Chapter 22

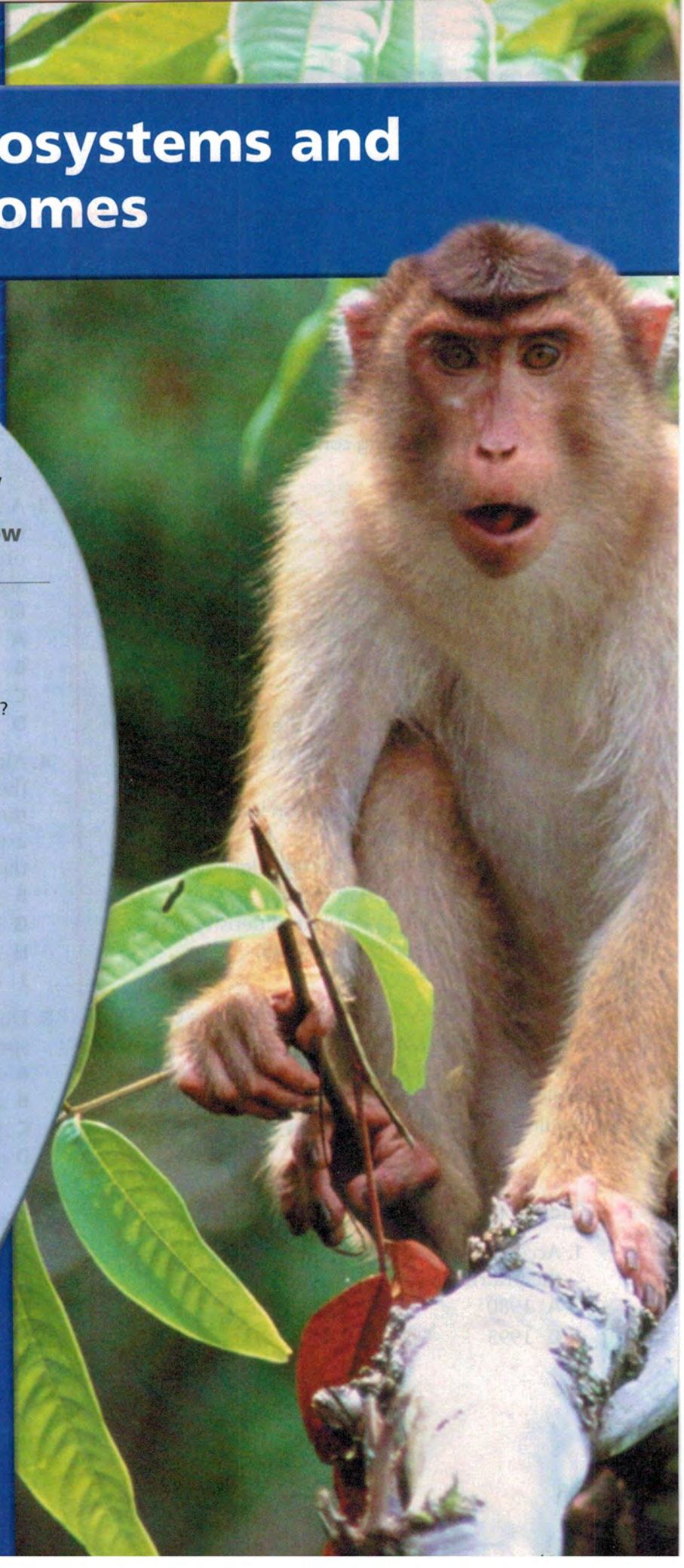
Ecosystems and Biomes

The BIG Idea

Cycles of Matter and Energy

How do matter and energy flow through ecosystems?

Chapter Preview

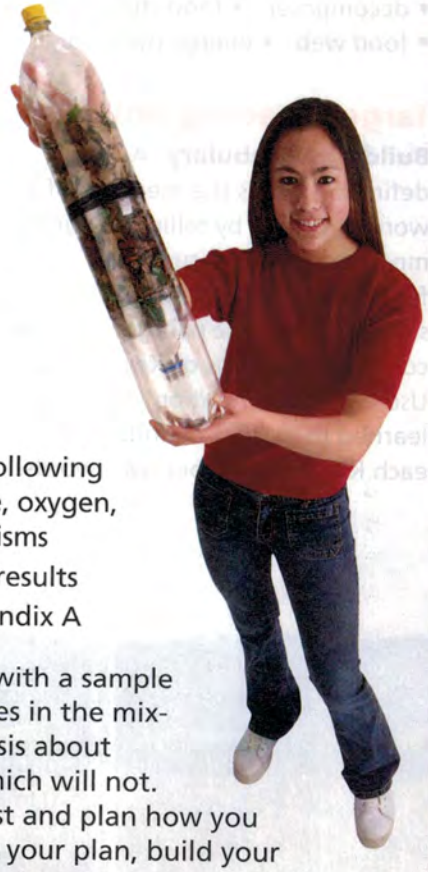


This macaque adds to the rich diversity of organisms in the tropical rain forest. ▶

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?**

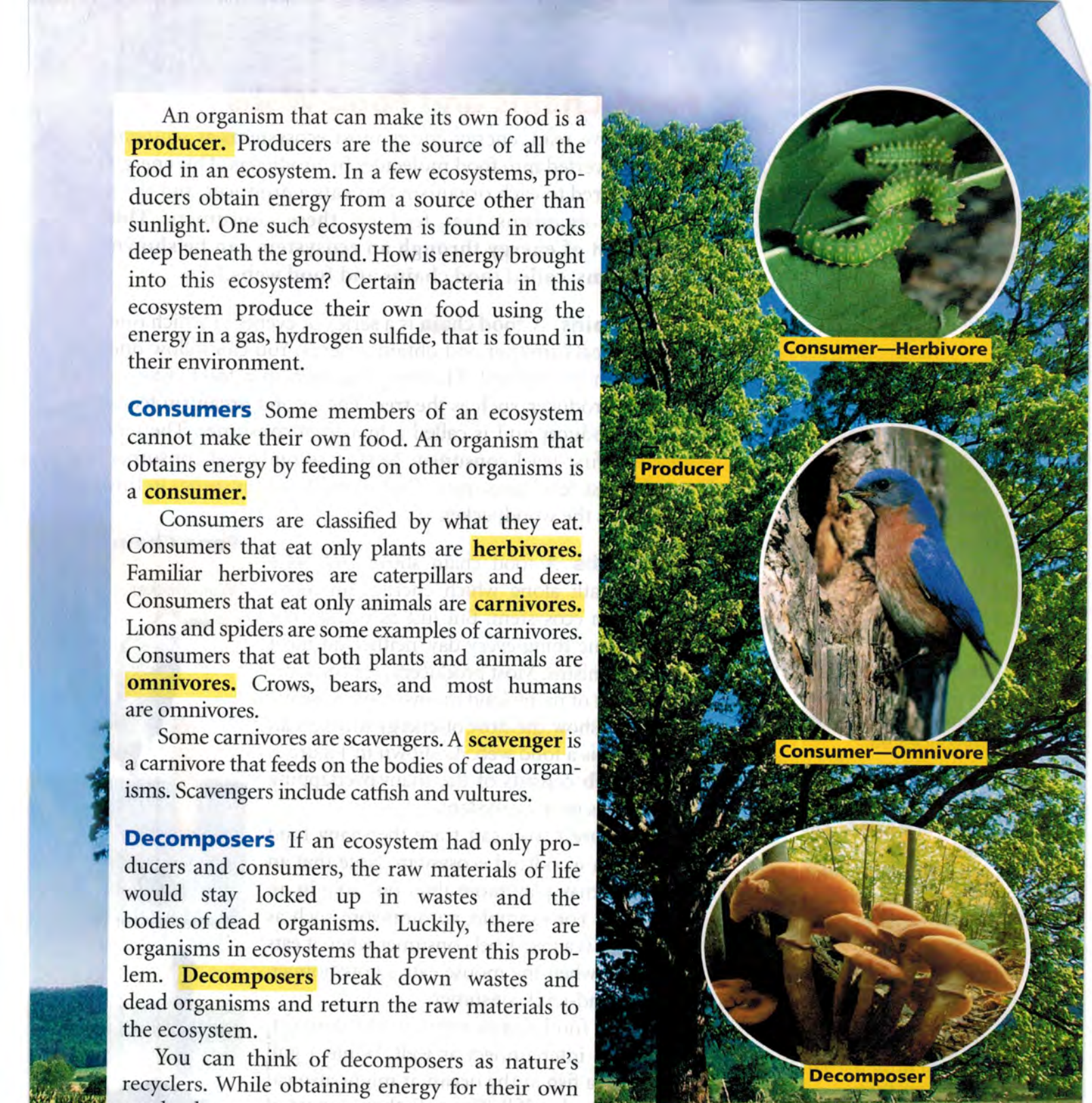


FIGURE 1
Energy Roles
Each organism in an ecosystem fills a specific energy role. Producers, such as oak trees, make their own food. Consumers, such as luna moth larvae and eastern bluebirds, obtain energy by feeding on other organisms. **Classifying** *What role do decomposers play in ecosystems?*

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For: Links on food chains and food webs
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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.**

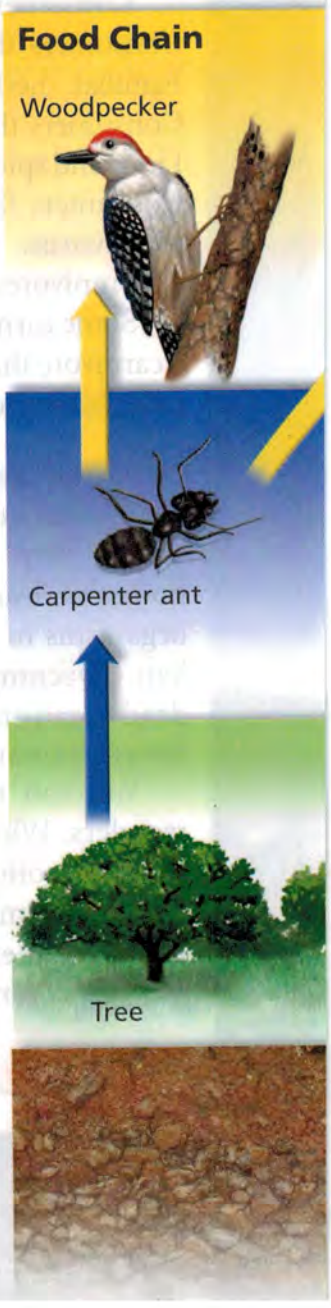
Food Chains A **food chain** is a series of events in which one organism eats another and obtains energy. You can follow one food chain in Figure 2. The first organism in a food chain is always a producer, such as the tree. The second organism feeds on the producer and is called a first-level consumer.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

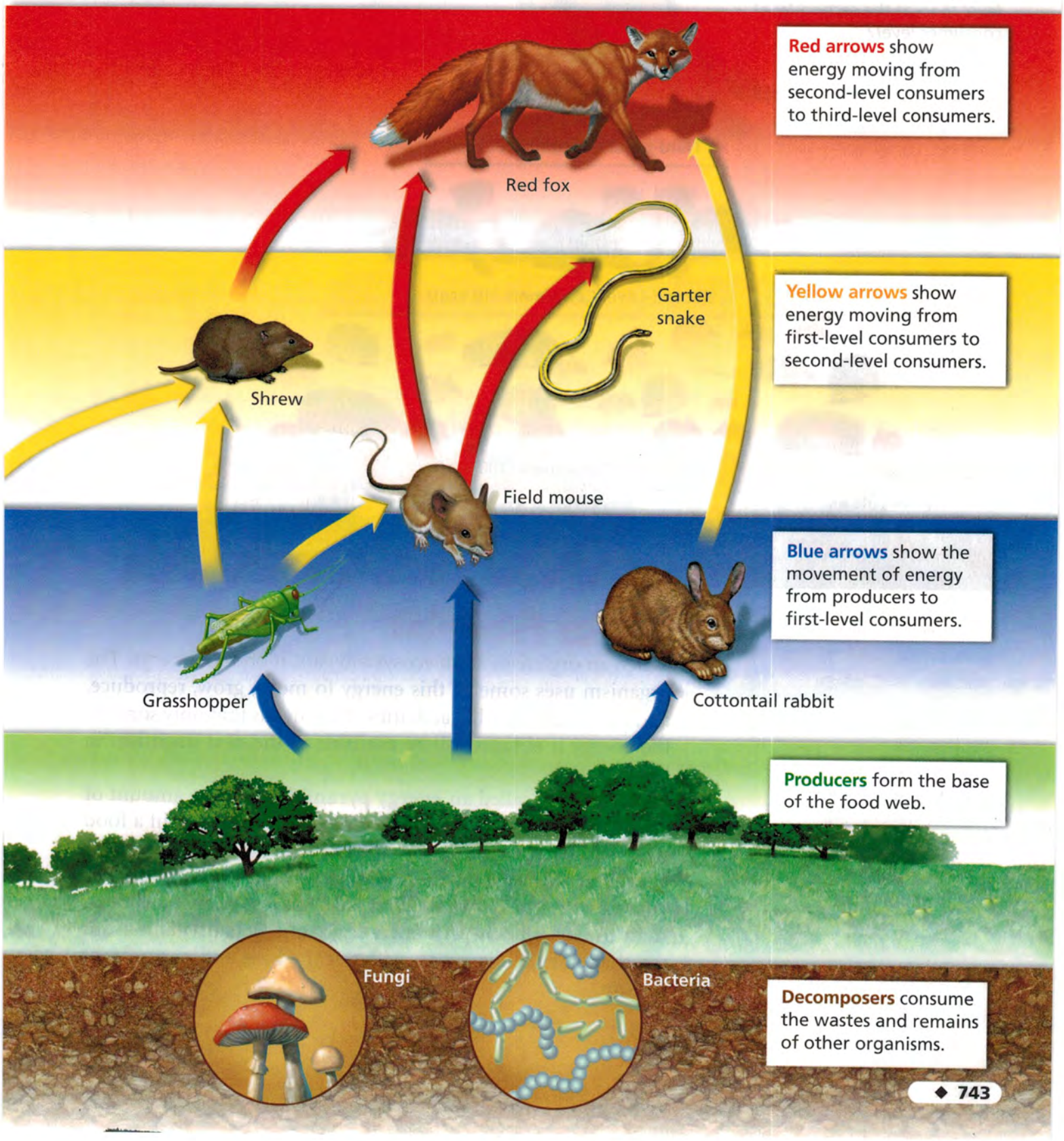
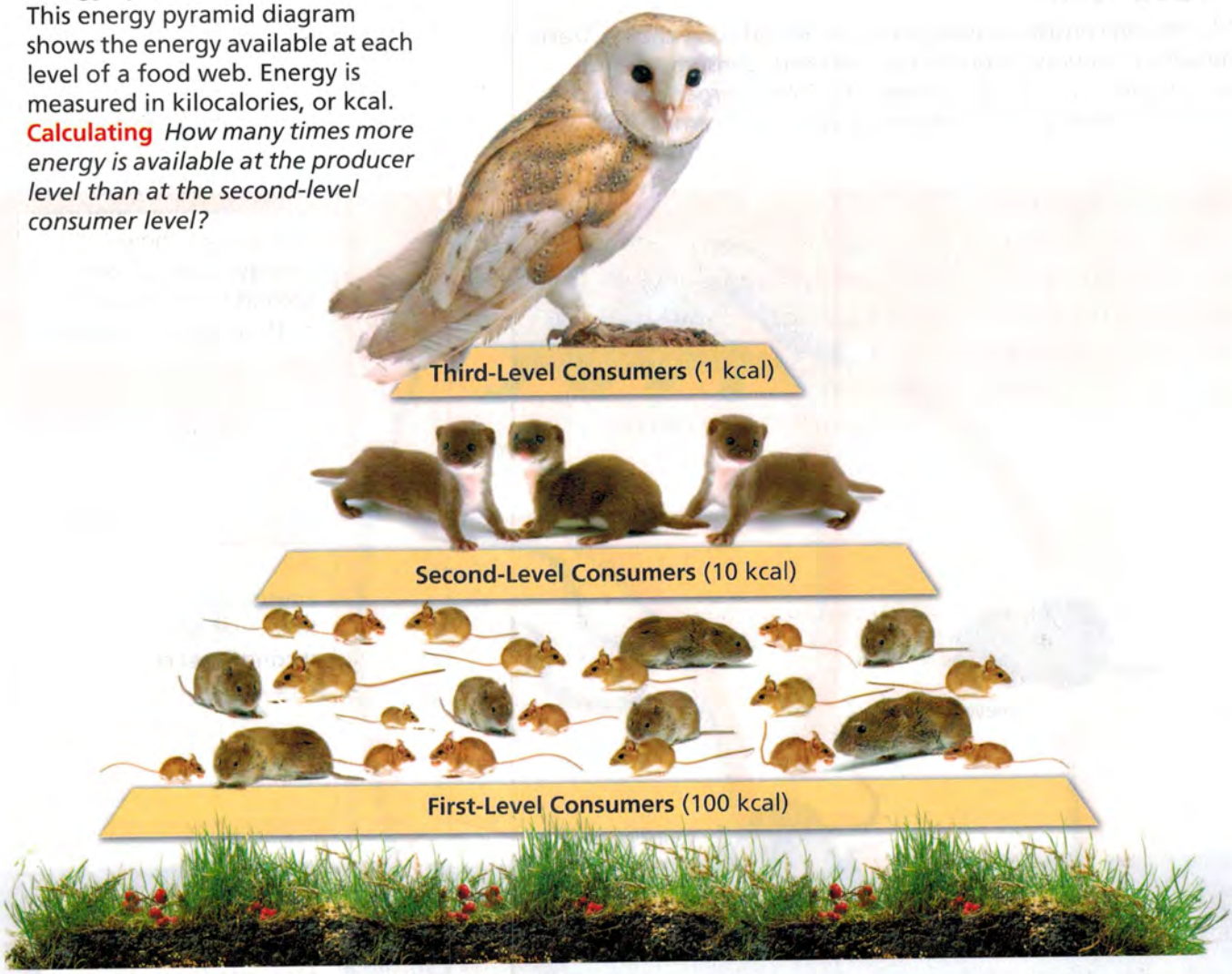


FIGURE 3
Energy Pyramid
This energy pyramid diagram shows the energy available at each level of a food web. Energy is measured in kilocalories, or kcal.
Calculating *How many times more energy is available at the producer level than at the second-level consumer level?*



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.

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?

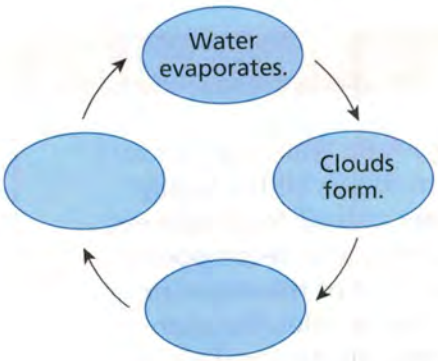
Key Terms

- 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.

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.

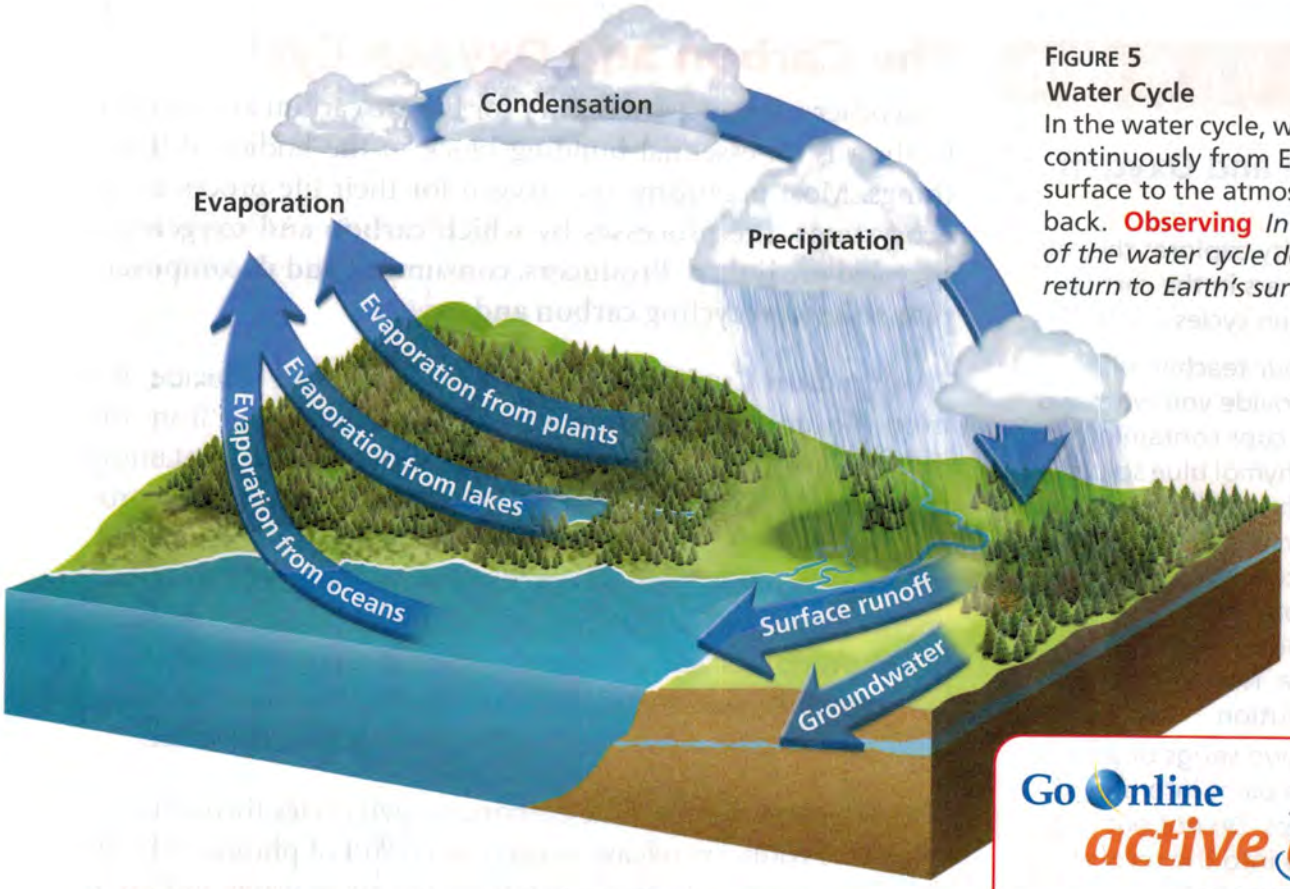


FIGURE 5
Water Cycle
In the water cycle, water moves continuously from Earth's surface to the atmosphere and back. **Observing** *In which step of the water cycle does water return to Earth's surface?*

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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?**

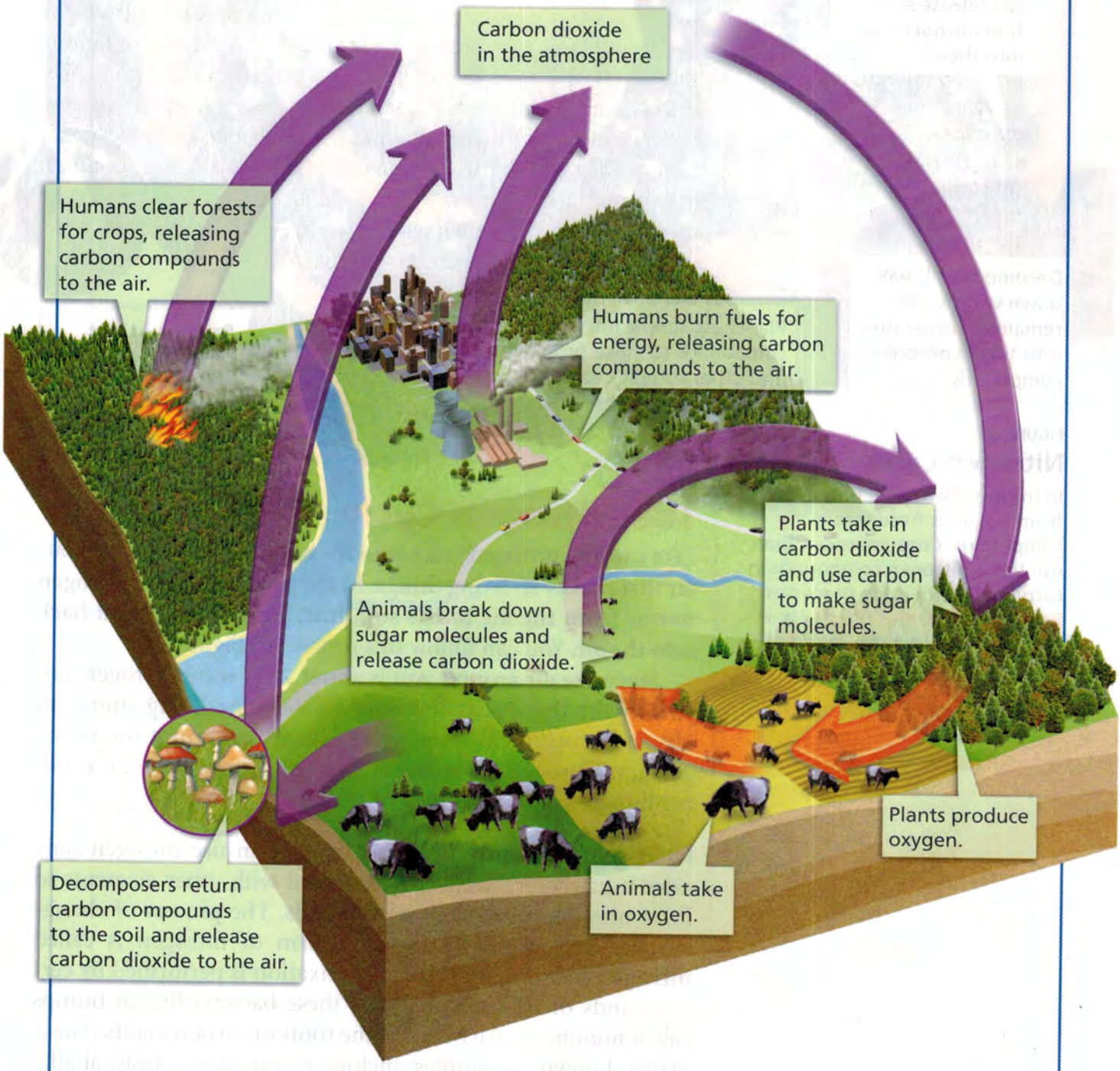
FIGURE 6
Rising Carbon Dioxide Levels
When forests burn, large amounts of carbon dioxide are released into the air. In addition, there are fewer trees available to absorb carbon dioxide from the air.

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?*



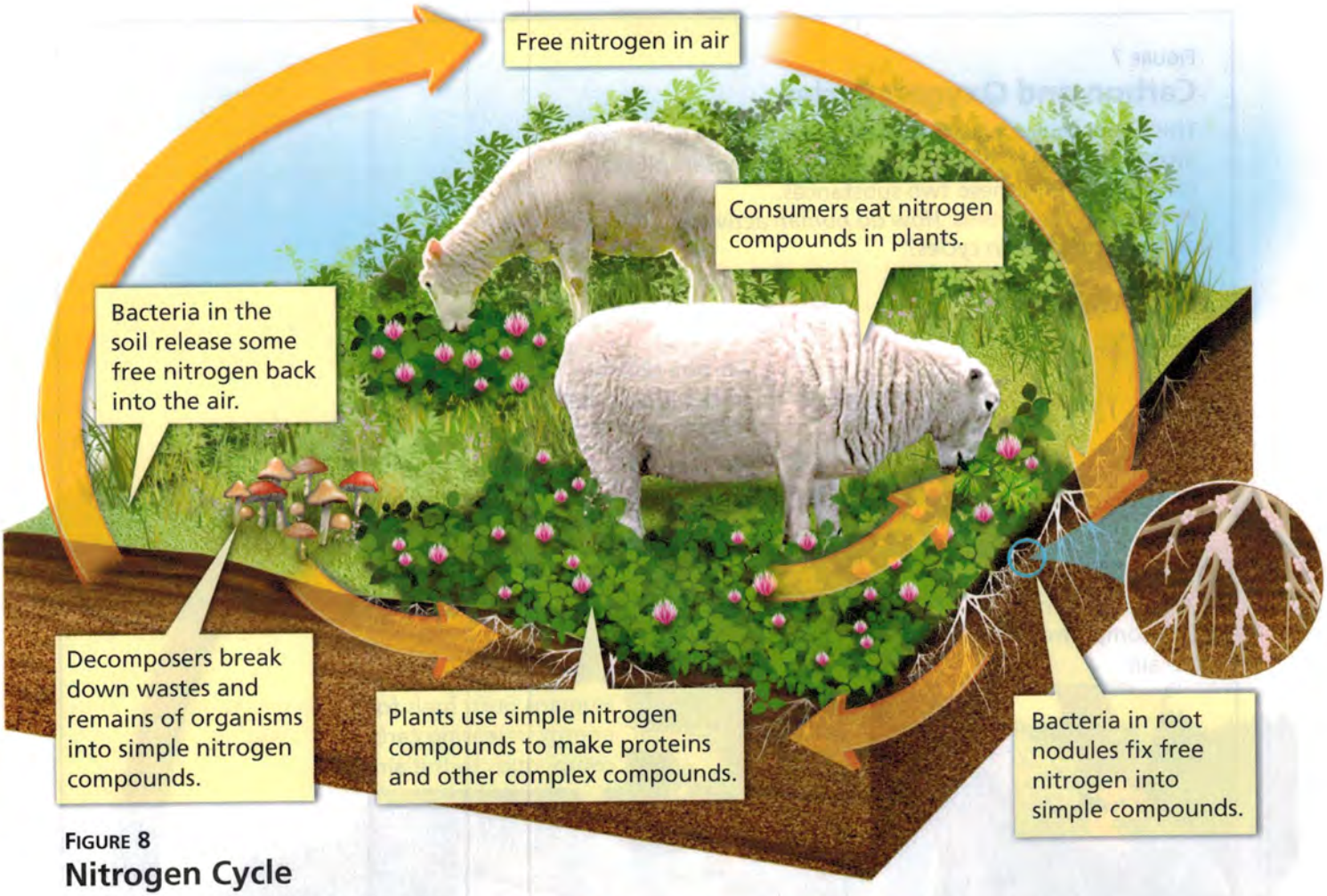


FIGURE 8
Nitrogen Cycle
In the nitrogen cycle, free nitrogen from the air is fixed into compounds. Consumers can then use these nitrogen compounds in carrying out their life processes. **Relating Cause and Effect** *How does nitrogen get returned to the environment?*

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

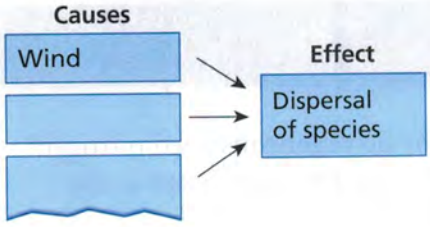
- How has the movement of the continents affected the distribution of species?
- What are three ways that dispersal of organisms occurs?
- What factors can limit the dispersal of a species?

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.

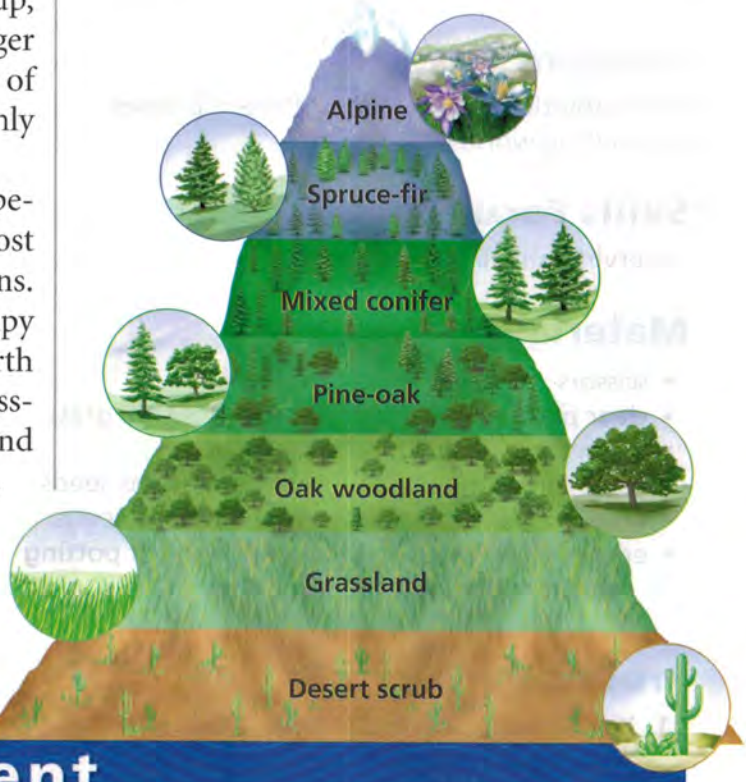
Competition When an organism enters a new area, it must compete for resources with the species already there. To survive, the organism must find a unique niche. Existing species may outcompete the new species. In this case, competition is a barrier to dispersal. Sometimes, however, new species outcompete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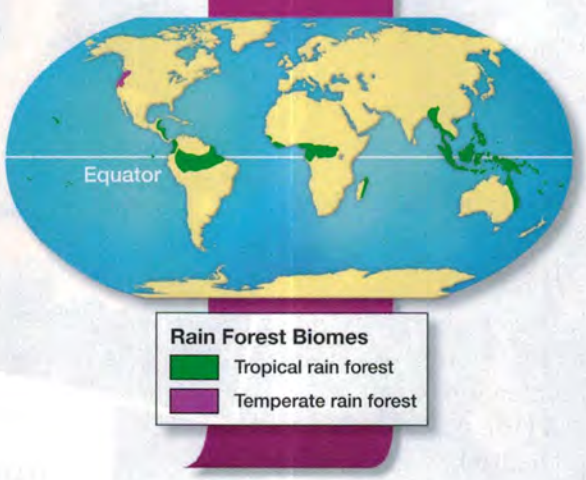


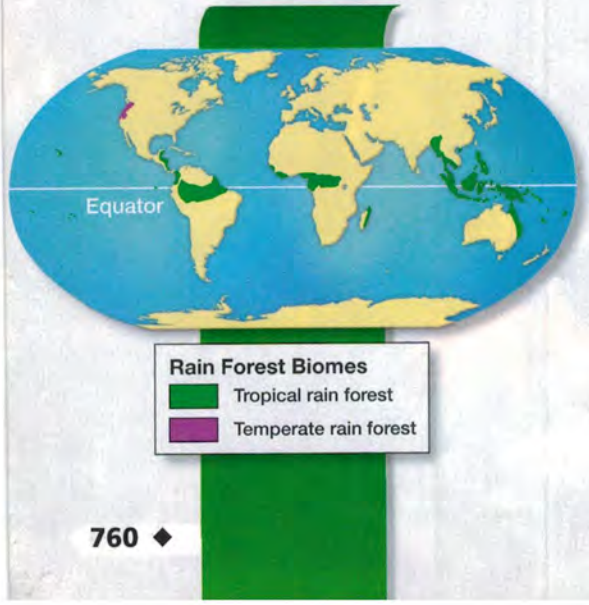
FIGURE 13 Temperate Rain Forest
Temperate rain forests receive a great deal of rain and have moderate temperatures. Mule deer are commonly found in the Olympic Rain Forest in Washington State. **Interpreting Maps** *Where is one temperate rain forest located?*

◀ 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.

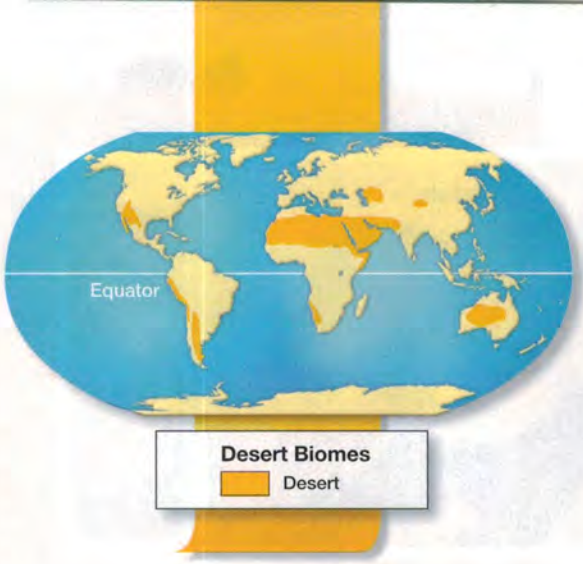
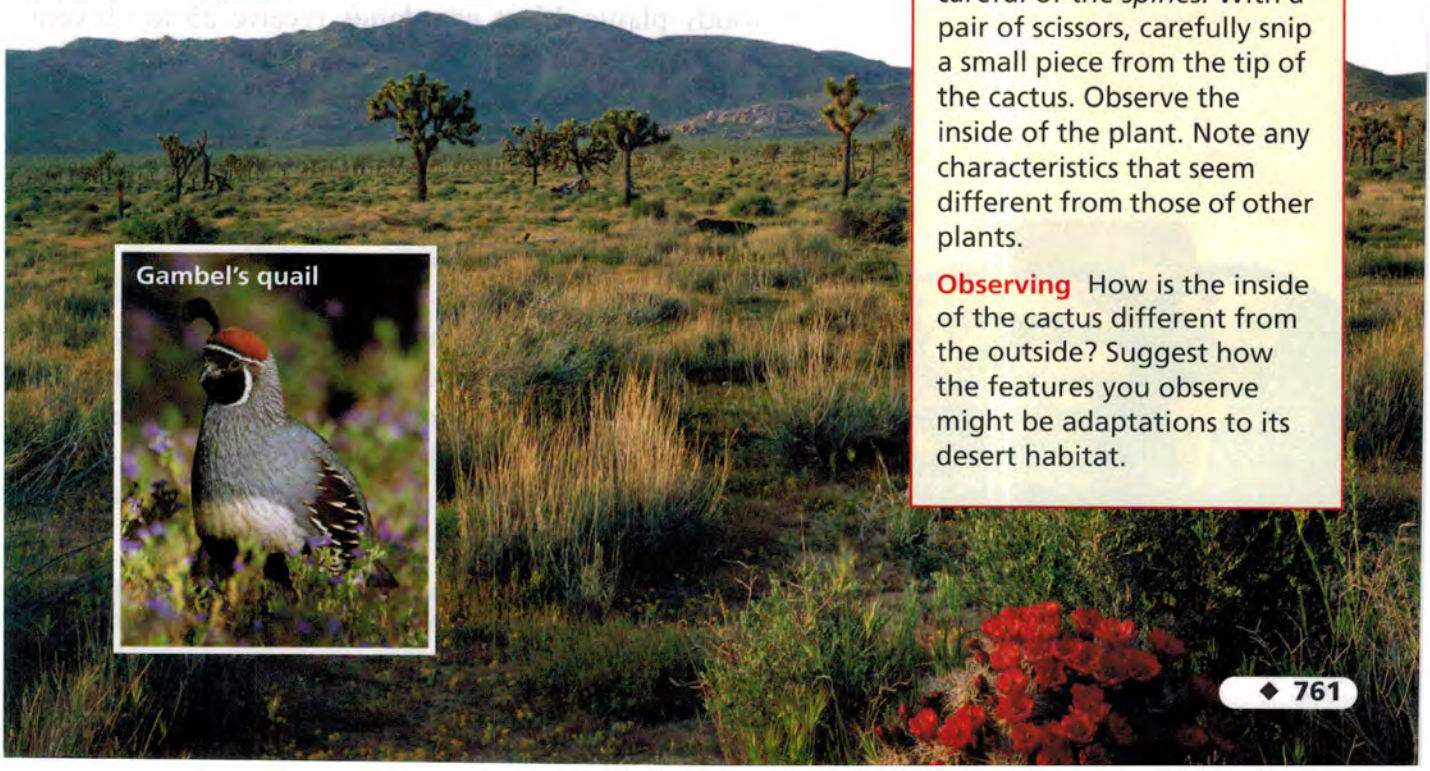


FIGURE 15
Desert
The Mojave Desert in the southwestern United States is a typical hot desert.
Making Generalizations *Describe the climate conditions of a typical desert.*



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.

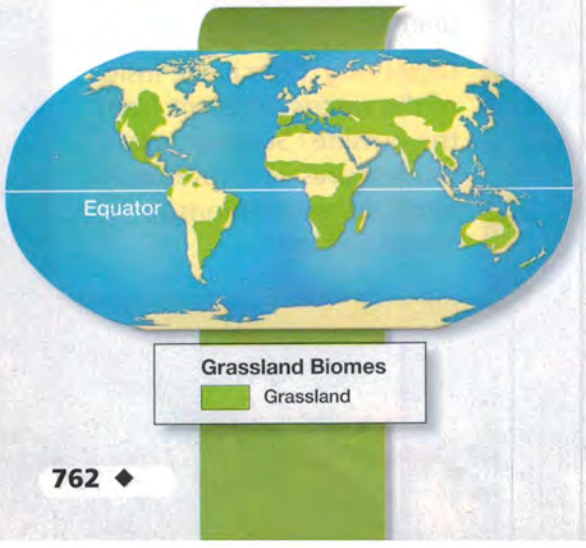
FIGURE 16
Savanna
Migrating wildebeest make their way across a vast Kenyan savanna. A savanna is one type of grassland biome—an area populated mostly by grasses and other non-woody plants.

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?**

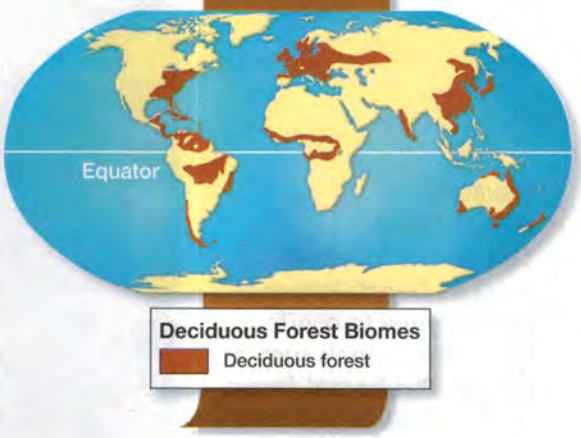


FIGURE 17
Deciduous Forest
This forest is a beautiful example of a deciduous forest in autumn. Most of the trees in a deciduous forest have leaves that change color and drop each autumn.
Comparing and Contrasting *How do deciduous forests differ from rain forests?*

▼ Southern flying squirrel

▼ Red fox

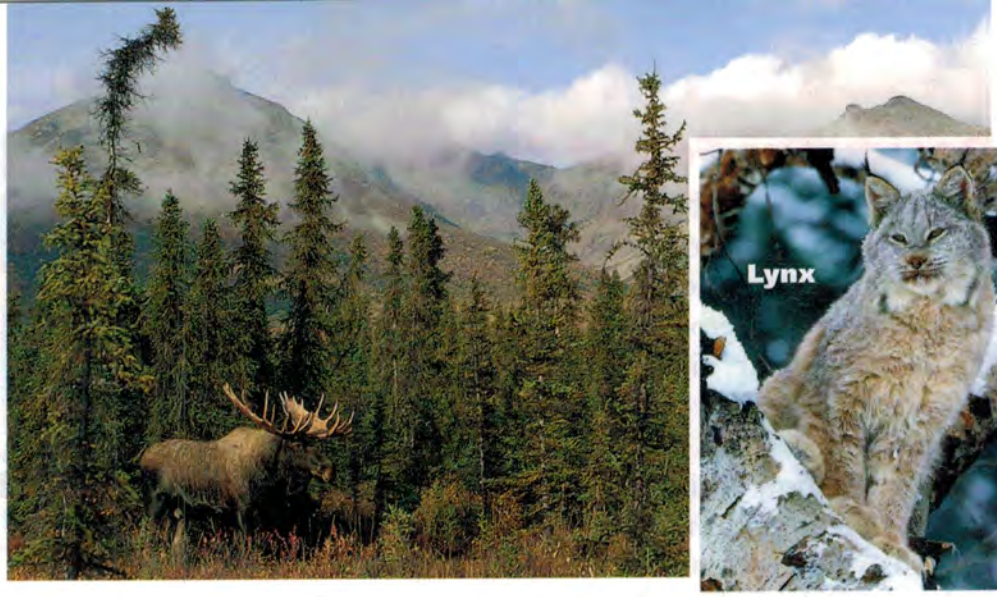


FIGURE 18
Boreal Forest
This boreal forest in Alaska's Denali National Park is home to coniferous trees and animals such as moose. The boreal forest is often called the "spruce-moose" forest.

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.

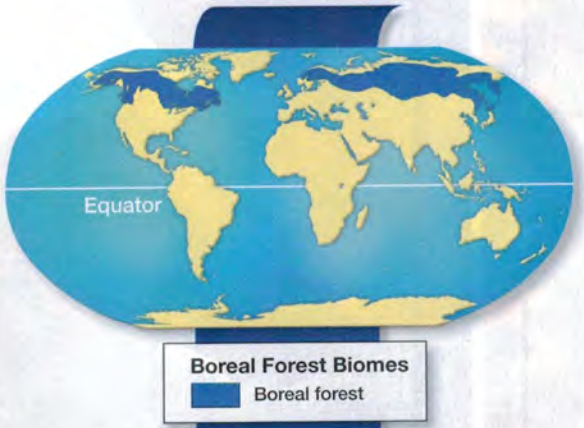
Boreal Forest Animals Many of the animals of the boreal forest eat the seeds produced by the coniferous trees. These animals include red squirrels, insects, and birds such as finches and chickadees. Some herbivores, such as snowshoe hares, moose, and beavers, eat tree bark and new shoots. The variety 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?**

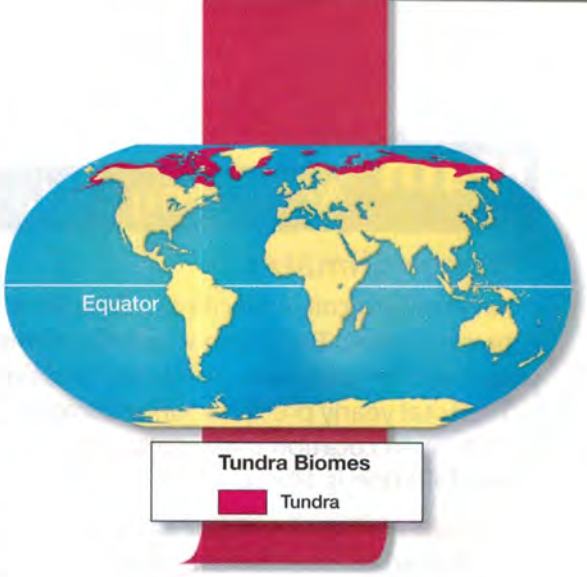


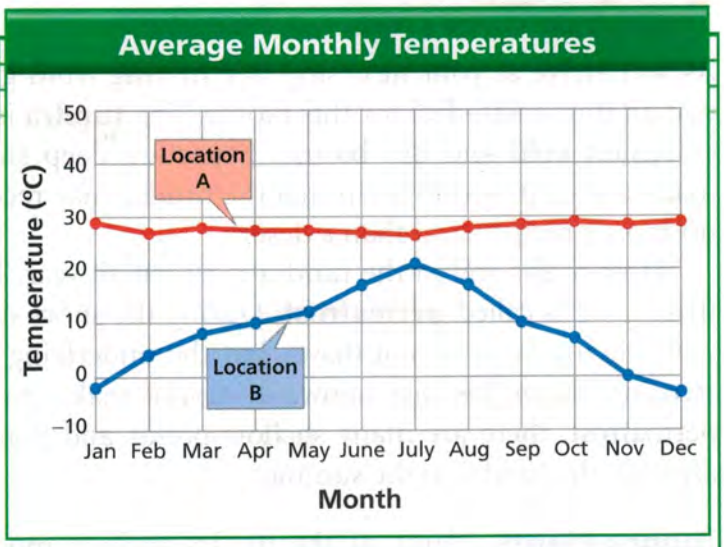
FIGURE 19
Tundra
Although it is frozen and seemingly barren in winter, the tundra in Alaska explodes with color in autumn.
Relating Cause and Effect *Why are there no tall trees on the tundra?*

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.

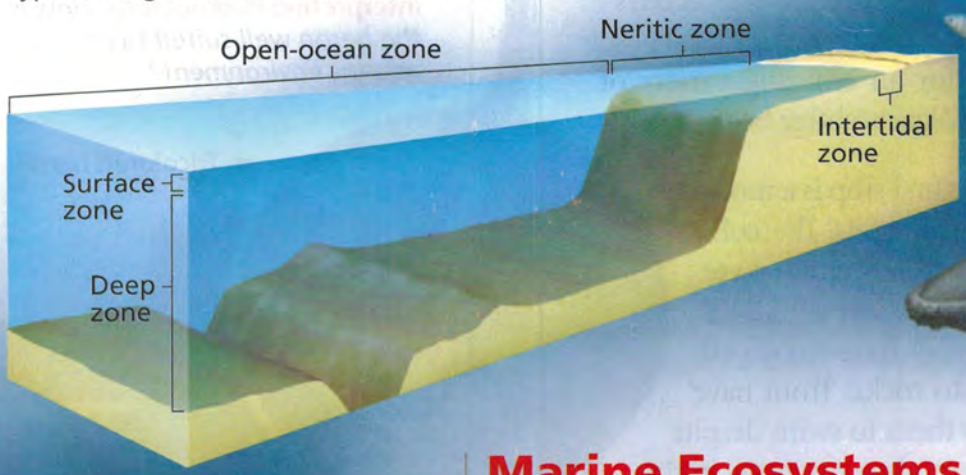
Many animals are adapted for life in the still water. Along the shore of the pond, you observe dragonflies, turtles, snails, and frogs. Sunfish live in the open water, feeding on insects and algae from the surface. Scavengers such as catfish live near the pond bottom. Bacteria and other decomposers also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

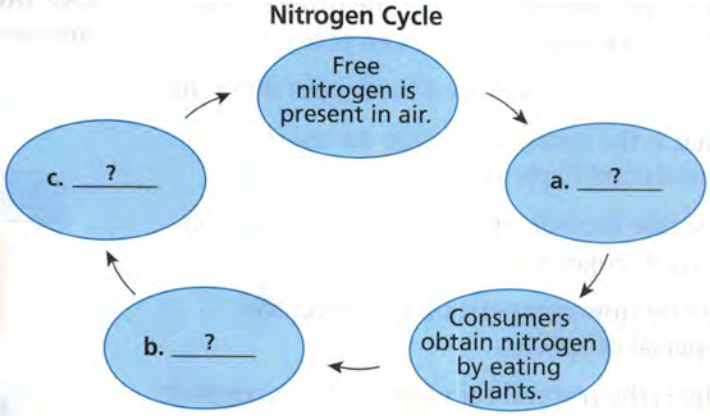
biome
canopy
understory
desert
grassland
savanna
deciduous tree
coniferous tree
tundra
permafrost
estuary
intertidal zone
neritic zone

Review and Assessment

Go Online
PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cha-4220

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

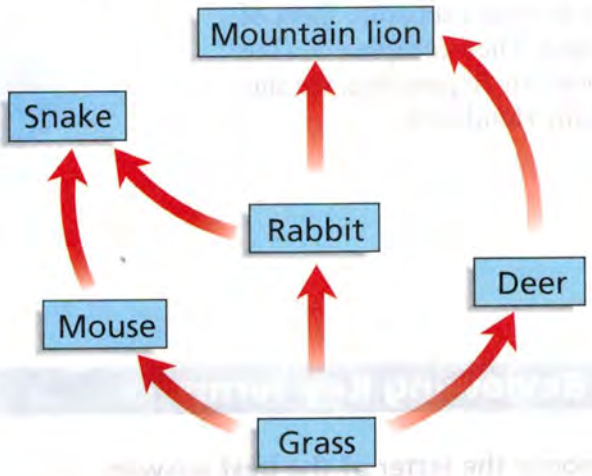
9. Name and describe each of the three energy roles organisms can play in an ecosystem.
10. How are food chains and food webs different?
11. What is the source of energy for most ecosystems? Explain.
12. Describe the role of nitrogen-fixing bacteria in the nitrogen cycle.
13. Explain how competition 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

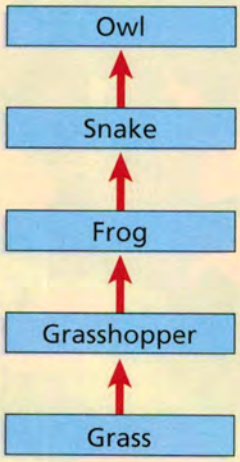
Performance Assessment Create a report, poster, or other product that clearly presents your data and conclusions from your decomposition experiment. In your notebook, compare your results to your predictions about the different waste materials in the compost mixture. Were you surprised by any of your 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

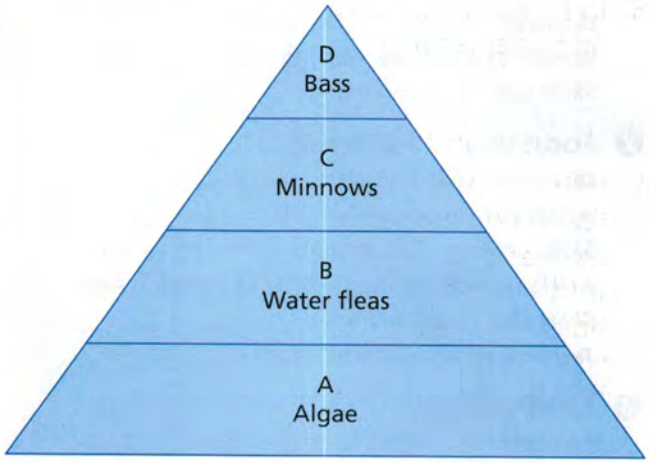
2. Which pair of terms could apply to the same organism?

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.

Chapter

23 Living Resources

The BIG Idea

Environment and Resources

What are the main types of environmental issues?

Chapter Preview

Coral reefs are the most diverse ecosystems in the ocean. ▶

Discovery CHANNEL SCHOOL

Living Resources

- ▶ Video Preview
- Video Field Trip
- Video Assessment

Lab zone™ **Chapter Project**

Variety Show

In this chapter's project, you will become an ecologist as you study the diversity of life in a small plot of land. Keep in mind that the area you will study has just a tiny sample of the huge variety of organisms that live on Earth.

Your Goal To observe the diversity of organisms in a plot of land

To complete this project, you must

- stake out a 1.5 meter-by-1.5 meter plot of ground
- keep a record of your observations of the abiotic conditions
- identify the species of organisms you observe
- follow the safety guidelines in Appendix A

Plan It! Look for a location for your plot. With your teacher's approval, stake out a square plot measuring 1.5 meters on each side. Prepare a notebook in which to record your observations, including the date, time, air temperature, and other weather conditions. Also include places for drawings or photographs of the organisms in your plot.

Environmental Issues

Reading Preview

Key Concepts

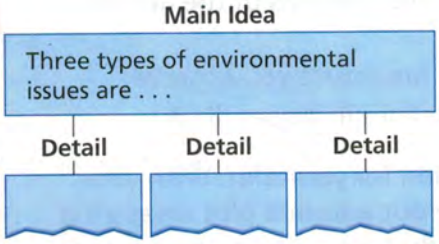
- What are the general categories of environmental issues?
- How do decision makers balance different needs and concerns?

Key Terms

- natural resource
- renewable resource
- nonrenewable resource
- pollution
- environmental science

Target Reading Skill

Identifying Main Ideas As you read the Types of Environmental Issues section, write the main idea in a graphic organizer like the one below. Then write three supporting details that give examples of the main idea.



Lab zone Discover Activity

How Do You Decide?

1. On a sheet of paper, list the three environmental issues you think are most important today.
2. Next to each issue, write the reason it is important.
3. Join with three other classmates and share your lists. Decide which issue on your lists is the most important.

Think It Over

Forming Operational Definitions Based on your group's discussion, how would you define *environmental issue?*

Here's a riddle for you: What is bigger than the United States and Mexico combined; is covered with more than two kilometers of ice; is a unique habitat for many animals; and is a source of oil, coal, and iron? The answer is Antarctica.

People have different ideas about the best way to make use of Antarctica. Some people want access to the minerals. Some want to build hotels, parks, and ski resorts. Others want to protect the ecosystems. What should be done? Who should decide the continent's future?

Types of Environmental Issues

The debate about Antarctica's future is just one environmental issue that people face today. **Environmental issues fall into three general categories: resource use, population growth, and pollution.** Because these three types of issues are interconnected, they are very difficult to study and solve.

Resource Use Anything in the environment that is used by people is called a **natural resource.** Some natural resources are renewable. **Renewable resources** are either always available or are naturally replaced in a relatively short time. Renewable resources include sunlight, wind, fresh water, and trees. Some people think that renewable resources can never be used up. This is not always true. If people cut down trees faster than they can grow back, the supply of trees could run out.

Natural resources that are not replaced in a useful time frame are called **nonrenewable resources.** As nonrenewable resources such as coal or oil are used, the supply decreases.

Population Growth Figure 1 shows how the human population has changed in the last 3,000 years. The population grew very slowly until about A.D. 1650. Then, improvements in medicine, agriculture, and waste disposal resulted in people living longer. The human population has been growing faster and faster ever since. But scientists do not expect it to grow as rapidly in the future.

When a population grows, the demand for resources also grows. Has your town ever experienced a water shortage? If so, you might have noticed that people have been asked to restrict their water use. The water supplies in many areas were designed to serve fewer people than they now do, so shortages sometimes occur during unusually warm or dry weather.

Pollution The contamination of Earth's land, water, or air is called **pollution.** Pollution can be caused by a variety of factors, including chemicals, wastes, noise, heat, and light. Pollution can destroy wildlife and cause human health problems.

Pollution can be related to both resource use and population growth. For example, as more people need to be fed, more fertilizers and other chemicals may be used to produce food. These chemicals can run off the land and pollute bodies of water.

Reading Checkpoint **What are three factors that can cause pollution?**

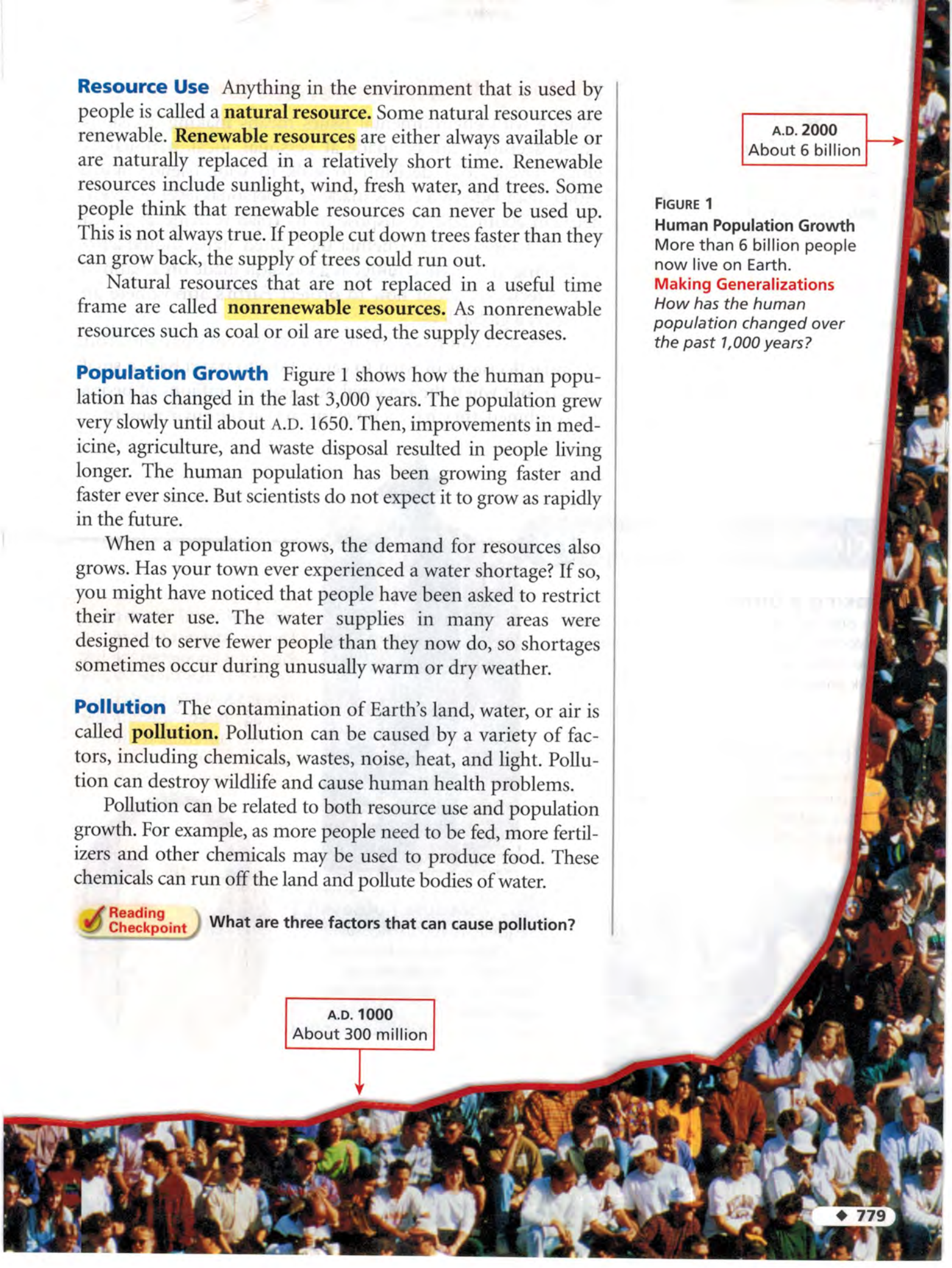


FIGURE 1
Human Population Growth
More than 6 billion people now live on Earth.
Making Generalizations
How has the human population changed over the past 1,000 years?

Go Online
SCILINKS NSTA
For: Links on the environment
Visit: www.SciLinks.org
Web Code: scn-0531

Making Environmental Decisions

Dealing with environmental issues means making decisions. These decisions can be made at personal, local, national, or global levels. Your decision to walk to your friend's house rather than ride in a car is made at a personal level. A town's decision about how to dispose of its trash is made at a local level. A decision about whether the United States should allow oil drilling in a wildlife refuge is a decision made on a national level. Decisions about how to protect Earth's atmosphere are made on a global level.

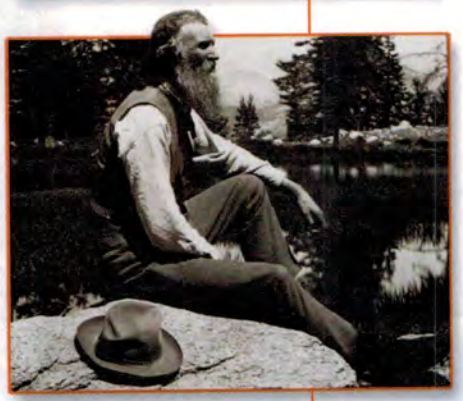
Every decision has some impact on the environment. Your personal decisions of what to eat or how to travel have a small impact. But when the personal decisions of millions of people are combined, they have a huge impact on the environment.

Science and History

Making a Difference

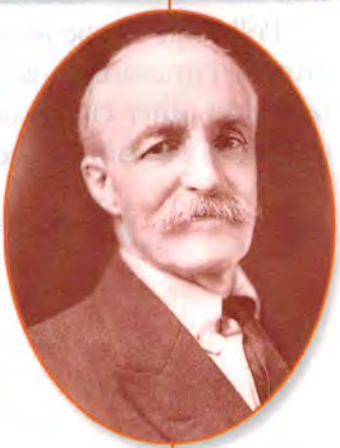
Can one individual change the way people think? The leaders featured in this timeline have influenced the way that many people think about environmental issues.

1890 John Muir
The actions of John Muir, a nature writer from California, lead to the establishment of Yosemite National Park.



1903 Theodore Roosevelt
President Theodore Roosevelt establishes the first National Wildlife Refuge on Pelican Island, Florida, to protect the brown pelican.

1905 Gifford Pinchot
Forestry scientist Gifford Pinchot is appointed the first director of the United States Forest Service. His goal is to manage forests scientifically to meet current and future lumber needs.



1880 1900 1920

Balancing Different Needs Lawmakers work with environmental scientists and other groups to make environmental decisions. **Environmental science** is the study of natural processes in the environment and how humans can affect them. But the data provided by scientists are only part of the process. Environmental decision making requires a balance between the needs of the environment and the needs of people. **To help balance the different opinions on an environmental issue, decision makers weigh the costs and benefits of a proposal.**

Types of Costs and Benefits Many costs and benefits are economic, but not all. Others can be ecological, recreational, or scenic. For example, suppose a state is deciding whether to allow logging in a park. Removing trees is an ecological cost because it changes the ecosystem. In addition, popular recreational or scenic areas may be lost. But providing jobs and a supply of wood has economic benefits.

Writing in Science

Research and Write Find out more about one of the people featured in this timeline. Write a short biography of the person's life that explains how he or she became involved in environmental issues. What obstacles did the person overcome to accomplish his or her goal?

1962 Rachel Carson
Biologist Rachel Carson writes *Silent Spring*, which describes the harmful effects of pesticides on the environment. The book raises awareness of how human activities can affect the environment.

1969 Marjory Stoneman Douglas
At the age of 79, journalist Marjory Stoneman Douglas founds Friends of the Everglades. This grassroots organization is dedicated to preserving the unique Florida ecosystem. She continued to work for the Everglades until her death in 1998.

1949 Aldo Leopold
A Sand County Almanac is published shortly after the death of its author, Aldo Leopold. This classic book links wildlife management to the science of ecology.

1977 Wangari Maathai
Biologist Wangari Maathai founds the Green Belt Movement. This organization encourages restoring forests in Kenya and in other African nations.

1940 1960 1980

FIGURE 2
Identifying Costs and Benefits
Drilling for oil in Antarctica could provide a new source of energy. But an oil spill could harm the area's penguins and other wildlife.

Weighing Costs and Benefits Once you have identified the potential costs and benefits of a decision, you must analyze them. For example, it is important to consider a decision's short-term and long-term costs and benefits. A plan's short-term costs might be outweighed by its long-term benefits.

Consider the costs and benefits of drilling for oil in Antarctica. There would be many costs. It would be very expensive to set up a drilling operation in such a cold and distant place. Transporting the oil would also be difficult and costly. An oil spill in the seas around Antarctica could harm the fish, penguins, and seals there.

On the other hand, there would be benefits to drilling for oil in Antarctica. Oil drilling would provide a new supply of oil for heat, electricity, and transportation. If the worldwide supply of oil were larger, the price might drop, making oil available to more people. The plan would also create many new jobs. Would the benefits of drilling for oil in Antarctica outweigh the costs? This is the kind of question lawmakers must ask before they make environmental decisions.

Reading Checkpoint **What are two types of costs and benefits?**

Section 1 Assessment

Target Reading Skill **Identifying Main Ideas** Use your graphic organizer about types of environmental issues to help you answer Question 1 below.

Reviewing Key Concepts

1. a. **Identifying** What are the three main types of environmental issues?
   b. **Explaining** Why is population growth an environmental issue?
   c. **Relating Cause and Effect** How might a growing population affect the supply of a renewable resource such as trees? Explain your answer.
2. a. **Reviewing** Why is weighing costs and benefits useful for decision makers?
   b. **Classifying** Name one economic cost and one noneconomic cost of drilling for oil in Antarctica. List one benefit of drilling in Antarctica.
   c. **Making Judgments** Suppose you were a world leader faced with the question of drilling in Antarctica. What decision would you make? Give reasons for your decision.

Writing in Science

Persuasive Letter Write a letter to the editor expressing your viewpoint on whether people should be allowed to use powerboats on a lake in your town. Your letter should clearly show how you weighed the costs and benefits to arrive at your viewpoint.

Lab zone Skills Lab

Recycling Paper

Problem

Is paper a renewable resource?

Skills Focus

observing, predicting

Materials

- newspaper
- microscope
- water
- eggbeater
- square pan
- screen
- plastic wrap
- mixing bowl
- heavy book
- microscope slide

Procedure

1. Tear off a small piece of newspaper. Place it on a microscope slide and examine it under a microscope. Record your observations.
2. Tear a sheet of newspaper into pieces about the size of postage stamps. Place the pieces in the mixing bowl. Add enough water to cover the newspaper. Cover the bowl and let the mixture stand overnight.
3. The next day, add more water to cover the paper if necessary. Use the eggbeater to mix the wet paper until it is smooth. This thick liquid is called paper pulp.
4. Place the screen in the bottom of the pan. Pour the pulp onto the screen, spreading it out evenly. Then lift the screen above the pan, allowing most of the water to drip into the pan.
5. Place the screen and pulp on several layers of newspaper to absorb the rest of the water. Lay a sheet of plastic wrap over the pulp. Place a heavy book on top of the plastic wrap to press more water out of the pulp.
6. After 30 minutes, remove the book. Carefully turn over the screen, plastic wrap, and pulp. Remove the screen and plastic wrap. Let the pulp sit on the newspaper for one or two more days to dry. Replace the newspaper layers if necessary.
7. When the pulp is dry, observe it closely. Record your observations.

Analyze and Conclude

1. **Observing** What kind of structures did you observe when you examined torn newspaper under a microscope?
2. **Inferring** What are these structures made of? Where do they come from?
3. **Predicting** What do you think happens to the structures you observed when paper is recycled? How do you think this affects the number of times paper can be recycled?
4. **Communicating** Based on what you learned in this lab, do you think paper should be classified as a renewable or nonrenewable resource? Defend your answer with evidence and sound reasoning.

Design an Experiment

Using procedures like those in this lab, design an experiment to recycle three different types of paper, such as shiny magazine paper, paper towels, and cardboard. *Obtain your teacher's permission before carrying out your investigation.* How do the resulting papers differ?

Section 2

Forests and Fisheries

Reading Preview

Key Concepts

- How can forests be managed as renewable resources?
- How can fisheries be managed for a sustainable yield?

Key Terms

- clear-cutting
- selective cutting
- sustainable yield
- fishery
- aquaculture

Target Reading Skill

Using Prior Knowledge Before you read, write what you know about forests and fish resources in a graphic organizer like the one below. As you read, write what you learn.

What You Know
1. Forests provide people with lumber and paper. 2.

What You Learned
1. 2.

Lab zone Discover Activity

What Happened to the Tuna?

1. Use the data in the table to make a line graph. Label the axes of the graph and add a title. (To review graphing, see the Skills Handbook.)
2. Mark the high and low points on the graph.

Think It Over

Inferring Describe the changes in the tuna population during this period. Can you suggest a reason for these changes?

Year	Western Atlantic Bluefin Tuna Population
1970	218,000
1975	370,000
1980	67,000
1985	58,000
1990	46,000
1995	63,000
2000	67,000

At first glance, an oak tree and a bluefin tuna may not seem to have much in common. One is a plant and the other is an animal. One lives on land and the other lives in the ocean. However, oak trees and tuna are both living resources. People use oak trees to make furniture, lumber, and cork. Tuna are a source of food for people.

Every day you use many different products that are made from living organisms. In this section, you will read about two major types of living resources: forests and fisheries.

Forest Resources

Forests contain many valuable resources. Many products are made from the fruits, seeds, and other parts of forest plants. Some of these products, such as maple syrup, rubber, and nuts, come from living trees. Other products, such as lumber and wood pulp for making paper, require cutting trees down. Coniferous trees, including pine and spruce, are used for construction and for making paper. Hardwoods, such as oak, cherry, and maple, are used for furniture because of their strength and beauty.

Trees and other plants produce oxygen that organisms need to survive. They also absorb carbon dioxide and many pollutants from the air. Trees help prevent flooding and control soil erosion. Their roots absorb rainwater and hold the soil in place.

Managing Forests

There are about 300 million hectares of forests in the United States. That's nearly a third of the nation's area! Many forests are located on public land. Others are owned by individuals or by private timber and paper companies. Forest industries in the United States provide jobs for more than 1 million people.

Because new trees can be planted to replace trees that are cut down, forests can be renewable resources. The United States Forest Service and environmental organizations work with forestry companies to conserve forest resources. They try to develop logging methods that maintain forests as renewable resources.

Logging Methods There are two major methods of logging: clear-cutting and selective cutting. **Clear-cutting** is the process of cutting down all the trees in an area at once. Cutting down only some trees in a forest and leaving a mix of tree sizes and species behind is called **selective cutting.**

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For: Logging Methods activity
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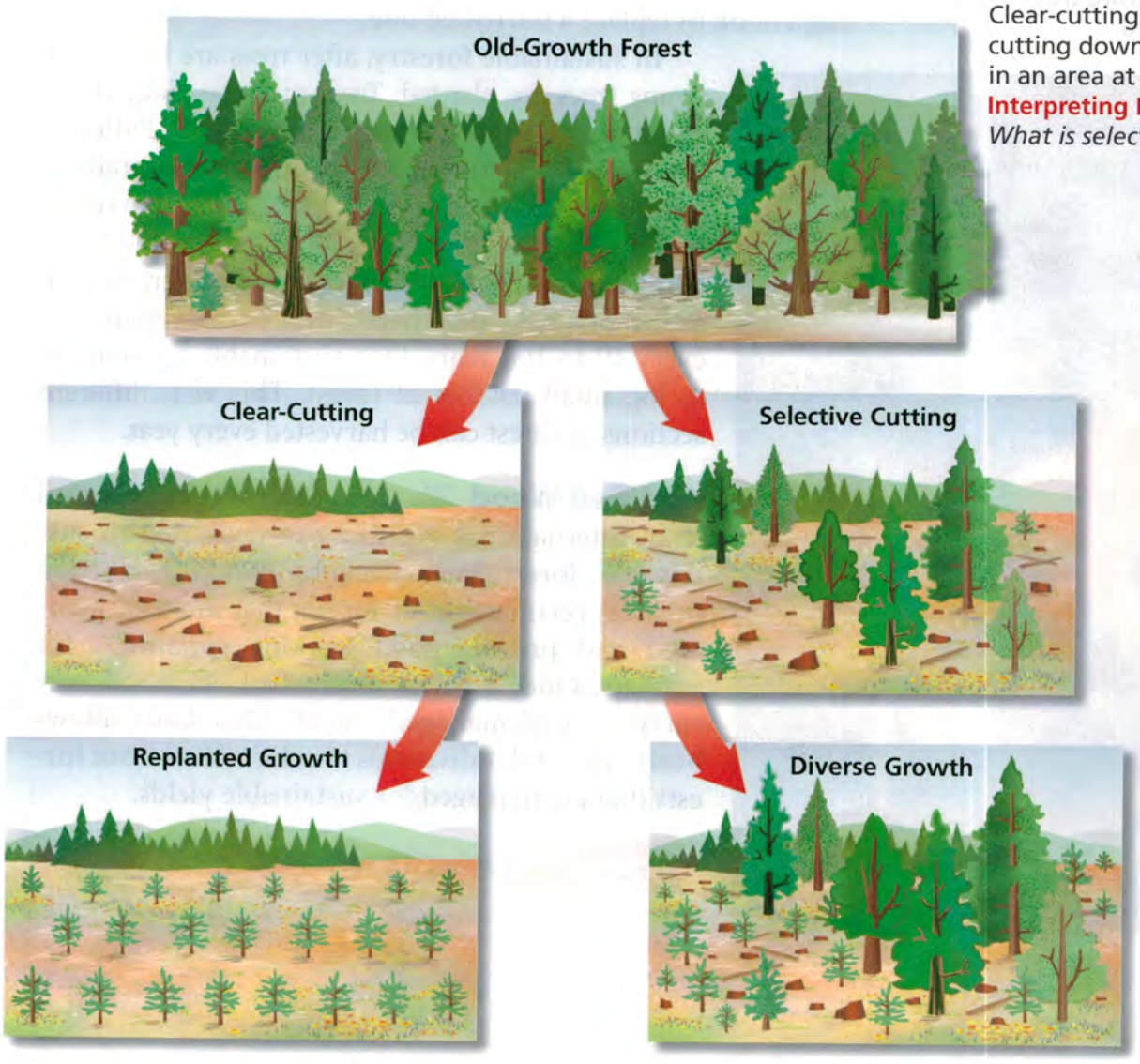


FIGURE 3
Logging Methods
Clear-cutting involves cutting down all the trees in an area at once.
Interpreting Diagrams
What is selective cutting?

Each logging method has advantages and disadvantages. Clear-cutting is usually quicker and cheaper than selective cutting. It may also be safer for the loggers. In selective cutting, the loggers must move the heavy equipment and logs around the remaining trees in the forest. But selective cutting is usually less damaging to the forest environment than clear-cutting. When an area of forest is clear-cut, the ecosystem changes. After clear-cutting, the soil is exposed to wind and rain. Without the protection of the tree roots, the soil is more easily blown or washed away. Soil washed into streams may harm the fish and other organisms that live there.

Sustainable Forestry Forests can be managed to provide a sustainable yield. A **sustainable yield** is an amount of a renewable resource such as trees that can be harvested regularly without reducing the future supply. Sustainable forestry works sort of like a book swap: as long as you donate a book each time you borrow one, the total supply of books will not be affected. Planting a tree to replace one that was cut down is like donating a book to replace a borrowed one.

FIGURE 4
Sustainable Forestry
Sustainable forestry practices include the planting of young trees after mature trees have been harvested.

In sustainable forestry, after trees are harvested, young trees are planted. Trees must be planted frequently enough to keep a constant supply. Different species grow at different rates. Forests containing faster-growing trees, such as pines, can be harvested and replanted every 20 to 30 years. On the other hand, some forests containing hardwood trees, such as hickory, oak, and cherry, may be harvested only every 40 to 100 years. One sustainable approach is to log small patches of forest. This way, different sections of forest can be harvested every year.

Certified Wood The Forest Stewardship Council is an international organization dedicated to sustainable forest management. This organization oversees certification of forests that are well managed and provide good working conditions for workers. Once a forest is certified, its wood may carry a "well-managed" label. This label allows businesses and individuals to select wood from forests that are managed for sustainable yields.

Reading Checkpoint **What is a sustainable yield?**

Fisheries

An area with a large population of valuable ocean organisms is called a **fishery.** Some major fisheries include the Grand Banks off Newfoundland, Georges Bank off New England, and Monterey Canyon off California. Fisheries like these are valuable renewable resources.

Until recently, fisheries seemed like an unlimited resource. The waters held such huge schools of fish. And fish reproduce in incredible numbers. A single codfish can lay as many as 9 million eggs in a single year! But people have discovered that this resource has limits. After many years of big catches, the number of sardines off the California coast suddenly declined. The same thing happened to the huge schools of cod off the New England coast. What caused these changes?

The fish were caught faster than they could breed, so the population decreased. This situation is known as overfishing. Scientists estimate that 70 percent of the world's major fisheries have been overfished. But if fish populations recover, a sustainable yield can again be harvested. **Managing fisheries for a sustainable yield includes strategies such as setting fishing limits, changing fishing methods, developing aquaculture techniques, and finding new resources.**

Fishing Limits Laws can ban the fishing of certain species. Laws may also limit the number or size of fish that can be caught or require that fish be within a certain range of sizes. These laws ensure that young fish survive long enough to reproduce and that all of the largest adult fish aren't caught. If a fishery has been severely overfished, however, the government may ban fishing completely until the populations recover.

Lab zone **Skills Activity**

Calculating

In a recent year, the total catch of fish in the world was 112.9 million metric tons. Based on the data below, calculate the percent of this total each country caught.

Country	Catch (millions of metric tons)
China	24.4
Japan	6.8
United States	5.6
Peru	8.9

FIGURE 5
Fisheries
Even though fisheries are renewable resources, they must be managed for sustainable yields, or the supply of fish may run out.

FIGURE 6
Aquaculture
Aquaculture is helping to meet the demand for fish. This fish farm in Hawaii raises tilapia.
Applying Concepts *What costs and benefits does aquaculture involve?*

Fishing Methods Today many fishing crews use nets with a larger mesh size that allow small, young fish to escape. In addition, many other fishing practices are regulated by laws. Some fishing methods have been outlawed. These methods include poisoning fish with cyanide and stunning them by exploding dynamite underwater. These techniques harm all the fish in an area rather than targeting certain fish.

Aquaculture The practice of raising fish and other water-dwelling organisms for food is called **aquaculture.** The fish may be raised in artificial ponds or bays. Salmon, catfish, and shrimp are farmed in this way in the United States.

However, aquaculture is not a perfect solution. The artificial ponds and bays often replace natural habitats such as salt marshes. Maintaining the farms can cause pollution and spread diseases into wild fish populations.

New Resources Today about 9,000 different fish species are harvested for food. More than half the animal protein eaten by people throughout the world comes from fish. One way to help feed a growing human population is to fish for new species. Scientists and chefs are working together to introduce people to deep-water species such as monkfish and tile fish, as well as easy-to-farm freshwater fish such as tilapia.

Reading Checkpoint **What is aquaculture?**

Section 2 Assessment

Target Reading Skills **Using Prior Knowledge** Review your graphic organizer and revise it based on what you just learned in the section.

Reviewing Key Concepts

1. a. **Reviewing** Why are forests considered renewable resources?
   b. **Comparing and Contrasting** How does the clear-cutting logging method differ from selective cutting?
   c. **Developing Hypotheses** You are walking in a clear-cut section of forest a few days after a heavy rainstorm. A nearby stream is very muddy and has many dead fish. What might have happened?
2. a. **Listing** What are four ways fisheries can be managed for a sustainable yield?
   b. **Explaining** What are two kinds of laws that regulate fishing? How can they help ensure the health of a fishery?
   c. **Predicting** What might happen to a fish population over time if all the largest fish in the population were caught? Explain.

Lab zone **At-Home Activity**

Renewable Resource Survey With a family member, conduct a "Forest and Fishery" survey of your home. Make a list of all the things that are made from either forest or fishery products. Then ask other family members to predict how many items are on the list. Are they surprised by the answer?

Lab zone **Skills Lab**

Tree Cookie Tales

Problem

What can tree cookies reveal about the past? A tree cookie is a slice of a tree trunk that contains clues about the tree's age, past weather conditions, and fires that occurred during its life.

Skills Focus

observing, inferring, interpreting data

Materials

- tree cookie
- metric ruler
- hand lens
- colored pencils
- calculator (optional)

Procedure

1. Your teacher will give you a "tree cookie." Use a hand lens to examine your tree cookie. Draw a simple diagram of your tree cookie. Label the bark, tree rings, and center, or pith.
2. Notice the light-colored and dark-colored rings. The light ring results from fast springtime growth. The dark ring, where the cells are smaller, results from slower summertime growth. Each pair of light and dark rings represents one year's growth, so the pair is called an annual ring. Observe and count the annual rings.
3. Compare the spring and summer portions of the annual rings. Identify the thinnest and thickest rings.
4. Measure the distance from the center to the outermost edge of the last summer growth ring. This is the radius of your tree cookie. Record your measurement.
5. Measure the distance from the center to the outermost edge of the tenth summer growth ring. Record your measurement.
6. Examine your tree cookie for any other evidence of its history, such as damaged bark or burn marks. Record your observations.

Analyze and Conclude

1. **Inferring** How old was your tree? How do you know?
2. **Calculating** What percent of the tree's growth took place during the first ten years of its life? (*Hint:* Divide the distance from the center to the tenth growth ring by the radius. Then multiply by 100. This gives you the percent of growth that occurred during the tree's first ten years.)
3. **Observing** How did the spring rings compare to the summer rings for the same year? Suggest a reason.
4. **Interpreting Data** Why might the annual rings be narrower for some years than for others?
5. **Communicating** Using evidence from your tree cookie, write a paragraph that summarizes the history of the tree. Be sure to include as much detail as possible in your summary.

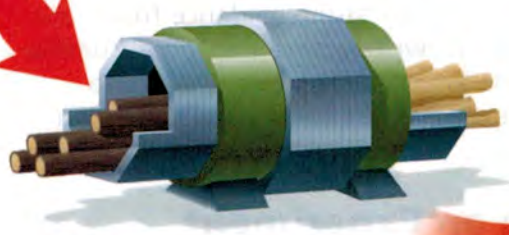
Design an Experiment

Suppose you had cookies from two other trees of the same species that grew near your tree. Write a plan for verifying the interpretations you made in this lab. *Obtain your teacher's permission before carrying out your investigation.*

Paper

What do a dollar bill, your report card, and a comic book have in common? They are all printed on paper, of course! But where does paper come from? As shown here, paper is made through a process that typically starts with wood from trees. The papermaking process was first invented in China about 2,000 years ago. Today, paper mills around the world rely on powerful machines to produce huge quantities of paper.

1 Trees are grown and harvested.
Paper is produced mostly from trees that are grown for this specific purpose.



2 Logs are de-barked.
The de-barker removes the bark from the logs.

3 Wood chips are made.
The chipper chops the wood into small pieces.

4 Pulp is formed.
Heat and chemicals break down the chips into fibers called pulp.

The Benefits of Paper

Paper benefits society in so many ways. Many everyday items are made out of paper—tissues, paper cups, and cardboard packaging. Perhaps most important, paper is used as a portable, inexpensive way to print words and images. Throughout time, paper has allowed people to express their thoughts, record history, and share knowledge. In addition, the paper industry employs many people, and generates income for the economy.

Paper and the Environment

Paper has negative impacts on the environment. Each step in the papermaking process requires energy and produces wastes. Some of these wastes, such as dioxins, are toxic. Dioxins form when water is used to flush chemicals from the paper. Paper products also make up a lot of the garbage in landfills. Because of the environmental costs, engineers are working to create a new type of "paper" called electronic paper, or e-paper. Someday soon, you might use flexible, ultra-thin, digital screens instead of paper.

5 Water is added.
Water is added to the pulp to form slush. The slush is then sprayed onto wide screens. The water begins to drain off.

6 Water is removed.
The paper is squeezed through several presses to remove the excess water.

7 Paper is dried.
Heated rollers dry the paper, making it flat and smooth.

Weigh the Impact

1. Identify the Need
How does society rely on paper? How would your life be different if paper had never been invented?

2. Research
Use the Internet to investigate e-paper, a new technology that may replace traditional paper. List some potential uses of e-paper.

3. Write
Write a paragraph or two comparing e-paper and regular paper. Be sure to include the pros and cons of both technologies based on your research.

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Section 3

Biodiversity

Reading Preview

Key Concepts

- In what ways is biodiversity valuable?
- What factors affect an area's biodiversity?
- Which human activities threaten biodiversity?
- How can biodiversity be protected?

Key Terms

- biodiversity
- keystone species
- extinction
- endangered species
- threatened species
- habitat destruction
- habitat fragmentation
- poaching
- captive breeding

Target Reading Skill

Building Vocabulary After you read this section, reread the paragraphs that contain definitions of Key Terms. Use all the information you have learned to write a meaningful sentence using each Key Term.

Lab zone **Discover Activity**

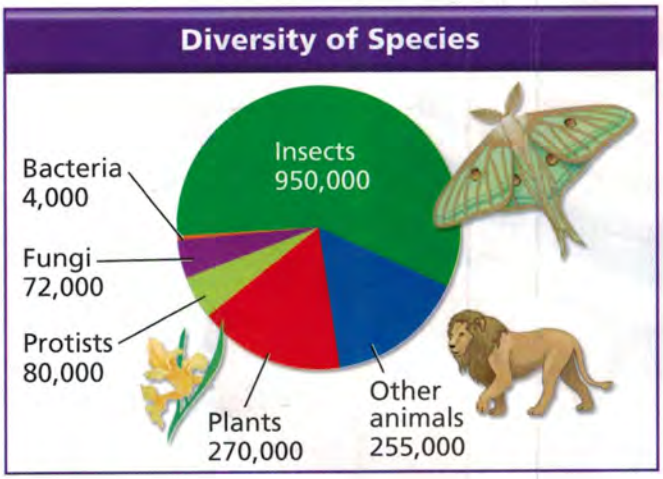
How Much Variety Is There?

1. You will be given two cups of seeds and two paper plates. The seeds in cup A represent the trees in a section of tropical rain forest. The seeds in cup B represent the trees in a section of deciduous forest.
2. Pour the seeds from cup A onto a plate. Sort the seeds by type. Count the different types of seeds. This number represents the number of different kinds of trees in that forest.
3. Repeat Step 2 with the seeds in cup B.
4. Share your results with your class. Use the class results to calculate the average number of different kinds of trees in each type of forest.

Think It Over

Inferring How do the variety of trees in the two forests differ? Can you suggest any advantages of having a wide variety of species?

No one knows exactly how many species live on Earth. As you can see in Figure 7, more than 1.5 million species have been identified so far. The number of different species in an area is called its **biodiversity.** It is difficult to estimate the total biodiversity on Earth because many areas of the planet have not been thoroughly studied. Some experts think that the deep oceans alone could contain 10 million new species! Protecting biodiversity is a major environmental issue today.



The Value of Biodiversity

Preserving biodiversity is important. One reason is that wild organisms and ecosystems are a source of beauty and recreation. **In addition, biodiversity has both economic value and ecological value within an ecosystem.**

FIGURE 7
Organisms of many kinds are part of Earth's biodiversity.

FIGURE 8
Economic Value of Biodiversity
These women are breast cancer survivors. Some of them probably received taxol as a treatment. Taxol was discovered in the Pacific yew tree by scientists investigating why the tree was unusually resistant to diseases and insects.

Economic Value Many plants, animals, and other organisms have economic value. They provide food and raw materials for medicines, clothing, and other products. For example, taxol, a cancer-fighting chemical, was first discovered in the Pacific yew tree. A country's ecosystems can also be economically valuable. Wildlife tours in rain forests, savannas, mountains ranges, and other locations are common. This ecosystem tourism, or ecotourism, is an important source of jobs for such nations as Brazil, Costa Rica, and Kenya.

Ecological Value All the species in an ecosystem are connected to one another. Species may depend on each other for food and shelter. A change that affects one species will surely affect all the others.

Some species play a particularly important role in their ecosystems. A **keystone species** is a species that influences the survival of many other species in an ecosystem. For example, the sea otter eating a sea urchin in Figure 9 belongs to a keystone species. In the 1800s, hunters on the Pacific coast killed most of the sea otters for fur. The sea urchins, now able to reproduce without control, ate up all the kelp. When sea otters were reintroduced, the kelp population recovered. The ecosystem's balance was restored.

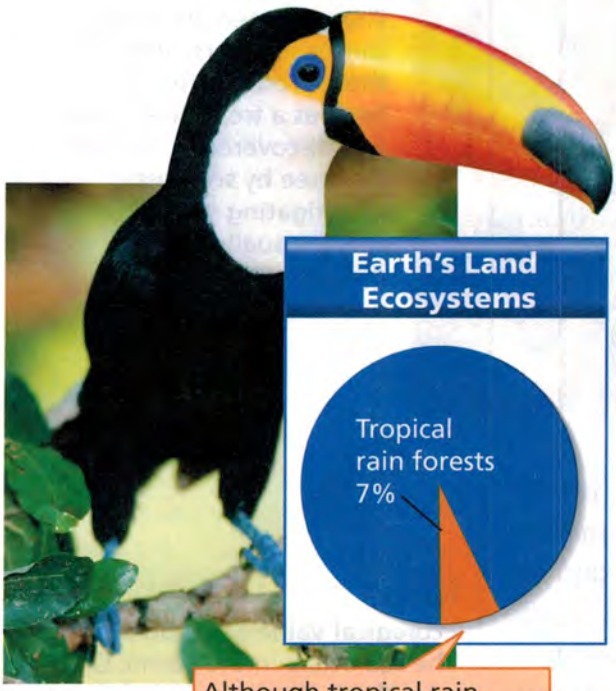
Reading Checkpoint **What is a keystone species?**

FIGURE 9
Ecological Value of Biodiversity
The sea otters in the Pacific Ocean near Washington are members of a keystone species. If the population of a keystone species drops too far, the entire ecosystem can be disrupted.
Relating Cause and Effect *How do sea otters help keep their ecosystem in balance?*

FIGURE 10

Land and Ocean Ecosystems

Three factors that affect the biodiversity of an ecosystem are area, climate, and niche diversity. **Making Generalizations** *Which factor is most likely responsible for the biodiversity of coral reefs? Of tropical rain forests?*



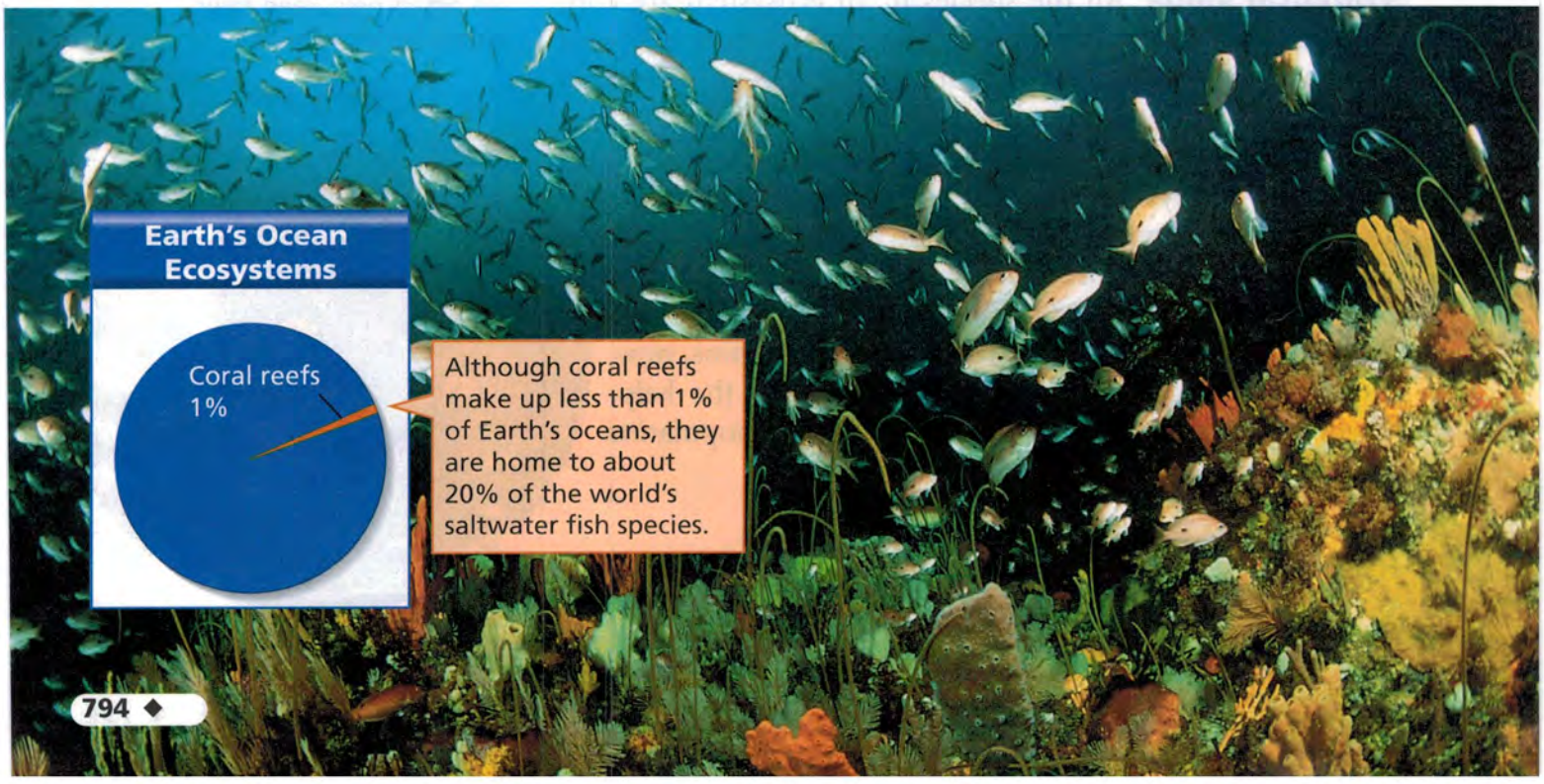
Factors Affecting Biodiversity

Biodiversity varies from place to place on Earth. **Factors that affect biodiversity in an ecosystem include area, climate, and diversity of niches.**

Area Within an ecosystem, a large area will contain more species than a small area. For example, suppose you were counting tree species in a forest. You would find far more tree species in a 100-square-meter area than in a 10-square-meter area.

Climate In general, the number of species increases from the poles toward the equator. The tropical rain forests of Latin America, southeast Asia, and central Africa are the most diverse ecosystems in the world. These forests cover only about 7 percent of Earth's land surface but contain more than half of the world's species.

The reason for the great biodiversity in the tropics is not fully understood. Many scientists hypothesize that it has to do with climate. For example, tropical rain forests have fairly constant temperatures and large amounts of rainfall throughout the year. Many plants in these regions grow year-round. This continuous growing season means that food is always available for other organisms.



Niche Diversity Coral reefs make up less than 1 percent of the oceans' area. But reefs are home to 20 percent of the world's saltwater fish species. Coral reefs are the second most diverse ecosystems in the world. Found only in shallow, warm waters, coral reefs are often called the rain forests of the sea. A reef supports many different niches for organisms that live under, on, and among the coral. This enables more species to live in the reef than in a more uniform habitat, such as a flat sandbar.

Gene Pool Diversity

Just as the diversity of species is important within an ecosystem, diversity is also important within a species. The organisms in a healthy population have a diversity of traits. Traits such as color, size, and ability to fight disease are determined by genes. Genes are the structures in an organism's cells that carry its hereditary information.

Organisms receive a combination of genes from their parents. Genes determine an organism's characteristics, from its size and appearance to its ability to fight disease.

The organisms in one species share many genes. But each organism also has some genes that differ from those of other individuals. These individual differences make up the total gene "pool" of that species.

Species that lack a diverse gene pool are less able to adapt to changes in the environment. For example, some food crops have little diversity. A fungus once wiped out much of the corn crop in the United States. Fortunately, some wild varieties of corn have genes that make them resistant to the fungus. Scientists were able to use some of those wild varieties to breed corn that could fight off the fungus. A species with a diverse gene pool is better able to survive such challenges.

Reading Checkpoint **What do an organism's genes determine?**

Lab zone Try This Activity

Grocery Gene Pool

With a parent or other adult, visit a supermarket or produce market in your area. Choose one type of fruit or vegetable, such as apples or potatoes. Make a list of all the different varieties of that fruit or vegetable the store sells. Note any differences in appearance between the varieties.

Inferring Judging from the appearance of the different varieties, do you think your fruit or vegetable has a diverse gene pool? Explain.

FIGURE 11
Genetic Diversity
Diverse genes give these potatoes their rainbow of colors. Having a diverse gene pool helps a species fight disease and adapt to changes in its environment.

Extinction of Species

The disappearance of all members of a species from Earth is called **extinction.** Extinction is a natural process. But in the last few centuries, the number of species becoming extinct has increased dramatically.

Once the size of a population drops below a certain level, the species may not be able to recover. For example, in the 1800s, there were millions of passenger pigeons in the United States. People hunted the birds, killing many hundreds of thousands. This was only part of the total population. But the remaining birds could not reproduce enough to sustain the population. Only after 1914, when the species became extinct, did people realize that the species could not survive without its enormous numbers.

FIGURE 12

Endangered Species

A broad range of species and habitats are represented on the endangered list in the United States.

California Tiger Salamander ▲
Towns have replaced much of this salamander's habitat. The salamanders that remain are in danger of being run over by cars or washed down storm drains.

◀ Tennessee Purple Coneflower
These daisy-like plants grow only in cedar forests in central Tennessee. Conservation organizations and landowners are working together to protect these plants.

◀ Grizzly Bear
This omnivore needs a large area to obtain enough food. Shrinking wilderness areas have limited its numbers.

Species in danger of becoming extinct in the near future are called **endangered species.** Species that could become endangered in the near future are called **threatened species.** Threatened and endangered species are found on every continent and in every ocean.

Some endangered or threatened species are well-known animals, such as the tiger or China's giant panda. Others are little known, such as hutias, rodents that live on only a few Caribbean islands. Ensuring that these species survive is one way to protect Earth's biodiversity.

Reading Checkpoint **How has the number of species becoming extinct changed in the last few centuries?**

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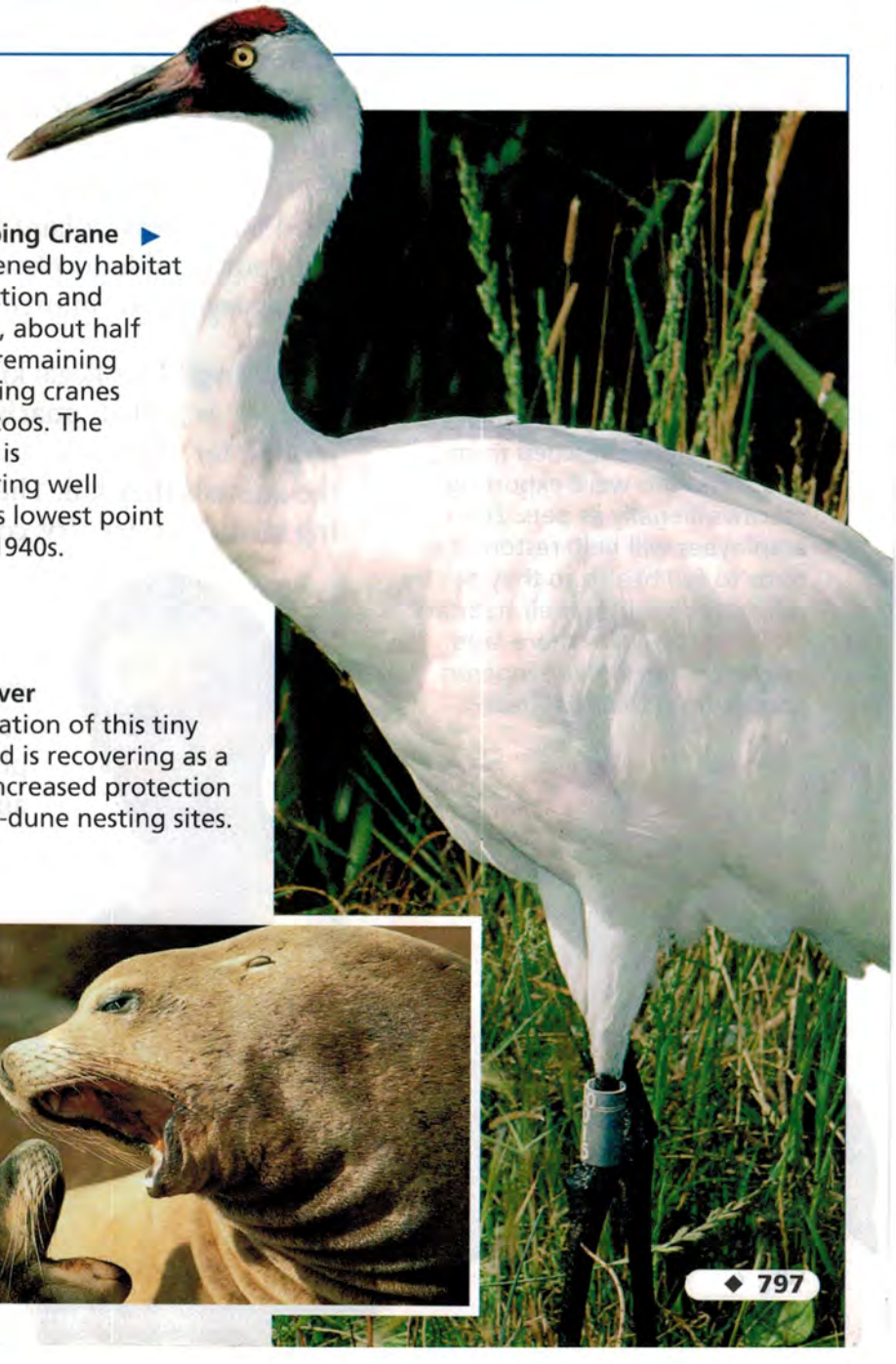
▲ **Schaus Swallowtail Butterfly**
Threatened by habitat loss and pesticide pollution in the Florida Keys, this butterfly was nearly wiped out by Hurricane Andrew in 1992.



Whooping Crane ▶
Threatened by habitat destruction and disease, about half of the remaining whooping cranes are in zoos. The species is recovering well since its lowest point in the 1940s.

◀ **Piping Plover**
The population of this tiny coastal bird is recovering as a result of increased protection of its sand-dune nesting sites.

Steller's Sea Lion ▶
Overfishing has led to a decline in this mammal's sources of food. Other factors may also be threatening this species.

Causes of Extinction

A natural event, such as an earthquake or a volcanic eruption, can damage an ecosystem, wiping out populations or even species. **Human activities can also threaten biodiversity. These activities include habitat destruction, poaching, pollution, and the introduction of exotic species.**

Habitat Destruction The major cause of extinction is **habitat destruction,** the loss of a natural habitat. This can occur when forests are cleared to build towns or create grazing land. Plowing grasslands or filling in wetlands greatly changes those ecosystems. Some species may not be able to survive such changes to their habitats.

Breaking larger habitats into smaller, isolated pieces, or fragments, is called **habitat fragmentation.** For example, building a road through a forest disrupts habitats. This makes trees more vulnerable to wind damage. Plants may be less likely to disperse their seeds successfully. Habitat fragmentation is also very harmful to large mammals. These animals usually need large areas of land to find enough food to survive. They may not be able to obtain enough resources in a small area. They may also be injured trying to cross to another area.

Poaching The illegal killing or removal of wildlife from their habitats is called **poaching.** Many endangered animals are hunted for their skin, fur, teeth, horns, or claws. Hunters sell the animals they kill. The animal parts are then used for making medicines, jewelry, coats, belts, and shoes.

People illegally remove organisms from their habitats to sell them as exotic pets. Tropical fish, tortoises, and parrots are very popular pets, making them valuable to poachers. Endangered plants are sometimes illegally dug up and sold as houseplants or medicines.

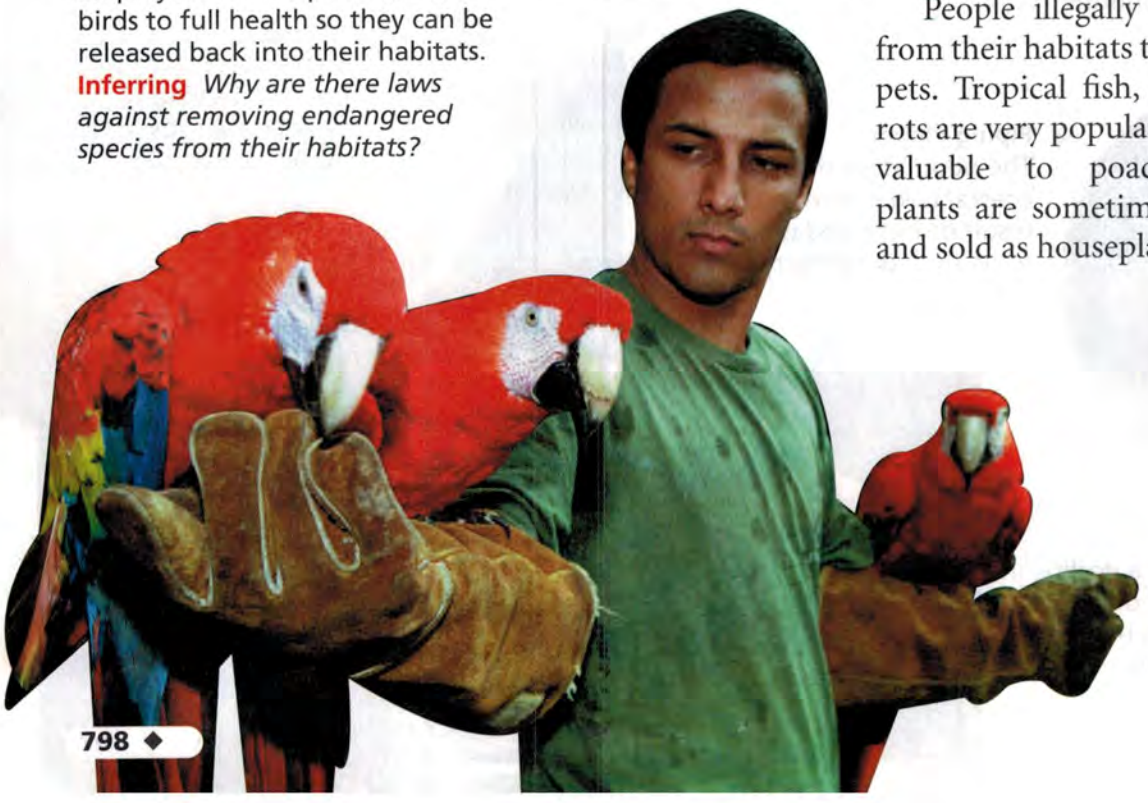


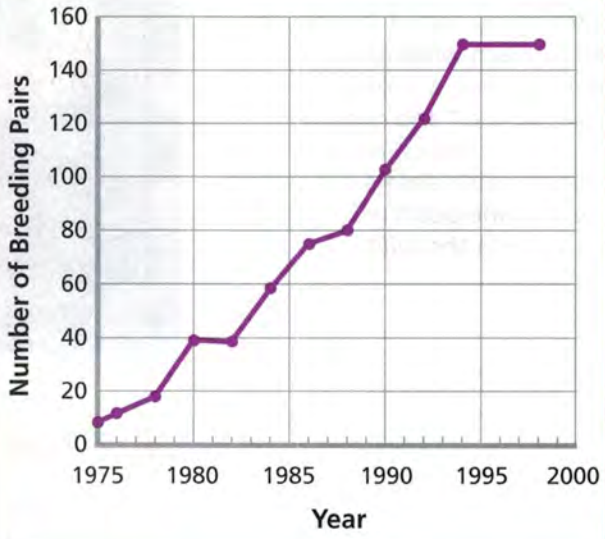
FIGURE 13
Poaching
These scarlet macaws at a zoo in Costa Rica were rescued from poachers who were exporting macaws illegally as pets. Zoo employees will help restore the birds to full health so they can be released back into their habitats.
Inferring *Why are there laws against removing endangered species from their habitats?*

Math Analyzing Data

California Peregrine Falcon Recovery

The peregrine falcon, the world's fastest bird of prey, was nearly extinct in the United States in 1970. The pesticide DDT was weakening peregrine eggshells, so the eggs rarely hatched. In 1972, the United States banned DDT. Use the graph to answer questions about the peregrine population in California.

Peregrine Population in California



1. **Reading Graphs** What variable is plotted on the *x*-axis? What variable is plotted on the *y*-axis?
2. **Interpreting Data** How did California's peregrine population change from 1976 to 1998?
3. **Inferring** Why do you think the peregrine population grew fairly slowly at first?
4. **Predicting** What might this graph have looked like if DDT had not been banned?

Pollution Some species are endangered because of pollution. Substances that cause pollution, called pollutants, may reach animals through the water they drink or air they breathe. Pollutants may also settle in the soil. From there, they are absorbed by plants and build up in other organisms through the food chain. Pollutants may kill or weaken organisms or cause birth defects.

Exotic Species Introducing exotic species into an ecosystem can threaten biodiversity. When European sailors began visiting Hawaii hundreds of years ago, rats from their ships escaped onto the islands. Without any predators in Hawaii, the rats multiplied quickly. They ate the eggs of the nene goose. To protect the geese, people brought the rat-eating mongoose from India to help control the rat population. Unfortunately, the mongooses preferred eating eggs to rats. With both the rats and the mongoose eating its eggs, the nene goose is now endangered.

Reading Checkpoint What is poaching?

FIGURE 14
Kudzu
Kudzu is an exotic species that was introduced to the United States from Japan in 1876. It can grow up to 30 centimeters a day, so its vines can quickly strangle native trees and shrubs. It can also take over abandoned structures, such as this house in Georgia.

FIGURE 15
Captive Breeding
Captive breeding programs use a scientific approach to protect endangered species. California condor chicks raised in captivity need to learn what adult condors look like. Here, a scientist uses a puppet to feed and groom a chick. **Predicting** *What sort of problems could animals raised by humans come upon when they are released into the wild?*

Protecting Biodiversity

Some people who work to preserve biodiversity focus on protecting individual endangered species. Others try to protect entire ecosystems, such as the Great Barrier Reef in Australia. **Three successful approaches to protecting biodiversity are captive breeding, laws and treaties, and habitat preservation.**

Captive Breeding **Captive breeding** is the mating of animals in zoos or wildlife preserves. Scientists care for the young, and then release them into the wild when they are grown.

Captive breeding was the only hope for the California condor, the largest bird in North America. Condors became endangered due to habitat destruction, poaching, and pollution. By 1984, there were only 15 California condors. Scientists captured all the condors and brought them to zoos to breed. Today, there are more than 200 California condors. Though successful, this program has cost more than $20 million. You can see the drawback of captive breeding.

FIGURE 16
A Protected Species
Laws against selling products made from endangered species have helped protect animals such as these ocelots. These small cats were once hunted nearly to extinction for their fur.

Laws and Treaties Laws can help protect individual species. In the United States, the Endangered Species Act prohibits trade in products made from threatened or endangered species. This law also requires the development of plans to save endangered species. American alligators and green sea turtles have begun to recover as a result of this law.

The most important international treaty protecting wildlife is the Convention on International Trade in Endangered Species. This treaty lists more than 800 threatened and endangered species that cannot be traded for profit. Treaties like this are difficult to enforce. Even so, this treaty has helped to protect many endangered species, including African elephants.

Habitat Preservation The most effective way to preserve biodiversity is to protect whole ecosystems. Protecting whole ecosystems saves not only endangered species, but also the species they depend upon and those that depend upon them.

Beginning in 1872 with Yellowstone National Park, the world's first national park, many countries have set aside wildlife habitats as parks and refuges. In addition, private organizations have purchased millions of hectares of endangered habitats throughout the world. Today, there are about 7,000 nature parks, preserves, and refuges in the world.

To be most effective, reserves must have the characteristics of diverse ecosystems. For example, they must be large enough to support the populations that live there. The reserves must contain a variety of niches. And of course, it is still necessary to keep the air, land, and water clean, control poaching, and remove exotic species.

FIGURE 17
Habitat Preservation
Preserving whole habitats is an effective way to protect biodiversity. Habitat preservation is the aim of national parks such as Yellowstone.

Reading Checkpoint **What is the most effective way to preserve biodiversity?**

Section 3 Assessment

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

Reviewing Key Concepts

1. a. **Listing** What are two ways in which biodiversity is valuable?
   b. **Problem Solving** What economic reasons could you give people in the rain forest for preserving the ecosystem?
2. a. **Identifying** What are three factors that affect the biodiversity in an ecosystem?
   b. **Explaining** How does each of these factors affect biodiversity?
   c. **Developing Hypotheses** Would you expect to find great biodiversity in the tundra biome? Why or why not?
3. a. **Listing** Name four human activities that can threaten biodiversity.
   b. **Applying Concepts** Black bears are roaming through a new housing development in search of food, even though the housing development is still surrounded by forest. How can you account for the bears' behavior?
4. a. **Reviewing** What are three approaches to protecting biodiversity?
   b. **Relating Cause and Effect** For each approach to protecting biodiversity, list at least one factor that might limit its success.
   c. **Making Judgments** List some ways in which those limitations might be dealt with.

Lab zone At-Home Activity

Species Refuges Obtain a map of your community or state. With a family member, identify any city, state, or national parks, reserves, or refuges in your area. Choose one location and find out whether there are endangered or threatened species living there. Then prepare a five-minute presentation for your class on what you learned.

Chapter 23

Study Guide

The BIG Idea **Environment and Resources** Environmental issues include the use of renewable and nonrenewable resources, population growth, and pollution. Another major issue is the value of biodiversity to the economy and to ecosystems.

1 Environmental Issues

Key Concepts

- Environmental issues fall into three general categories: resource use, population growth, and pollution.
- To help balance the different opinions on an environmental issue, decision makers weigh the costs and benefits of a proposal.

Key Terms

• natural resource • renewable resource
• nonrenewable resource • pollution
• environmental science

2 Forests and Fisheries

Key Concepts

- Because new trees can be planted, forests can be renewable resources.
- Managing fisheries includes setting fishing limits, changing fishing methods, developing aquaculture, and finding new resources.

Key Terms

• clear-cutting • selective cutting
• sustainable yield • fishery • aquaculture

3 Biodiversity

Key Concepts

- Biodiversity has both economic value and ecological value within an ecosystem.
- Factors that affect biodiversity in an ecosystem include area, climate, and diversity of niches.
- Habitat destruction, poaching, pollution, and the introduction of exotic species can threaten biodiversity.
- Three successful approaches to protecting biodiversity are captive breeding, laws and treaties, and habitat preservation.

Key Terms

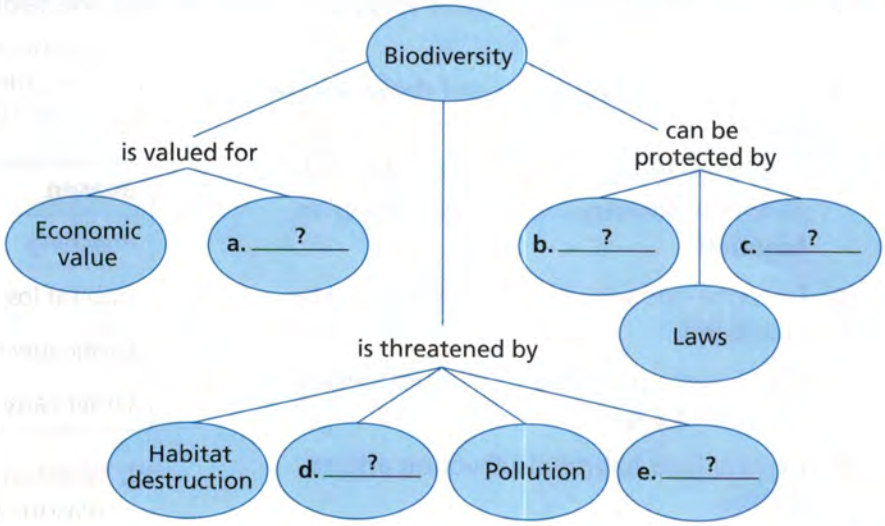
biodiversity
keystone species
extinction
endangered species
threatened species
habitat destruction
habitat fragmentation
poaching
captive breeding

Review and Assessment

Go Online PHSchool.com
For: Self-Assessment
Visit: PHSchool.com
Web Code: cha-4230

Organizing Information

Concept Mapping Copy the concept map about biodiversity onto a separate sheet of paper. Then complete it and add a title. (For more on Concept Mapping, see the Skills Handbook.)



Reviewing Key Terms

Choose the letter of the best answer.

1. The contamination of Earth's air, land, or water is called
   a. extinction.
   b. aquaculture.
   c. pollution.
   d. habitat destruction.
2. The practice of raising fish for food is called
   a. aquaculture.
   b. overfishing.
   c. poaching.
   d. captive breeding.
3. The most diverse ecosystems in the world are
   a. coral reefs.
   b. deserts.
   c. grasslands.
   d. tropical rain forests.
4. If all members of a species disappear from Earth, that species is
   a. extinct.
   b. endangered.
   c. renewable.
   d. threatened.
5. Species that are in danger of becoming extinct in the near future are called
   a. exotic species.
   b. endangered species.
   c. keystone species.
   d. threatened species.
6. The most effective way to preserve biodiversity is through
   a. habitat fragmentation.
   b. habitat destruction.
   c. habitat preservation.
   d. captive breeding.

Writing in Science

Dialogue The salmon population in an area of the ocean has declined significantly. Fishers depend on catching salmon to make a living. Write a dialogue in which an environmental scientist and a fisher try to find a solution to the problem.

Discovery Channel School

Living Resources
Video Preview
Video Field Trip
▶ Video Assessment

Review and Assessment

Checking Concepts

7. What is a renewable resource? What is a nonrenewable resource?
8. Describe how environmental decisions are made.
9. How does the idea of a sustainable yield pertain to forestry? How does it apply to fisheries?
10. Describe one way that overfishing can be prevented.
11. Why is gene pool diversity important to survival of a species?
12. Explain how habitat destruction affects species.
13. How can an exotic species threaten an ecosystem?

Thinking Critically

14. **Relating Cause and Effect** Explain how human population growth affects resource use and pollution.
15. **Comparing and Contrasting** Which logging method is shown below? Compare the effects of this method with those of selective cutting.

16. **Making Generalizations** Describe how an exotic species can threaten other species in an ecosystem.
17. **Predicting** How could the extinction of a species today affect your life in 20 years?
18. **Making Judgments** Should keystone species get special legal protection? Explain.

Applying Skills

Use the table to answer Questions 19–23.

A study was done to identify the reasons why mammal and bird species become endangered or threatened. The data are shown in the table below.

Reason	Mammals	Birds
Poaching	31%	20%
Habitat loss	32%	60%
Exotic species	17%	12%
Other causes	20%	8%

19. **Graphing** Make a bar graph comparing the reasons why mammals and birds become endangered or threatened. Show reasons on the horizontal axis and percentages of animal groups on the vertical axis.
20. **Interpreting Data** What is the major reason that mammals become endangered or threatened? What is the main threat to birds?
21. **Predicting** Would stricter laws against poaching be likely to benefit mammal species or bird species more? Explain.
22. **Making Judgments** If you were on a committee formed to protect bird species in your state, what action would you recommend? Support your recommendation using the data in the table.
23. **Developing Hypotheses** Suggest two explanations for the differences between the data for mammals and birds.

Lab zone Chapter Project

Performance Assessment In your presentation, clearly describe the biodiversity you observed in your plot. You can use drawings, video, photos, or a computer for your presentation. Be sure to include the data you collected on abiotic factors as well.

Standardized Test Prep

Test-Taking Tip

Reading All the Answer Choices

Always read every answer choice before selecting the answer you think is correct. If you don't read all the answer choices, you may not notice another choice that is more complete and precise.

Sample Question

The major cause of extinction today is

A poaching.
B pollution.
C habitat destruction.
D introduction of exotic species.

Answer

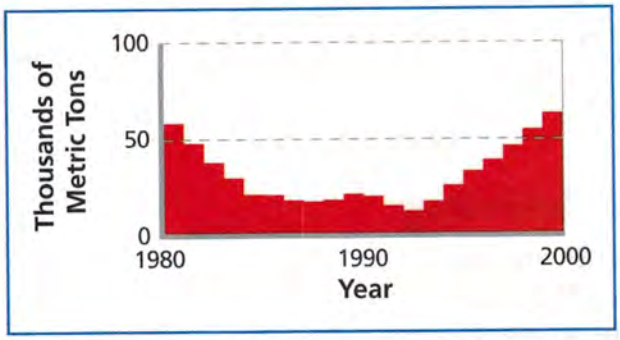
The correct answer is **C**. **A**, **B**, and **D** are also causes of extinction, but **C**—habitat destruction—is the major cause.

Choose the letter of the best answer.

1. A disease kills most members of a plant species in an ecosystem. Several animal species feed on that plant species. After a time, the populations of those animal species decline. Which of the following inferences is valid?
   A The ecosystem will soon recover.
   B The plant species will become extinct.
   C The plant species is a keystone species in that ecosystem.
   D Several animal species in the ecosystem will eventually become extinct.

2. In some areas, foresters plant one tree for every tree they cut. This activity is an example of
   F a nonsustainable approach to a nonrenewable natural resource.
   G a sustainable approach to a nonrenewable natural resource.
   H a nonsustainable approach to a renewable natural resource.
   J a sustainable approach to a renewable natural resource.

The graph below shows how the population of one kind of fish, haddock, changed in Georges Bank between 1980 and 2000. Use the graph below to answer Questions 3 and 4.



3. Which of the following statements is a valid interpretation of the graphed data?
   A Overfishing of haddock began in 1990 and stopped in 2000.
   B By 2000, the haddock population had recovered.
   C The haddock population from 1980 to 1990 demonstrates the idea of sustainable use.
   D The haddock population is decreasing and will probably continue to decrease.

4. Which of the following probably accounts for the trend shown between 1992 and 2000?
   F laws regulating haddock fishing
   G overfishing
   H niche diversity
   J habitat fragmentation

5. An environmental impact statement describes the possible effects that a project might have on the environment. Which of the following would be included in an environmental impact statement on drilling for oil in Antarctica?
   A the costs of setting up a drilling operation
   B the estimated amount of oil produced by the drilling operation
   C the effect of oil spills on organisms living in Antarctica
   D the effect of increased oil production on the economy

Constructed Response

6. Explain how people benefit when biodiversity is maintained and worldwide ecosystems contain a wide variety of organisms.

SKILLS Handbook

Think Like a Scientist

Scientists have a particular way of looking at the world, or scientific habits of mind. Whenever you ask a question and explore possible answers, you use many of the same skills that scientists do. Some of these skills are described on this page.

Observing

When you use one or more of your five senses to gather information about the world, you are **observing.** Hearing a dog bark, counting twelve green seeds, and smelling smoke are all observations. To increase the power of their senses, scientists sometimes use microscopes, telescopes, or other instruments that help them make more detailed observations.

An observation must be an accurate report of what your senses detect. It is important to keep careful records of your observations in science class by writing or drawing in a notebook. The information collected through observations is called evidence, or data.

Inferring

When you interpret an observation, you are **inferring,** or making an inference. For example, if you hear your dog barking, you may infer that someone is at your front door. To make this inference, you combine the evidence—the barking dog—and your experience or knowledge—you know that your dog barks when strangers approach—to reach a logical conclusion.

Notice that an inference is not a fact; it is only one of many possible interpretations for an observation. For example, your dog may be barking because it wants to go for a walk. An inference may turn out to be incorrect even if it is based on accurate observations and logical reasoning. The only way to find out if an inference is correct is to investigate further.

Predicting

When you listen to the weather forecast, you hear many predictions about the next day's weather—what the temperature will be, whether it will rain, and how windy it will be. Weather forecasters use observations and knowledge of weather patterns to predict the weather. The skill of **predicting** involves making an inference about a future event based on current evidence or past experience.

Because a prediction is an inference, it may prove to be false. In science class, you can test some of your predictions by doing experiments. For example, suppose you predict that larger paper airplanes can fly farther than smaller airplanes. How could you test your prediction?

Activity

Use the photograph to answer the questions below.

Observing Look closely at the photograph. List at least three observations.

Inferring Use your observations to make an inference about what has happened. What experience or knowledge did you use to make the inference?

Predicting Predict what will happen next. On what evidence or experience do you base your prediction?

Classifying

Could you imagine searching for a book in the library if the books were shelved in no particular order? Your trip to the library would be an all-day event! Luckily, librarians group together books on similar topics or by the same author. Grouping together items that are alike in some way is called **classifying.** You can classify items in many ways: by size, by shape, by use, and by other important characteristics.

Like librarians, scientists use the skill of classifying to organize information and objects. When things are sorted into groups, the relationships among them become easier to understand.

Activity

Classify the objects in the photograph into two groups based on any characteristic you choose. Then use another characteristic to classify the objects into three groups.

Activity

This student is using a model to demonstrate what causes day and night on Earth. What do the flashlight and the tennis ball in the model represent?

Making Models

Have you ever drawn a picture to help someone understand what you were saying? Such a drawing is one type of model. A model is a picture, diagram, computer image, or other representation of a complex object or process. **Making models** helps people understand things that they cannot observe directly.

Scientists often use models to represent things that are either very large or very small, such as the planets in the solar system, or the parts of a cell. Such models are physical models—drawings or three-dimensional structures that look like the real thing. Other models are mental models—mathematical equations or words that describe how something works.

Communicating

Whenever you talk on the phone, write a report, or listen to your teacher at school, you are communicating. **Communicating** is the process of sharing ideas and information with other people. Communicating effectively requires many skills, including writing, reading, speaking, listening, and making models.

Scientists communicate to share results, information, and opinions. Scientists often communicate about their work in journals, over the telephone, in letters, and on the Internet. They also attend scientific meetings where they share their ideas with one another in person.

Activity

On a sheet of paper, write out clear, detailed directions for tying your shoe. Then exchange directions with a partner. Follow your partner's directions exactly. How successful were you at tying your shoe? How could your partner have communicated more clearly?

Making Measurements

By measuring, scientists can express their observations more precisely and communicate more information about what they observe.

Measuring in SI

The standard system of measurement used by scientists around the world is known as the International System of Units, which is abbreviated as SI (**Système International d'Unités,** in French). SI units are easy to use because they are based on powers of 10. Each unit is ten times larger than the next smallest unit and one tenth the size of the next largest unit. The table lists the prefixes used to name the most common SI units.

Common SI Prefixes

Prefix	Symbol	Meaning
kilo-	k	1,000
hecto-	h	100
deka-	da	10
deci-	d	0.1 (one tenth)
centi-	c	0.01 (one hundredth)
milli-	m	0.001 (one thousandth)

Length To measure length, or the distance between two points, the unit of measure is the **meter (m).** The distance from the floor to a doorknob is approximately one meter. Long distances, such as the distance between two cities, are measured in kilometers (km). Small lengths are measured in centimeters (cm) or millimeters (mm). Scientists use metric rulers and meter sticks to measure length.

Common Conversions

1 km	=	1,000 m
1 m	=	100 cm
1 m	=	1,000 mm
1 cm	=	10 mm

Activity

The larger lines on the metric ruler in the picture show centimeter divisions, while the smaller, unnumbered lines show millimeter divisions. How many centimeters long is the shell? How many millimeters long is it?

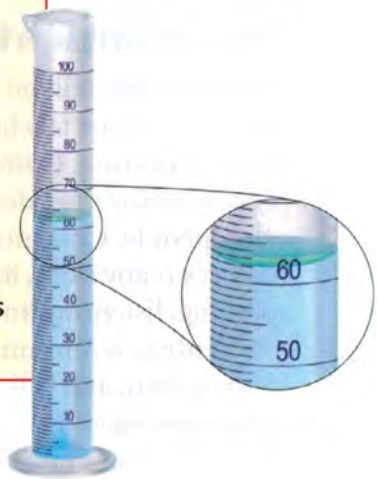
Liquid Volume To measure the volume of a liquid, or the amount of space it takes up, you will use a unit of measure known as the **liter (L).** One liter is the approximate volume of a medium-size carton of milk. Smaller volumes are measured in milliliters (mL). Scientists use graduated cylinders to measure liquid volume.

Activity

The graduated cylinder in the picture is marked in milliliter divisions. Notice that the water in the cylinder has a curved surface. This curved surface is called the *meniscus*. To measure the volume, you must read the level at the lowest point of the meniscus. What is the volume of water in this graduated cylinder?

Common Conversion

1 L	=	1,000 mL



Mass To measure mass, or the amount of matter in an object, you will use a unit of measure known as the **gram (g).** One gram is approximately the mass of a paper clip. Larger masses are measured in kilograms (kg). Scientists use a balance to find the mass of an object.

Common Conversion
1 kg = 1,000 g

Activity

The mass of the potato in the picture is measured in kilograms. What is the mass of the potato? Suppose a recipe for potato salad called for one kilogram of potatoes. About how many potatoes would you need?

Temperature To measure the temperature of a substance, you will use the **Celsius scale.** Temperature is measured in degrees Celsius (°C) using a Celsius thermometer. Water freezes at 0°C and boils at 100°C.

Time The unit scientists use to measure time is the **second (s).**

Activity

What is the temperature of the liquid in degrees Celsius?

Converting SI Units

To use the SI system, you must know how to convert between units. Converting from one unit to another involves the skill of **calculating,** or using mathematical operations. Converting between SI units is similar to converting between dollars and dimes because both systems are based on powers of ten.

Suppose you want to convert a length of 80 centimeters to meters. Follow these steps to convert between units.

1. Begin by writing down the measurement you want to convert—in this example, 80 centimeters.
2. Write a conversion factor that represents the relationship between the two units you are converting. In this example, the relationship is 1 meter = 100 centimeters. Write this conversion factor as a fraction, making sure to place the units you are converting from (centimeters, in this example) in the denominator.
3. Multiply the measurement you want to convert by the fraction. When you do this, the units in the first measurement will cancel out with the units in the denominator. Your answer will be in the units you are converting to (meters, in this example).

Example

80 centimeters = ■ meters

$$80 \text{ centimeters} \times \frac{1 \text{ meter}}{100 \text{ centimeters}} = \frac{80 \text{ meters}}{100}$$

$$= 0.8 \text{ meters}$$

Activity

Convert between the following units.

1. 600 millimeters = ■ meters
2. 0.35 liters = ■ milliliters
3. 1,050 grams = ■ kilograms

Conducting a Scientific Investigation

In some ways, scientists are like detectives, piecing together clues to learn about a process or event. One way that scientists gather clues is by carrying out experiments. An experiment tests an idea in a careful, orderly manner. Although experiments do not all follow the same steps in the same order, many follow a pattern similar to the one described here.

Posing Questions

Experiments begin by asking a scientific question. A scientific question is one that can be answered by gathering evidence. For example, the question "Which freezes faster—fresh water or salt water?" is a scientific question because you can carry out an investigation and gather information to answer the question.

Developing a Hypothesis

The next step is to form a hypothesis. A **hypothesis** is a possible explanation for a set of observations or answer to a scientific question. In science, a hypothesis must be something that can be tested. A hypothesis can be worded as an *If . . . then . . .* statement. For example, a hypothesis might be *"If I add table salt to fresh water, then the water will freeze at a lower temperature."* A hypothesis worded this way serves as a rough outline of the experiment you should perform.

Designing an Experiment

Next you need to plan a way to test your hypothesis. Your plan should be written out as a step-by-step procedure and should describe the observations or measurements you will make.

Two important steps involved in designing an experiment are controlling variables and forming operational definitions.

Controlling Variables In a well-designed experiment, you need to keep all variables the same except for one. A **variable** is any factor that can change in an experiment. The factor that you change is called the **manipulated variable.** In this experiment, the manipulated variable is the amount of table salt added to the water. Other factors, such as the amount of water or the starting temperature, are kept constant.

The factor that changes as a result of the manipulated variable is called the **responding variable.** The responding variable is what you measure or observe to obtain your results. In this experiment, the responding variable is the temperature at which the water freezes.

An experiment in which all factors except one are kept constant is called a **controlled experiment.** Most controlled experiments include a test called the control. In this experiment, Container 3 is the control. Because no salt is added to Container 3, you can compare the results from the other containers to it. Any difference in results must be due to the addition of salt alone.

Forming Operational Definitions Another important aspect of a well-designed experiment is having clear operational definitions. An **operational definition** is a statement that describes how a particular variable is to be measured or how a term is to be defined. For example, in this experiment, how will you determine if the water has frozen? You might decide to insert a stick in each container at the start of the experiment. Your operational definition of "frozen" would be the time at which the stick can no longer move.

Experimental Procedure

1. Fill 3 containers with 300 milliliters of cold tap water.
2. Add 10 grams of salt to Container 1; stir.
   Add 20 grams of salt to Container 2; stir.
   Add no salt to Container 3.
3. Place the 3 containers in a freezer.
4. Check the containers every 15 minutes.
   Record your observations.

Interpreting Data

The observations and measurements you make in an experiment are called **data.** At the end of an experiment, you need to analyze the data to look for any patterns or trends. Patterns often become clear if you organize your data in a data table or graph. Then think through what the data reveal. Do they support your hypothesis? Do they point out a flaw in your experiment? Do you need to collect more data?

Drawing Conclusions

A **conclusion** is a statement that sums up what you have learned from an experiment. When you draw a conclusion, you need to decide whether the data you collected support your hypothesis or not. You may need to repeat an experiment several times before you can draw any conclusions from it. Conclusions often lead you to pose new questions and plan new experiments to answer them.

Activity

Is a ball's bounce affected by the height from which it is dropped? Using the steps just described, plan a controlled experiment to investigate this problem.

Technology Design Skills

Engineers are people who use scientific and technological knowledge to solve practical problems. To design new products, engineers usually follow the process described here, even though they may not follow these steps in the exact order. As you read the steps, think about how you might apply them in technology labs.

Identify a Need

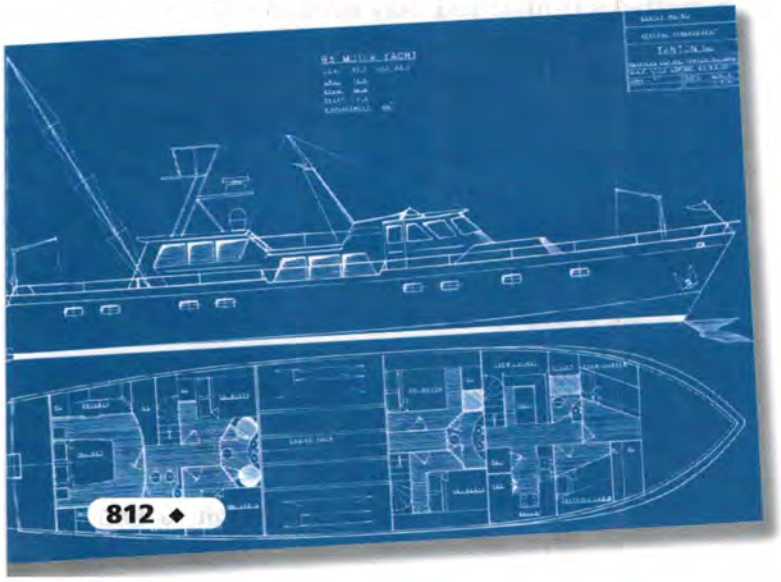
Before engineers begin designing a new product, they must first identify the need they are trying to meet. For example, suppose you are a member of a design team in a company that makes toys. Your team has identified a need: a toy boat that is inexpensive and easy to assemble.

Research the Problem

Engineers often begin by gathering information that will help them with their new design. This research may include finding articles in books, magazines, or on the Internet. It may also include talking to other engineers who have solved similar problems. Engineers often perform experiments related to the product they want to design.

For your toy boat, you could look at toys that are similar to the one you want to design. You might do research on the Internet. You could also test some materials to see whether they will work well in a toy boat.

Drawing for a boat design ▼



Design a Solution

Research gives engineers information that helps them design a product. When engineers design new products, they usually work in teams.

Generating Ideas Often design teams hold brainstorming meetings in which any team member can contribute ideas. **Brainstorming** is a creative process in which one team member's suggestions often spark ideas in other group members. Brainstorming can lead to new approaches to solving a design problem.

Evaluating Constraints During brainstorming, a design team will often come up with several possible designs. The team must then evaluate each one.

As part of their evaluation, engineers consider constraints. **Constraints** are factors that limit or restrict a product design. Physical characteristics, such as the properties of materials used to make your toy boat, are constraints. Money and time are also constraints. If the materials in a product cost a lot, or if the product takes a long time to make, the design may be impractical.

Making Trade-offs Design teams usually need to make trade-offs. In a **trade-off,** engineers give up one benefit of a proposed design in order to obtain another. In designing your toy boat, you will have to make trade-offs. For example, suppose one material is sturdy but not fully waterproof. Another material is more waterproof, but breakable. You may decide to give up the benefit of sturdiness in order to obtain the benefit of waterproofing.

Build and Evaluate a Prototype

Once the team has chosen a design plan, the engineers build a prototype of the product. A **prototype** is a working model used to test a design. Engineers evaluate the prototype to see whether it works well, is easy to operate, is safe to use, and holds up to repeated use.

Think of your toy boat. What would the prototype be like? Of what materials would it be made? How would you test it?

Troubleshoot and Redesign

Few prototypes work perfectly, which is why they need to be tested. Once a design team has tested a prototype, the members analyze the results and identify any problems. The team then tries to **troubleshoot,** or fix the design problems. For example, if your toy boat leaks or wobbles, the boat should be redesigned to eliminate those problems.

Communicate the Solution

A team needs to communicate the final design to the people who will manufacture and use the product. To do this, teams may use sketches, detailed drawings, computer simulations, and word descriptions.

Activity

You can use the technology design process to design and build a toy boat.

Research and Investigate

1. Visit the library or go online to research toy boats.
2. Investigate how a toy boat can be powered, including wind, rubber bands, or baking soda and vinegar.
3. Brainstorm materials, shapes, and steering for your boat.

Design and Build

4. Based on your research, design a toy boat that
   - is made of readily available materials
   - is no larger than 15 cm long and 10 cm wide
   - includes a power system, a rudder, and an area for cargo
   - travels 2 meters in a straight line carrying a load of 20 pennies
5. Sketch your design and write a step-by-step plan for building your boat. After your teacher approves your plan, build your boat.

Evaluate and Redesign

6. Test your boat, evaluate the results, and troubleshoot any problems.
7. Based on your evaluation, redesign your toy boat so it performs better.

Creating Data Tables and Graphs

How can you make sense of the data in a science experiment? The first step is to organize the data to help you understand them. Data tables and graphs are helpful tools for organizing data.

Data Tables

You have gathered your materials and set up your experiment. But before you start, you need to plan a way to record what happens during the experiment. By creating a data table, you can record your observations and measurements in an orderly way.

Suppose, for example, that a scientist conducted an experiment to find out how many Calories people of different body masses burn while doing various activities. The data table shows the results.

Notice in this data table that the manipulated variable (body mass) is the heading of one column. The responding variable (for Experiment 1, the number of Calories burned while bicycling) is the heading of the next column. Additional columns were added for related experiments.

Calories Burned in 30 Minutes

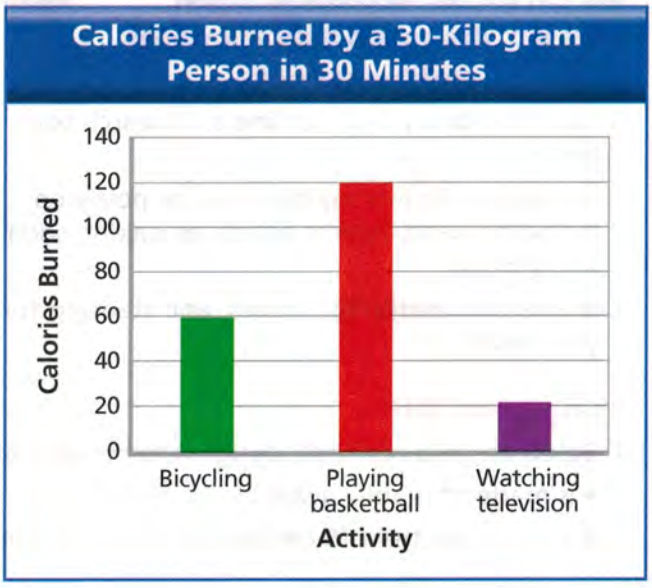
Body Mass	Experiment 1: Bicycling	Experiment 2: Playing Basketball	Experiment 3: Watching Television
30 kg	60 Calories	120 Calories	21 Calories
40 kg	77 Calories	164 Calories	27 Calories
50 kg	95 Calories	206 Calories	33 Calories
60 kg	114 Calories	248 Calories	38 Calories

Bar Graphs

To compare how many Calories a person burns doing various activities, you could create a bar graph. A bar graph is used to display data in a number of separate, or distinct, categories. In this example, bicycling, playing basketball, and watching television are the three categories.

To create a bar graph, follow these steps.

1. On graph paper, draw a horizontal, or *x*-, axis and a vertical, or *y*-, axis.
2. Write the names of the categories to be graphed along the horizontal axis. Include an overall label for the axis as well.
3. Label the vertical axis with the name of the responding variable. Include units of measurement. Then create a scale along the axis by marking off equally spaced numbers that cover the range of the data collected.
4. For each category, draw a solid bar using the scale on the vertical axis to determine the height. Make all the bars the same width.
5. Add a title that describes the graph.



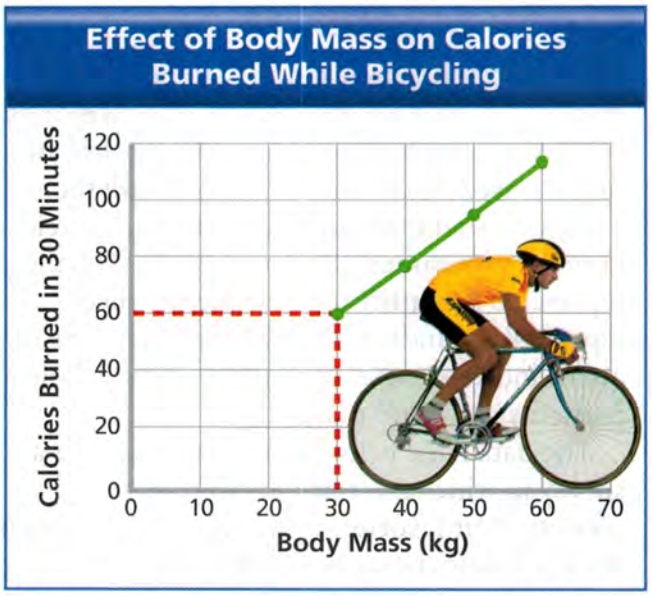
Line Graphs

To see whether a relationship exists between body mass and the number of Calories burned while bicycling, you could create a line graph. A line graph is used to display data that show how one variable (the responding variable) changes in response to another variable (the manipulated variable). You can use a line graph when your manipulated variable is *continuous*, that is, when there are other points between the ones that you tested. In this example, body mass is a continuous variable because there are other body masses between 30 and 40 kilograms (for example, 31 kilograms). Time is another example of a continuous variable.

Line graphs are powerful tools because they allow you to estimate values for conditions that you did not test in the experiment. For example, you can use the line graph to estimate that a 35-kilogram person would burn 68 Calories while bicycling.

To create a line graph, follow these steps.

1. On graph paper, draw a horizontal, or *x*-, axis and a vertical, or *y*-, axis.
2. Label the horizontal axis with the name of the manipulated variable. Label the vertical axis with the name of the responding variable. Include units of measurement.
3. Create a scale on each axis by marking off equally spaced numbers that cover the range of the data collected.
4. Plot a point on the graph for each piece of data. In the line graph above, the dotted lines show how to plot the first data point (30 kilograms and 60 Calories). Follow an imaginary vertical line extending up from the horizontal axis at the 30-kilogram mark. Then follow an imaginary horizontal line extending across from the vertical axis at the 60-Calorie mark. Plot the point where the two lines intersect.



5. Connect the plotted points with a solid line. (In some cases, it may be more appropriate to draw a line that shows the general trend of the plotted points. In those cases, some of the points may fall above or below the line. Also, not all graphs are linear. It may be more appropriate to draw a curve to connect the points.)
6. Add a title that identifies the variables or relationship in the graph.

Activity

Create line graphs to display the data from Experiment 2 and Experiment 3 in the data table.

Activity

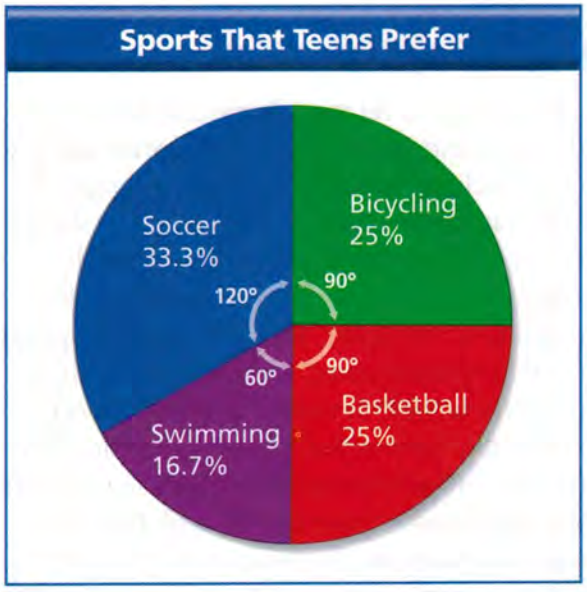
You read in the newspaper that a total of 4 centimeters of rain fell in your area in June, 2.5 centimeters fell in July, and 1.5 centimeters fell in August. What type of graph would you use to display these data? Use graph paper to create the graph.

Circle Graphs

Like bar graphs, circle graphs can be used to display data in a number of separate categories. Unlike bar graphs, however, circle graphs can only be used when you have data for *all* the categories that make up a given topic. A circle graph is sometimes called a pie chart. The pie represents the entire topic, while the slices represent the individual categories. The size of a slice indicates what percentage of the whole a particular category makes up.

The data table below shows the results of a survey in which 24 teenagers were asked to identify their favorite sport. The data were then used to create the circle graph at the right.

Favorite Sports	
Sport	Students
Soccer	8
Basketball	6
Bicycling	6
Swimming	4



To create a circle graph, follow these steps.

1. Use a compass to draw a circle. Mark the center with a point. Then draw a line from the center point to the top of the circle.
2. Determine the size of each "slice" by setting up a proportion where x equals the number of degrees in a slice. (*Note:* A circle contains 360 degrees.) For example, to find the number of degrees in the "soccer" slice, set up the following proportion:

$$\frac{\text{Students who prefer soccer}}{\text{Total number of students}} = \frac{x}{\text{Total number of degrees in a circle}}$$

$$\frac{8}{24} = \frac{x}{360}$$

Cross-multiply and solve for x.

$$24x = 8 \times 360$$
$$x = 120$$

The "soccer" slice should contain 120 degrees.

3. Use a protractor to measure the angle of the first slice, using the line you drew to the top of the circle as the 0° line. Draw a line from the center of the circle to the edge for the angle you measured.
4. Continue around the circle by measuring the size of each slice with the protractor. Start measuring from the edge of the previous slice so the wedges do not overlap. When you are done, the entire circle should be filled in.
5. Determine the percentage of the whole circle that each slice represents. To do this, divide the number of degrees in a slice by the total number of degrees in a circle (360), and multiply by 100%. For the "soccer" slice, you can find the percentage as follows:

$$\frac{120}{360} \times 100\% = 33.3\%$$

6. Use a different color for each slice. Label each slice with the category and with the percentage of the whole it represents.
7. Add a title to the circle graph.

Activity

In a class of 28 students, 12 students take the bus to school, 10 students walk, and 6 students ride their bicycles. Create a circle graph to display these data.

Math Review

Scientists use math to organize, analyze, and present data. This appendix will help you review some basic math skills.

Mean, Median, and Mode

The **mean** is the average, or the sum of the data divided by the number of data items. The middle number in a set of ordered data is called the **median.** The **mode** is the number that appears most often in a set of data.

Example

A scientist counted the number of distinct songs sung by seven different male birds and collected the data shown below.

Male Bird Songs

Bird	A	B	C	D	E	F	G
Number of Songs	36	29	40	35	28	36	27

To determine the mean number of songs, add the total number of songs and divide by the number of data items—in this case, the number of male birds.

$$\text{Mean} = \frac{231}{7} = 33 \text{ songs}$$

To find the median number of songs, arrange the data in numerical order and find the number in the middle of the series.

27 28 29 35 36 36 40

The number in the middle is 35, so the median number of songs is 35.

The mode is the value that appears most frequently. In the data, 36 appears twice, while each other item appears only once. Therefore, 36 songs is the mode.

Practice

Find out how many minutes it takes each student in your class to get to school. Then find the mean, median, and mode for the data.

Probability

Probability is the chance that an event will occur. Probability can be expressed as a ratio, a fraction, or a percentage. For example, when you flip a coin, the probability that the coin will land heads up is 1 in 2, or $\frac{1}{2}$, or 50 percent.

The probability that an event will happen can be expressed in the following formula.

$$P(\text{event}) = \frac{\text{Number of times the event can occur}}{\text{Total number of possible events}}$$

Example

A paper bag contains 25 blue marbles, 5 green marbles, 5 orange marbles, and 15 yellow marbles. If you close your eyes and pick a marble from the bag, what is the probability that it will be yellow?

$$P(\text{yellow marbles}) = \frac{\text{15 yellow marbles}}{\text{50 marbles total}}$$

$$P = \frac{15}{50}, \text{ or } \frac{3}{10}, \text{ or } 30\%$$

Practice

Each side of a cube has a letter on it. Two sides have *A*, three sides have *B*, and one side has *C*. If you roll the cube, what is the probability that *A* will land on top?

Area

The **area** of a surface is the number of square units that cover it. The front cover of your textbook has an area of about 600 cm^2.

Area of a Rectangle and a Square To find the area of a rectangle, multiply its length times its width. The formula for the area of a rectangle is

$$A = \ell \times w, \text{ or } A = \ell w$$

Since all four sides of a square have the same length, the area of a square is the length of one side multiplied by itself, or squared.

$$A = s \times s, \text{ or } A = s^2$$

Example

A scientist is studying the plants in a field that measures 75 m × 45 m. What is the area of the field?

$A = \ell \times w$

$A = 75 \text{ m} \times 45 \text{ m}$

$A = 3{,}375 \text{ m}^2$

Area of a Circle The formula for the area of a circle is

$$A = \pi \times r \times r, \text{ or } A = \pi r^2$$

The length of the radius is represented by r, and the value of π is approximately $\frac{22}{7}$.

Example

Find the area of a circle with a radius of 14 cm.

$A = \pi r^2$

$A = 14 \times 14 \times \frac{22}{7}$

$A = 616 \text{ cm}^2$

Practice

Find the area of a circle that has a radius of 21 m.

Circumference

The distance around a circle is called the circumference. The formula for finding the circumference of a circle is

$$C = 2 \times \pi \times r, \text{ or } C = 2\pi r$$

Example

The radius of a circle is 35 cm. What is its circumference?

$C = 2\pi r$

$C = 2 \times 35 \times \frac{22}{7}$

$C = 220 \text{ cm}$

Practice

What is the circumference of a circle with a radius of 28 m?

Volume

The volume of an object is the number of cubic units it contains. The volume of a wastebasket, for example, might be about 26,000 cm^3.

Volume of a Rectangular Object To find the volume of a rectangular object, multiply the object's length times its width times its height.

$$V = \ell \times w \times h, \text{ or } V = \ell wh$$

Example

Find the volume of a box with length 24 cm, width 12 cm, and height 9 cm.

$V = \ell wh$

$V = 24 \text{ cm} \times 12 \text{ cm} \times 9 \text{ cm}$

$V = 2{,}592 \text{ cm}^3$

Practice

What is the volume of a rectangular object with length 17 cm, width 11 cm, and height 6 cm?

Fractions

A **fraction** is a way to express a part of a whole. In the fraction $\frac{4}{7}$, 4 is the numerator and 7 is the denominator.

Adding and Subtracting Fractions To add or subtract two or more fractions that have a common denominator, first add or subtract the numerators. Then write the sum or difference over the common denominator.

To find the sum or difference of fractions with different denominators, first find the least common multiple of the denominators. This is known as the least common denominator. Then convert each fraction to equivalent fractions with the least common denominator. Add or subtract the numerators. Then write the sum or difference over the common denominator.

Example

$$\frac{5}{6} - \frac{3}{4} = \frac{10}{12} - \frac{9}{12} = \frac{10 - 9}{12} = \frac{1}{12}$$

Multiplying Fractions To multiply two fractions, first multiply the two numerators, then multiply the two denominators.

Example

$$\frac{5}{6} \times \frac{2}{3} = \frac{5 \times 2}{6 \times 3} = \frac{10}{18} = \frac{5}{9}$$

Dividing Fractions Dividing by a fraction is the same as multiplying by its reciprocal. Reciprocals are numbers whose numerators and denominators have been switched. To divide one fraction by another, first invert the fraction you are dividing by—in other words, turn it upside down. Then multiply the two fractions.

Example

$$\frac{2}{5} \div \frac{7}{8} = \frac{2}{5} \times \frac{8}{7} = \frac{2 \times 8}{5 \times 7} = \frac{16}{35}$$

Practice

Solve the following: $\frac{3}{7} \div \frac{4}{5}$.

Decimals

Fractions whose denominators are 10, 100, or some other power of 10 are often expressed as decimals. For example, the fraction $\frac{9}{10}$ can be expressed as the decimal 0.9, and the fraction $\frac{7}{100}$ can be written as 0.07.

Adding and Subtracting With Decimals To add or subtract decimals, line up the decimal points before you carry out the operation.

Example

$$\begin{array}{r} 27.4 \\ +\ 6.19 \\ \hline 33.59 \end{array} \qquad \begin{array}{r} 278.635 \\ -\ 191.4 \\ \hline 87.235 \end{array}$$

Multiplying With Decimals When you multiply two numbers with decimals, the number of decimal places in the product is equal to the total number of decimal places in each number being multiplied.

Example

$$\begin{array}{rl} 46.2 & \text{(one decimal place)} \\ \times\ 2.37 & \text{(two decimal places)} \\ \hline 109.494 & \text{(three decimal places)} \end{array}$$

Dividing With Decimals To divide a decimal by a whole number, put the decimal point in the quotient above the decimal point in the dividend.

Example

$$15.5 \div 5$$

$$5\overline{)15.5}\ \ 3.1$$

To divide a decimal by a decimal, you need to rewrite the divisor as a whole number. Do this by multiplying both the divisor and dividend by the same multiple of 10.

Example

$$1.68 \div 4.2 = 16.8 \div 42$$

$$42\overline{)16.8}\ \ 0.4$$

Practice

Multiply 6.21 by 8.5.

Ratio and Proportion

A **ratio** compares two numbers by division. For example, suppose a scientist counts 800 wolves and 1,200 moose on an island. The ratio of wolves to moose can be written as a fraction, $\frac{800}{1{,}200}$, which can be reduced to $\frac{2}{3}$. The same ratio can also be expressed as 2 to 3 or 2 : 3.

A **proportion** is a mathematical sentence saying that two ratios are equivalent. For example, a proportion could state that $\frac{800 \text{ wolves}}{1{,}200 \text{ moose}} = \frac{2 \text{ wolves}}{3 \text{ moose}}$. You can sometimes set up a proportion to determine or estimate an unknown quantity. For example, suppose a scientist counts 25 beetles in an area of 10 square meters. The scientist wants to estimate the number of beetles in 100 square meters.

Example

1. Express the relationship between beetles and area as a ratio: $\frac{25}{10}$, simplified to $\frac{5}{2}$.
2. Set up a proportion, with x representing the number of beetles. The proportion can be stated as $\frac{5}{2} = \frac{x}{100}$.
3. Begin by cross-multiplying. In other words, multiply each fraction's numerator by the other fraction's denominator.

   $5 \times 100 = 2 \times x$, or $500 = 2x$
4. To find the value of x, divide both sides by 2. The result is 250, or 250 beetles in 100 square meters.

Practice

Find the value of x in the following proportion: $\frac{6}{7} = \frac{x}{49}$.

Percentage

A **percentage** is a ratio that compares a number to 100. For example, there are 37 granite rocks in a collection that consists of 100 rocks. The ratio $\frac{37}{100}$ can be written as 37%. Granite rocks make up 37% of the rock collection.

You can calculate percentages of numbers other than 100 by setting up a proportion.

Example

Rain falls on 9 days out of 30 in June. What percentage of the days in June were rainy?

$$\frac{9 \text{ days}}{30 \text{ days}} = \frac{d\%}{100\%}$$

To find the value of d, begin by cross-multiplying, as for any proportion:

$9 \times 100 = 30 \times d \qquad d = \frac{900}{30} \qquad d = 30$

Practice

There are 300 marbles in a jar, and 42 of those marbles are blue. What percentage of the marbles are blue?

Significant Figures

The **precision** of a measurement depends on the instrument you use to take the measurement. For example, if the smallest unit on the ruler is millimeters, then the most precise measurement you can make will be in millimeters.

The sum or difference of measurements can only be as precise as the least precise measurement being added or subtracted. Round your answer so that it has the same number of digits after the decimal as the least precise measurement. Round up if the last digit is 5 or more, and round down if the last digit is 4 or less.

Example

Subtract a temperature of 5.2°C from the temperature 75.46°C.

$$75.46 - 5.2 = 70.26$$

5.2 has the fewest digits after the decimal, so it is the least precise measurement. Since the last digit of the answer is 6, round up to 3. The most precise difference between the measurements is 70.3°C.

Practice

Add 26.4 m to 8.37 m. Round your answer according to the precision of the measurements.

Significant figures are the number of nonzero digits in a measurement. Zeroes between nonzero digits are also significant. For example, the measurements 12,500 L, 0.125 cm, and 2.05 kg all have three significant figures. When you multiply and divide measurements, the one with the fewest significant figures determines the number of significant figures in your answer.

Example

Multiply 110 g by 5.75 g.

$$110 \times 5.75 = 632.5$$

Because 110 has only two significant figures, round the answer to 630 g.

Scientific Notation

A **factor** is a number that divides into another number with no remainder. In the example, the number 3 is used as a factor four times.

An **exponent** tells how many times a number is used as a factor. For example, $3 \times 3 \times 3 \times 3$ can be written as 3^4. The exponent ^{4} indicates that the number 3 is used as a factor four times. Another way of expressing this is to say that 81 is equal to 3 to the fourth power.

Example

$$3^4 = 3 \times 3 \times 3 \times 3 = 81$$

Scientific notation uses exponents and powers of ten to write very large or very small numbers in shorter form. When you write a number in scientific notation, you write the number as two factors. The first factor is any number between 1 and 10. The second factor is a power of 10, such as 10^3 or 10^6.

Example

The average distance between the planet Mercury and the sun is 58,000,000 km. To write the first factor in scientific notation, insert a decimal point in the original number so that you have a number between 1 and 10. In the case of 58,000,000, the number is 5.8.

To determine the power of 10, count the number of places that the decimal point moved. In this case, it moved 7 places.

$$58{,}000{,}000 \text{ km} = 5.8 \times 10^7 \text{ km}$$

Practice

Express 6,590,000 in scientific notation.

Reading Comprehension Skills

Each section in your textbook introduces a Target Reading Skill. You will improve your reading comprehension by using the Target Reading Skills described below.

Using Prior Knowledge

Your prior knowledge is what you already know before you begin to read about a topic. Building on what you already know gives you a head start on learning new information. Before you begin a new assignment, think about what you know. You might look at the headings and the visuals to spark your memory. You can list what you know. Then, as you read, consider questions like these.

- How does what you learn relate to what you know?
- How did something you already know help you learn something new?
- Did your original ideas agree with what you have just learned?

Asking Questions

Asking yourself questions is an excellent way to focus on and remember new information in your textbook. For example, you can turn the text headings into questions. Then your questions can guide you to identify the important information as you read. Look at these examples:

Heading: Using Seismographic Data

Question: How are seismographic data used?

Heading: Kinds of Faults

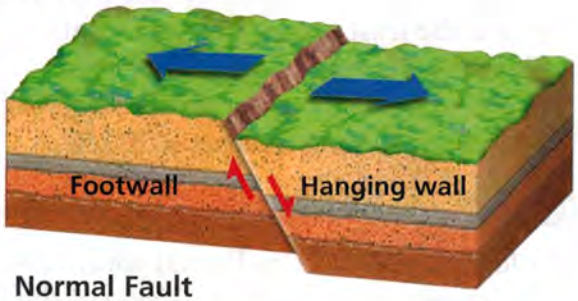
Question: What are the kinds of faults?

You do not have to limit your questions to text headings. Ask questions about anything that you need to clarify or that will help you understand the content. *What* and *how* are probably the most common question words, but you may also ask *why*, *who*, *when*, or *where* questions.

Previewing Visuals

Visuals are photographs, graphs, tables, diagrams, and illustrations. Visuals contain important information. Before you read, look at visuals and their labels and captions. This preview will help you prepare for what you will be reading.

Often you will be asked what you want to learn about a visual. For example, after you look at the normal fault diagram below, you might ask: What is the movement along a normal fault? Questions about visuals give you a purpose for reading—to answer your questions.



Normal Fault

Outlining

An outline shows the relationship between main ideas and supporting ideas. An outline has a formal structure. You write the main ideas, called topics, next to Roman numerals. The supporting ideas, called subtopics, are written under the main ideas and labeled A, B, C, and so on. An outline looks like this:

Technology and Society

I. Technology through history

II. The impact of technology on society

A.

B.

Identifying Main Ideas

When you are reading science material, it is important to try to understand the ideas and concepts that are in a passage. Each paragraph has a lot of information and detail. Good readers try to identify the most important—or biggest—idea in every paragraph or section. That's the main idea. The other information in the paragraph supports or further explains the main idea.

Sometimes main ideas are stated directly. In this book, some main ideas are identified for you as key concepts. These are printed in boldface type. However, you must identify other main ideas yourself. In order to do this, you must identify all the ideas within a paragraph or section. Then ask yourself which idea is big enough to include all the other ideas.

Comparing and Contrasting

When you compare and contrast, you examine the similarities and differences between things. You can compare and contrast in a Venn diagram or in a table.

Venn Diagram A Venn diagram consists of two overlapping circles. In the space where the circles overlap, you write the characteristics that the two items have in common. In one of the circles outside the area of overlap, you write the differing features or characteristics of one of the items. In the other circle outside the area of overlap, you write the differing characteristics of the other item.

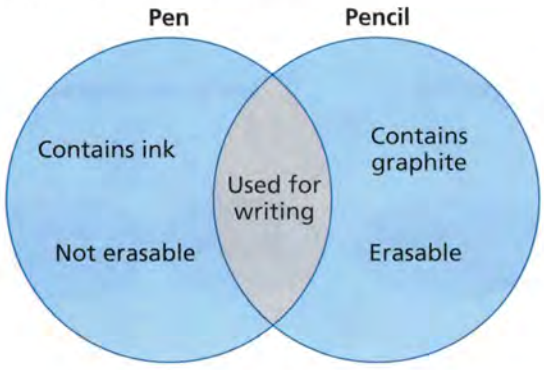


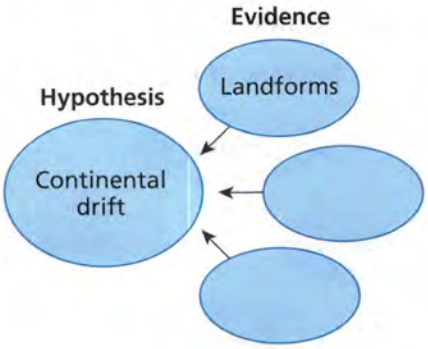
Table In a compare/contrast table, you list the characteristics or features to be compared across the top of the table. Then list the items to be compared in the left column. Complete the table by filling in information about each characteristic or feature.

Blood Vessel	Function	Structure of Wall
Artery	Carries blood away from heart	
Capillary		
Vein		

Identifying Supporting Evidence

A hypothesis is a possible explanation for observations made by scientists or an answer to a scientific question. Scientists must carry out investigations and gather evidence that either supports or disproves the hypothesis.

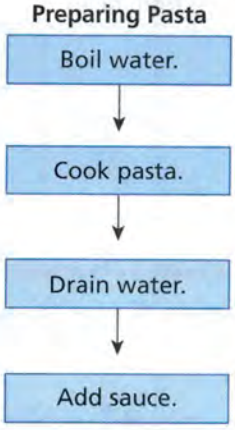
Identifying the supporting evidence for a hypothesis or theory can help you understand the hypothesis or theory. Evidence consists of facts—information whose accuracy can be confirmed by testing or observation.



Sequencing

A sequence is the order in which a series of events occurs. A flowchart or a cycle diagram can help you visualize a sequence.

Flowchart To make a flowchart, write a brief description of each step or event in a box. Place the boxes in order, with the first event at the top of the chart. Then draw an arrow to connect each step or event to the next.

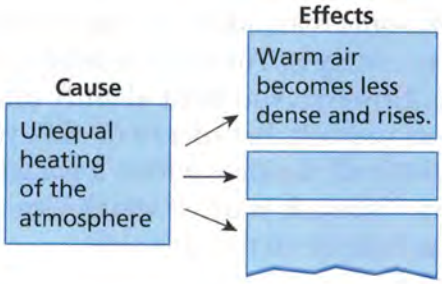


Cycle Diagram A cycle diagram shows a sequence that is continuous, or cyclical. A continuous sequence does not have an end because when the final event is over, the first event begins again. To create a cycle diagram, write the starting event in a box placed at the top of a page in the center. Then, moving in a clockwise direction, write each event in a box in its proper sequence. Draw arrows that connect each event to the one that occurs next.

Relating Cause and Effect

Science involves many cause-and-effect relationships. A cause makes something happen. An effect is what happens. When you recognize that one event causes another, you are relating cause and effect.

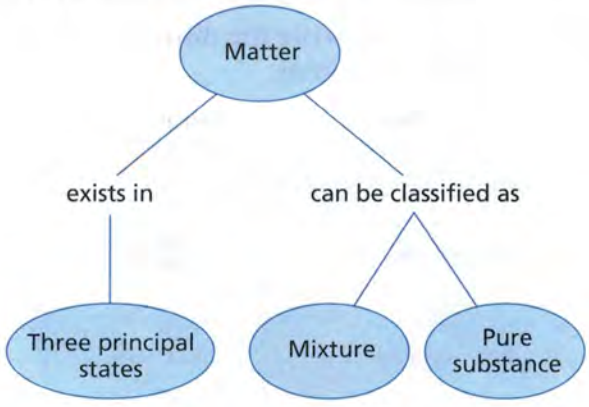
Words like *cause, because, effect, affect,* and *result* often signal a cause or an effect. Sometimes an effect can have more than one cause, or a cause can produce several effects.



Concept Mapping

Concept maps are useful tools for organizing information on any topic. A concept map begins with a main idea or core concept and shows how the idea can be subdivided into related subconcepts or smaller ideas.

You construct a concept map by placing concepts (usually nouns) in ovals and connecting them with linking words (usually verbs). The biggest concept or idea is placed in an oval at the top of the map. Related concepts are arranged in ovals below the big idea. The linking words connect the ovals.



Building Vocabulary

Knowing the meaning of these prefixes, suffixes, and roots will help you understand the meaning of words you do not recognize.

Word Origins Many science words come to English from other languages, such as Greek and Latin. By learning the meaning of a few common Greek and Latin roots, you can determine the meaning of unfamiliar science words.

Prefixes A prefix is a word part that is added at the beginning of a root or base word to change its meaning.

Suffixes A suffix is a word part that is added at the end of a root word to change the meaning.

Greek and Latin Roots

Greek Roots	Meaning	Example
ast-	star	astronaut
geo-	Earth	geology
metron-	measure	kilometer
opt-	eye	optician
photo-	light	photograph
scop-	see	microscope
therm-	heat	thermostat
Latin Roots	**Meaning**	**Example**
aqua-	water	aquarium
aud-	hear	auditorium
duc-, duct-	lead	conduct
flect-	bend	reflect
fract-, frag-	break	fracture
ject-	throw	reject
luc-	light	lucid
spec-	see	inspect

Prefixes and Suffixes

Prefix	Meaning	Example
com-, con-	with	communicate, concert
de-	from; down	decay
di-	two	divide
ex-, exo-	out	exhaust
in-, im-	in, into; not	inject, impossible
re-	again; back	reflect, recall
trans-	across	transfer
Suffix	**Meaning**	**Example**
-al	relating to	natural
-er, -or	one who	teacher, doctor
-ist	one who practices	scientist
-ity	state of	equality
-ology	study of	biology
-tion, -sion	state or quality of	reaction, tension

Safety Symbols

These symbols warn of possible dangers in the laboratory and remind you to work carefully.

Safety Goggles Wear safety goggles to protect your eyes in any activity involving chemicals, flames or heating, or glassware.

Lab Apron Wear a laboratory apron to protect your skin and clothing from damage.

Breakage Handle breakable materials, such as glassware, with care. Do not touch broken glassware.

Heat-Resistant Gloves Use an oven mitt or other hand protection when handling hot materials such as hot plates or hot glassware.

Plastic Gloves Wear disposable plastic gloves when working with organisms and harmful chemicals . Keep your hands away from your face, and dispose of the gloves according to your teacher's instructions.

Heating Use a clamp or tongs to pick up hot glassware. Do not touch hot objects with your bare hands.

Flames Before you work with flames, tie back loose hair and clothing. Follow instructions from your teacher about lighting and extinguishing flames.

No Flames When using flammable materials, make sure there are no flames, sparks, or other exposed heat sources present.

Corrosive Chemical Avoid getting acid or other corrosive chemicals on your skin or clothing or in your eyes. Do not inhale the vapors. Wash your hands after the activity.

Poison Do not let any poisonous chemical come into contact with your skin, and do not inhale its vapors. Wash your hands when you are finished with the activity.

Fumes Work in a ventilated area when harmful vapors may be involved. Avoid inhaling vapors directly. Only test an odor when directed to do so by your teacher, and use a wafting motion to direct the vapor toward your nose.

Sharp Object Scissors, scalpels, knives, needles, pins, and tacks can cut your skin. Always direct a sharp edge or point away from yourself and others.

Animal Safety Treat live or preserved animals or animal parts with care to avoid harming the animals or yourself. Wash your hands when you are finished with the activity.

Plant Safety Handle plants only as directed by your teacher. If you are allergic to certain plants, tell your teacher; do not do an activity involving those plants. Avoid touching harmful plants such as poison ivy. Wash your hands when you are finished with the activity.

Electric Shock To avoid electric shock, never use electrical equipment around water, or when the equipment is wet or your hands are wet. Be sure cords are untangled and cannot trip anyone. Unplug equipment not in use.

Physical Safety When an experiment involves physical activity, avoid injuring yourself or others. Alert your teacher if there is any reason you should not participate.

Disposal Dispose of chemicals and other laboratory materials safely. Follow the instructions from your teacher.

Hand Washing Wash your hands thoroughly when finished with the activity. Use soap and warm water. Rinse well.

General Safety Awareness When this symbol appears, follow the instructions provided. When you are asked to develop your own procedure in a lab, have your teacher approve your plan before you go further.

Science Safety Rules

General Precautions

Follow all instructions. Never perform activities without the approval and supervision of your teacher. Do not engage in horseplay. Never eat or drink in the laboratory. Keep work areas clean and uncluttered.

Dress Code

Wear safety goggles whenever you work with chemicals, glassware, heat sources such as burners, or any substance that might get into your eyes. If you wear contact lenses, notify your teacher.

Wear a lab apron or coat whenever you work with corrosive chemicals or substances that can stain. Wear disposable plastic gloves when working with organisms and harmful chemicals. Tie back long hair. Remove or tie back any article of clothing or jewelry that can hang down and touch chemicals, flames, or equipment. Roll up long sleeves. Never wear open shoes or sandals.

First Aid

Report all accidents, injuries, or fires to your teacher, no matter how minor. Be aware of the location of the first-aid kit, emergency equipment such as the fire extinguisher and fire blanket, and the nearest telephone. Know whom to contact in an emergency.

Heating and Fire Safety

Keep all combustible materials away from flames. When heating a substance in a test tube, make sure that the mouth of the tube is not pointed at you or anyone else. Never heat a liquid in a closed container. Use an oven mitt to pick up a container that has been heated.

Using Chemicals Safely

Never put your face near the mouth of a container that holds chemicals. Never touch, taste, or smell a chemical unless your teacher tells you to.

Use only those chemicals needed in the activity. Keep all containers closed when chemicals are not being used. Pour all chemicals over the sink or a container, not over your work surface. Dispose of excess chemicals as instructed by your teacher.

Be extra careful when working with acids or bases. When mixing an acid and water, always pour the water into the container first and then add the acid to the water. Never pour water into an acid. Wash chemical spills and splashes immediately with plenty of water.

Using Glassware Safely

If glassware is broken or chipped, notify your teacher immediately. Never handle broken or chipped glass with your bare hands.

Never force glass tubing or thermometers into a rubber stopper or rubber tubing. Have your teacher insert the glass tubing or thermometer if required for an activity.

Using Sharp Instruments

Handle sharp instruments with extreme care. Never cut material toward you; cut away from you.

Animal and Plant Safety

Never perform experiments that cause pain, discomfort, or harm to animals. Only handle animals if absolutely necessary. If you know that you are allergic to certain plants, molds, or animals, tell your teacher before doing an activity in which these are used. Wash your hands thoroughly after any activity involving animals, animal parts, plants, plant parts, or soil.

During field work, wear long pants, long sleeves, socks, and closed shoes. Avoid poisonous plants and fungi as well as plants with thorns.

End-of-Experiment Rules

Unplug all electrical equipment. Clean up your work area. Dispose of waste materials as instructed by your teacher. Wash your hands after every experiment.

Appendix B Using a Microscope

The microscope is an essential tool in the study of life science. It allows you to see things that are too small to be seen with the unaided eye.

You will probably use a compound microscope like the one you see here. The compound microscope has more than one lens that magnifies the object you view.

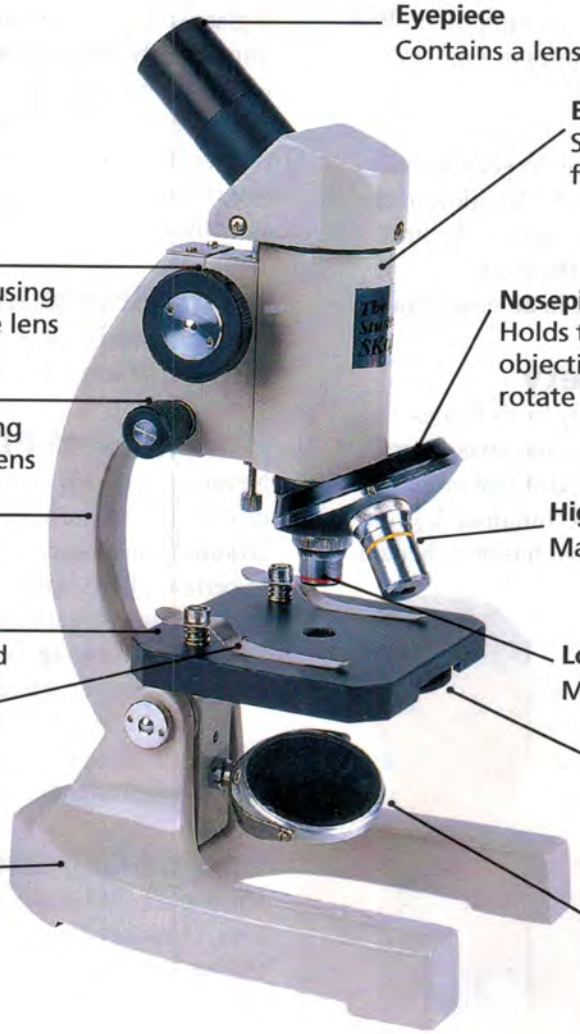
Typically, a compound microscope has one lens in the eyepiece, the part you look through. The eyepiece lens usually magnifies 10 ×. Any object you view through this lens would appear 10 times larger than it is.

The compound microscope may contain one or two other lenses called objective lenses. If there are two objective lenses, they are called the low-power and high-power objective lenses. The low-power objective lens usually magnifies 10 ×. The high-power objective lens usually magnifies 40 ×.

To calculate the total magnification with which you are viewing an object, multiply the magnification of the eyepiece lens by the magnification of the objective lens you are using. For example, the eyepiece's magnification of 10 × multiplied by the low-power objective's magnification of 10 × equals a total magnification of 100 ×.

Use the photo of the compound microscope to become familiar with the parts of the microscope and their functions.

The Parts of a Compound Microscope



Eyepiece
Contains a lens that magnifies about 10 ×

Body Tube
Separates the eyepiece lens from the objective lens

Coarse Adjustment Knob
Moves the body tube for focusing with the low-power objective lens

Nosepiece
Holds the low-power and high-power objective lenses; allows the lenses to rotate for viewing

Fine Adjustment Knob
Moves the body tube for focusing with the high-power objective lens

Arm
Supports the body tube

High-power Objective Lens
Magnifies about 40 ×

Stage
Supports the slide being used

Low-power Objective Lens
Magnifies about 10 ×

Stage Clip
Holds the slide in place

Diaphragm
Controls the amount of light passing through the opening of the stage

Base
Supports the microscope

Mirror
Reflects light upward through the diaphragm

Using the Microscope

Use the following procedures when you are working with a microscope.

1. To carry the microscope, grasp the microscope's arm with one hand. Place your other hand under the base.
2. Place the microscope on a table with the arm toward you.
3. Turn the coarse adjustment knob to raise the body tube.
4. Revolve the nosepiece until the low-power objective lens clicks into place.
5. Adjust the diaphragm. While looking through the eyepiece, also adjust the mirror until you see a bright white circle of light. **CAUTION:** *Never use direct sunlight as a light source.*
6. Place a slide on the stage. Center the specimen over the opening on the stage. Use the stage clips to hold the slide in place. **CAUTION:** *Glass slides are fragile.*
7. Look at the stage from the side. Carefully turn the coarse adjustment knob to lower the body tube until the low-power objective almost touches the slide.
8. Looking through the eyepiece, very slowly turn the coarse adjustment knob until the specimen comes into focus.
9. To switch to the high-power objective lens, look at the microscope from the side. Carefully revolve the nosepiece until the high-power objective lens clicks into place. Make sure the lens does not hit the slide.
10. Looking through the eyepiece, turn the fine adjustment knob until the specimen comes into focus.

Making a Wet-Mount Slide

Use the following procedures to make a wet-mount slide of a specimen.

1. Obtain a clean microscope slide and a coverslip. **CAUTION:** *Glass slides and coverslips are fragile.*
2. Place the specimen on the slide. The specimen must be thin enough for light to pass through it.
3. Using a plastic dropper, place a drop of water on the specimen.
4. Gently place one edge of the coverslip against the slide so that it touches the edge of the water drop at a 45° angle. Slowly lower the coverslip over the specimen. If air bubbles are trapped beneath the coverslip, tap the coverslip gently with the eraser end of a pencil.
5. Remove any excess water at the edge of the coverslip with a paper towel.