When drops of water in a cloud become heavy enough, they fall to Earth as
   a. condensation. **b.** evaporation.
   c. permafrost. **d.** precipitation.
4. Organisms may be dispersed in all the following ways *except* by
   a. wind.
   b. water.
   c. temperature.
   d. other organisms.
5. Much of Canada is covered in fir and spruce forests. The winter is cold and long. What is this biome?
   a. tundra
   b. boreal forest
   c. deciduous forest
   d. grassland

If the statement is true, write *true*. If it is false, change the underlined word or words to make the statement true.

6. An organism that eats the remains of dead organisms is called a(n) herbivore.
7. The study of where organisms live is called continental drift.
8. Precipitation and temperature are the two major abiotic factors that determine what types of plants can grow in an area.

Writing in Science

Encyclopedia Entry Write a half-page encyclopedia entry about life in the desert. Describe at least two plants and animals that live in the desert. Focus on the adaptations that allow these organisms to thrive in the harsh environment.

Discovery Channel School
Ecosystems and Biomes
Video Preview
Video Field Trip
Video Assessment

Review and Assessment

Checking Concepts

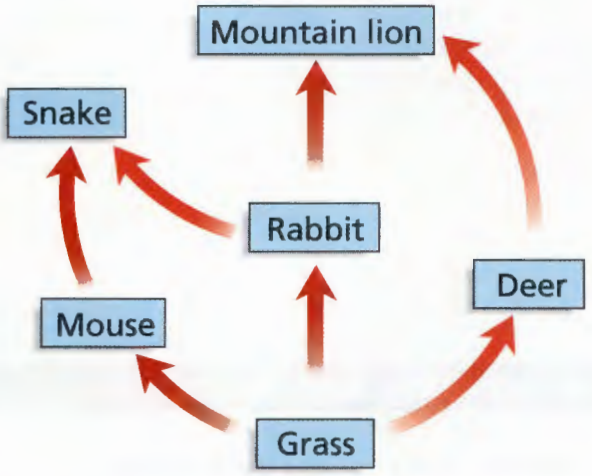
9. Name and describe each of the three energy roles organisms can play in an ecosystem.
10. How are food chains and food webs different?
11. What is the source of energy for most ecosystems? Explain.
12. Describe the role of nitrogen-fixing bacteria in the nitrogen cycle.
13. Explain how competition can affect the dispersal of species.
14. Why is the tropical rain forest able to support so many species?
15. In which biome would you find large herbivores such as elephants and zebras? Explain.
16. Describe the role of algae in freshwater and marine ecosystems.

Thinking Critically

17. **Inferring** Polar bears are very well adapted to life around the Arctic Ocean. Their white fur camouflages them in the snow. They can withstand freezing temperatures for a long time. They can swim and hunt in very cold water. Is the distribution of polar bears limited by physical barriers, competition, or climate? Explain your answer.
18. **Comparing and Contrasting** How are the temperate rain forest and the tropical rain forest similar? How are they different?
19. **Predicting** A chemical spill has just killed off all the algae in a part of the surface zone in the open ocean. How will this accident affect the food webs in that part of the surface zone?
20. **Classifying** Which organisms in the illustration are producers? Consumers?

Applying Skills

Use the diagram of a food web below to answer Questions 21–24.



21. **Interpreting Diagrams** Which organism in this food web fills the role of producer?
22. **Classifying** Specify whether each consumer in this food web is a first-level, second-level, or third-level consumer.
23. **Inferring** Which level of the food web contains the greatest amount of available energy?
24. **Predicting** If a disease were to kill most of the rabbits in this area, predict how the snakes, deer, and mountain lions would be affected.

Lab zone Chapter Project

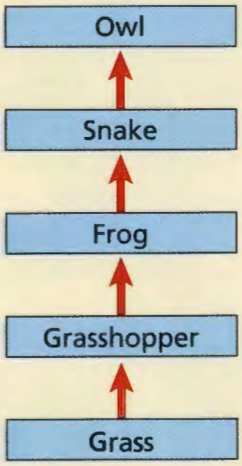
Performance Assessment Create a report, poster, or other product that clearly presents your data and conclusions from your decomposition experiment. In your notebook, compare your results to your predictions about the different waste materials in the compost mixture. Were you surprised by any of your results? Based on what you have learned from your project and those of your classmates, make a list of the ideal conditions for decomposition.

Standardized Test Prep

Test-Taking Tip

Interpreting a Diagram

When answering questions about diagrams, examine the diagram carefully, including labels. Ask yourself what the diagram is about and what it shows you. Make sure that you understand the meaning of any arrows. For example, the arrows in the diagram below indicate the direction of energy flow from producers to consumers in a food chain.



Sample Question

In the food chain shown in the diagram, which of the following organisms obtains its energy directly from the frog?

A the grass
B the grasshopper
C the snake
D the owl

Answer

The correct answer is **C**. By looking at the arrows in the diagram, you can see that the energy flows in this food chain directly from the frog to the snake.

Choose the letter of the best answer.

1. You are in an area in Maryland where the fresh water of the Chesapeake Bay meets the Atlantic Ocean. What type of habitat are you in?

A a neritic zone
B an intertidal zone
C an estuary
D the tundra

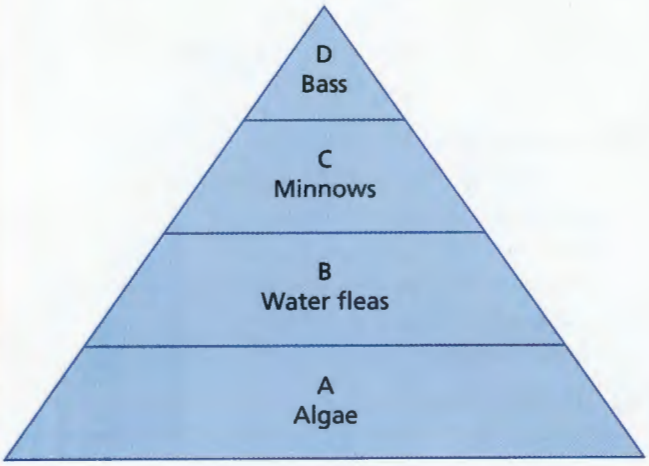
2. Which pair of terms could apply to the same organism?

F carnivore and producer
G decomposer and consumer
H scavenger and herbivore
J carnivore and consumer

3. You and your classmates have just set up a terrarium in a jar using gravel, moist soil, leafy plants, and mosses. The day after the jar was sealed, you noticed water droplets on the inside of the jar. What process caused the water droplets to form?

A evaporation
B condensation
C precipitation
D surface runoff

Use the energy pyramid diagram below and your knowledge of science to answer Questions 4 and 5.



4. Which organisms are the producers in this ecosystem?

F algae
G minnows
H water fleas
J bass

5. At which level of this energy pyramid is the LEAST energy available?

A level A
B level B
C level C
D level D

Constructed Response

6. Explain how the processes by which carbon and oxygen cycle through the atmosphere are interrelated.