Biomes

CHAPTER 6

PRE-READING ACTIVITY

FOLDNOTES

Four-Corner Fold

Before you read this chapter, create the **FoldNote** entitled "Four-Corner Fold" described in the Reading and Study Skills section of the Appendix. Label each flap of the four-corner fold with "Forest Biomes," "Grassland Biomes," "Desert Biomes," and "Tundra Biomes." As you read the chapter, define each biome, and write characteristics of each biome on the appropriate fold.

This thorny devil lives in the desert of Australia. The grooves in its rough skin help it collect water to drink. Water from rain or condensation lands on its back and runs along the tiny grooves to its mouth.

SECTION 1

What Is a Biome?

Earth is covered by many types of ecosystems. Ecologists group these ecosystems into larger areas known as biomes. A **biome** is a large region characterized by a specific type of climate and certain types of plants and animal communities. Each biome is made up of many individual ecosystems. The map in **Figure 1** shows the locations of the world's major land, or terrestrial, biomes. In this chapter, you will take a tour through these terrestrial biomes—from lush rain forests to scorching deserts and the frozen tundra. When you read about each biome, notice the adaptations that organisms have to their very different environments.

Objectives

- Describe how plants determine the name of a biome.
- Explain how temperature and precipitation determine which plants grow in an area.
- Explain how latitude and altitude affect which plants grow in an area.

Key Terms

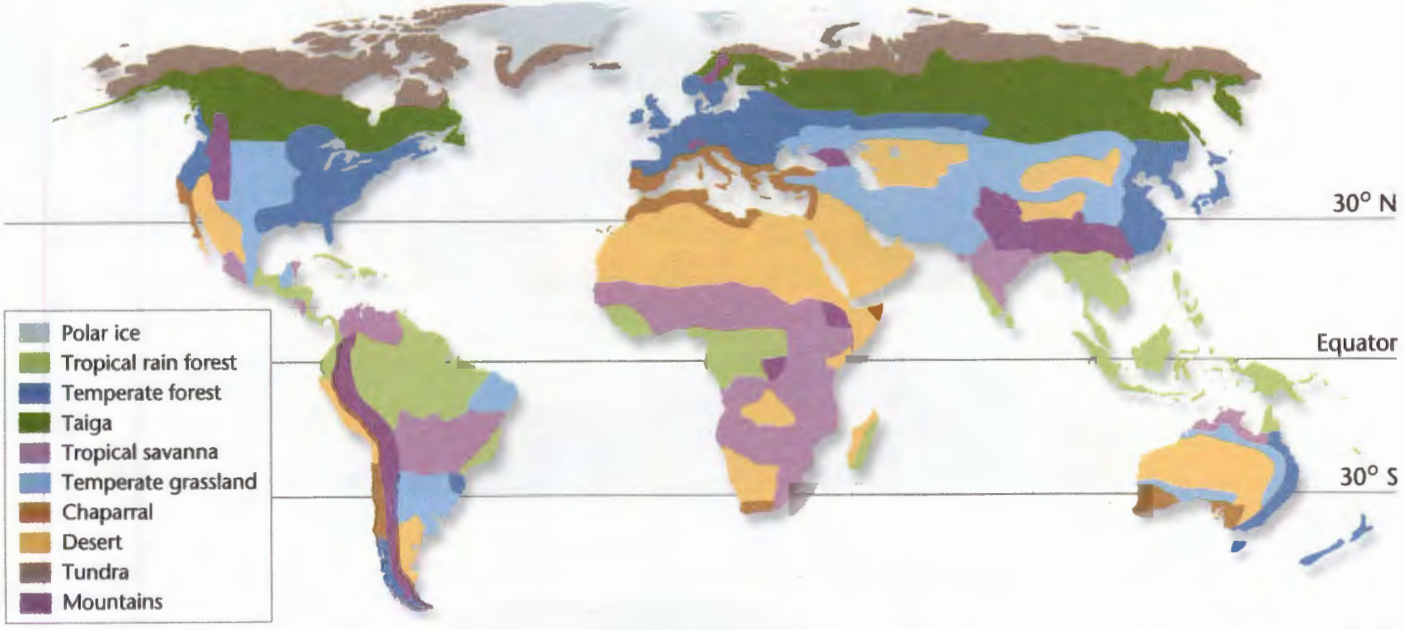
biome
climate
latitude
altitude

Biomes and Vegetation

Biomes are described by their vegetation because plants that grow in an area determine the other organisms that can live there. For example, shrubs called *rhododendrons* grow in northern temperate forests because they cannot survive high temperatures. However, mahogany trees grow in tropical rain forests because they cannot survive cold, dry weather. Organisms that depend on mahogany trees will live where mahogany trees grow.

Plants in a particular biome have characteristics, specialized structures, or adaptations that allow the plants to survive in that biome. These adaptations include size, shape, and color. For example, plants that grow in the tundra tend to be short because they cannot obtain enough water to grow larger. They also have a short summer growing season, while desert plants, such as cactuses, do not have leaves. Instead, cactuses have specialized structures to conserve and retain water.

Figure 1 ▶ The ecosystems of the world can be grouped into regions called *biomes*. These biomes shown below are named for the vegetation that grows there.



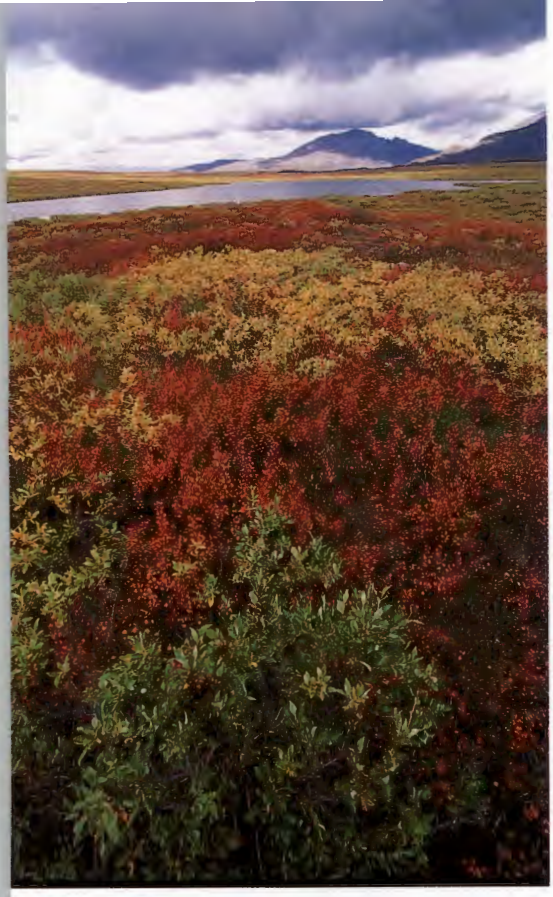


Figure 2 ▶ Plants in the tundra biome, such as those shown above, are usually short because the soil is frozen most of the year, which prevents the plants from obtaining much water.

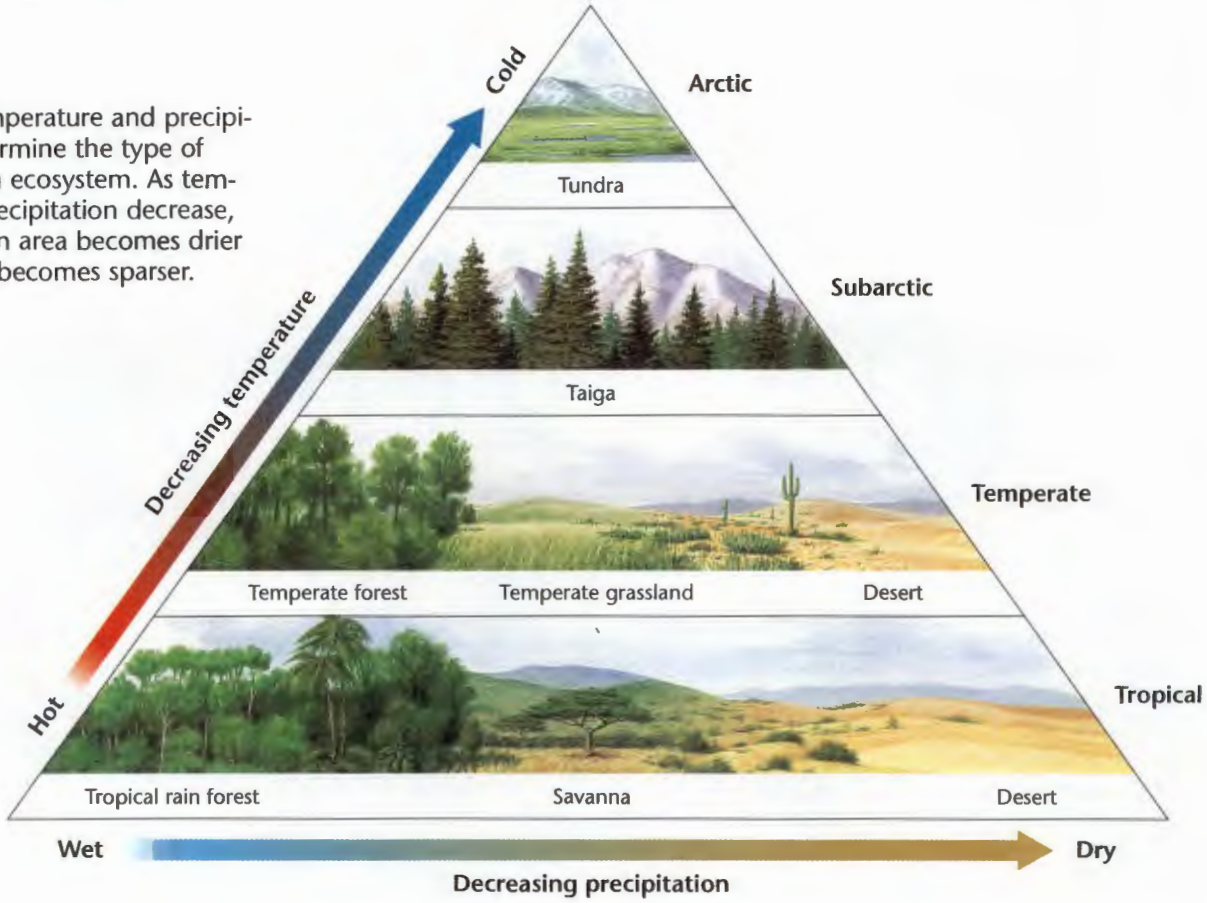
Biomes and Climate

Biomes are defined by their plant life, but what factors determine which plants can grow in a certain area? The main factor is climate. Climate refers to the weather conditions, such as temperature, precipitation, humidity, and winds, in an area over a long period of time. Temperature and precipitation are the two most important factors that determine a region's climate.

Temperature and Precipitation The climate of a biome is determined by average temperature and precipitation. Most organisms are adapted to live within a particular range of temperatures and will not survive at temperatures too far above or below their range.

Precipitation also limits the organisms that are found in a biome. All organisms need water, and the larger an organism is, the more water it needs. For example, biomes that do not receive enough rainfall to support large trees support communities dominated by small trees, shrubs, and grasses. In biomes where rainfall is not frequent, the vegetation is made up of mostly cactuses and desert shrubs. The plants in **Figure 2** grow close to the ground in the tundra because there is not enough water to support larger plants and trees. In extreme cases, lack of rainfall results in no plants, no matter what the temperature is. As shown in **Figure 3**, the higher the temperature and precipitation are, the taller and denser the vegetation is. Notice how much more vegetation exists in a hot, wet tropical rain forest than in a dry desert.

Figure 3 ▶ Temperature and precipitation help determine the type of vegetation in an ecosystem. As temperature and precipitation decrease, the climate of an area becomes drier and vegetation becomes sparser.



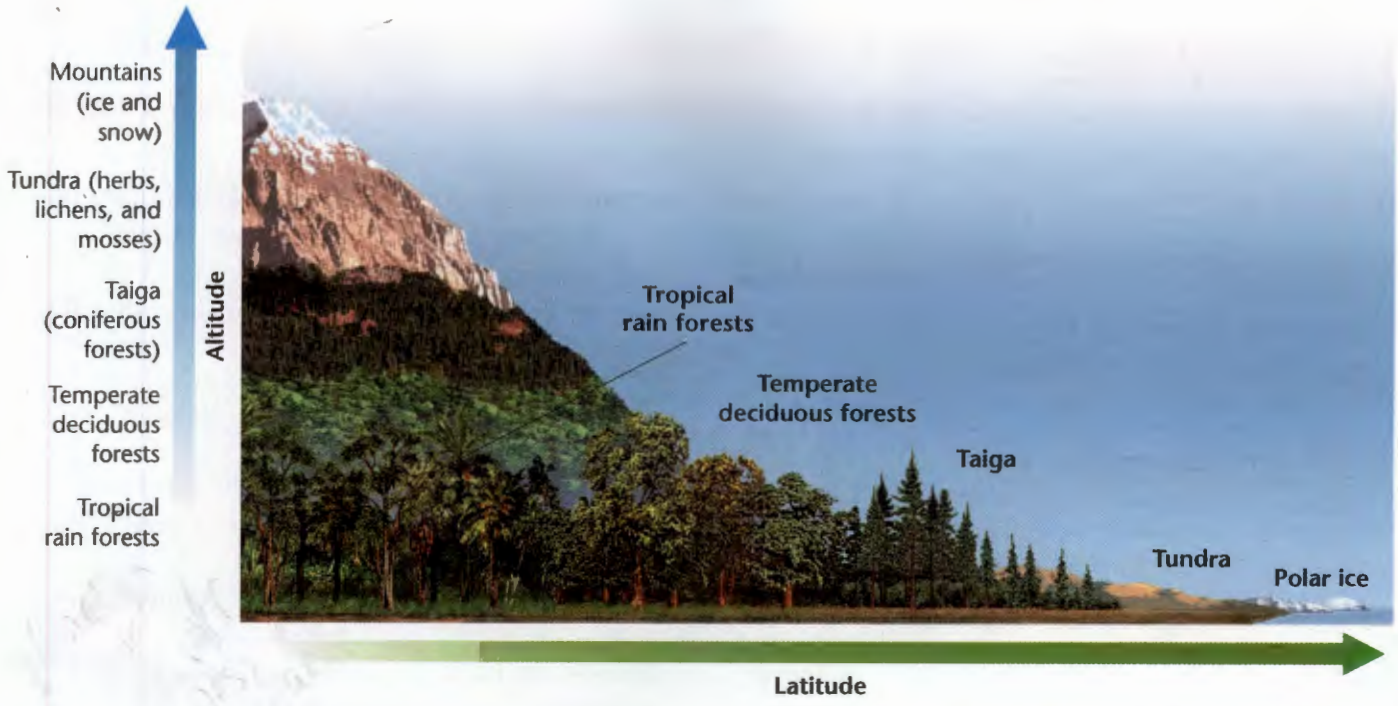
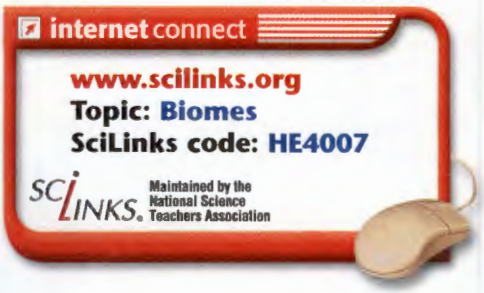


Figure 4 ▶ Latitude and altitude affect climate and vegetation in a biome.

Latitude and Altitude Biomes, climate, and vegetation vary with latitude and altitude. Latitude is the distance north or south of the equator and is measured in degrees. Altitude is the height of an object above sea level. Climate varies with latitude and altitude. For example, climate gets colder as latitude and altitude increase. So, climate also gets colder as you move farther up a mountain.

Figure 4 shows that as latitude and altitude increase, biomes and vegetation change. For example, the trees of tropical rain forests usually grow closer to the equator, while the mosses and lichens of the tundra usually grow closer to the poles. The land located in the temperate region of the world, between about 30° and 60° north latitude and 30° and 60° south latitude, is where most of the food in the world is grown. This region includes biomes such as temperate forests and grasslands, which usually have moderate temperatures and fertile soil that is ideal for agriculture.



SECTION 1 Review

1. **Describe** how plants determine the name of a biome.
2. **Explain** how temperature affects which plants grow in an area.
3. **Explain** how precipitation affects which plants grow in an area.
4. **Define** *latitude* and *altitude*. How is latitude different from altitude? How do these factors affect the organisms that live in a biome?

CRITICAL THINKING

5. **Making Inferences** The equator passes through the country of Ecuador. But the climate in Ecuador can range from hot and humid to cool and dry. Write a short paragraph that explains what might cause this range in climate. WRITING SKILLS
6. **Analyzing Relationships** Look at Figure 1, and locate the equator and 30° north latitude. Which biomes are located between these two lines?

SECTION 2

Forest Biomes

Objectives

- List three characteristics of tropical rain forests.
- Name and describe the main layers of a tropical rain forest.
- Describe one plant in a temperate deciduous forest and an adaptation that helps the plant survive.
- Describe one adaptation that may help an animal survive in the taiga.
- Name two threats to the world's forest biomes.

Key Terms

tropical rain forest
emergent layer
canopy
epiphyte
understory
temperate rain forest
temperate deciduous forest
taiga

The air is hot and heavy with humidity. You walk through the shade of the tropical rain forest, step carefully over tangles of roots and vines, and brush past enormous leaves. Life is all around you, but you see little vegetation on the forest floor. Birds call, and monkeys chatter from above.

Tropical Rain Forests

Of all the biomes in the world, forest biomes are the most widespread and the most diverse. The large trees of forests need a lot of water, so forests exist where temperatures are mild to hot and where rainfall is plentiful. Tropical, temperate, and coniferous forests are the three main forest biomes of the world.

Tropical rain forests are located in a belt around the Earth near the equator, as shown in **Figure 5.** They help regulate world climate and play vital roles in the nitrogen, oxygen, and carbon cycles. Tropical rain forests are always humid and warm and get about 200 to 450 cm of rain a year. Because they are near the equator, tropical rain forests get strong sunlight year-round and maintain a relatively constant temperature year-round. This climate is ideal for a wide variety of plants and animals, as shown in **Figure 6.** The warm, wet conditions also nourish more species of plants than any other biome does. While one hectare (10,000 m^2) of temperate forest usually contains a few species of trees, the same area of tropical rain forest may contain more than 100 species.

▶ Glasswing butterflies live in the rain forests of Costa Rica.

▶ The *Rafflesia keithii* flower grows in the rain forests of Borneo.

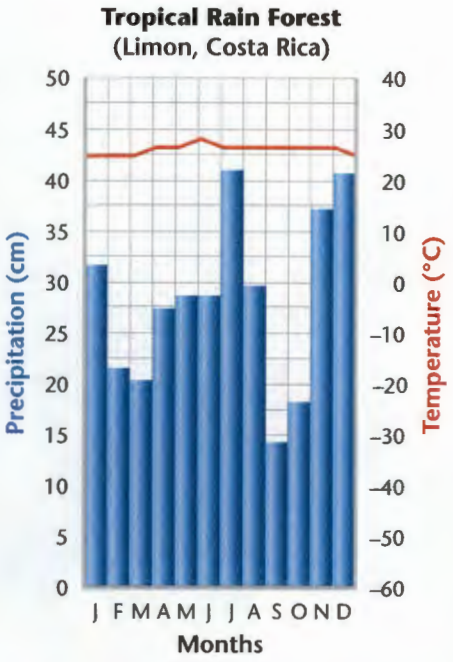


Figure 5 ▶ The world's tropical rain forests have heavy, year-round rainfall and fairly constant, warm temperatures.

Nutrients in Tropical Rain Forests You might think that the diverse plant life grows on rich soil, but it does not. Most nutrients are within plants, not within soil. Rapid decay of plants and animals occurs with the help of decomposers, organisms that break down dead organisms. Decomposers on the rain-forest floor break down dead organisms and return nutrients to the soil, but plants quickly absorb the nutrients. Some trees in the tropical rain forest support fungi that feed on dead organic matter on the rain-forest floor. In this relationship, fungi transfer the nutrients from the dead organic matter directly to the tree. Nutrients from dead organic matter are removed so efficiently that runoff from rain forests is often as pure as distilled water. Most tropical soils that are cleared of plants for agriculture lack nutrients and cannot support crops for more than a few years. Many of the trees form above-ground roots called *buttresses* or *braces* that grow sideways from the trees and provide extra support to the tree in the thin soil.

Figure 6 ▶ Species of Tropical Rain Forests

▶ The rain forests that blanket the Andes Mountains of Ecuador are always humid and warm.

▶ Scarlet macaws live in the trees of rain forests of Peru.

▶ These mountain gorillas live in the rain forests of Rwanda.

Figure 7 ▶ The plants in tropical rain forests form distinct layers. The plants in each layer are adapted to a particular level of light. The taller trees absorb the most light, while the plants near the forest floor are adapted to growing in the shade.

Layers of the Rain Forest In tropical rain forests, different types of plants grow in different layers, as shown in **Figure 7.** The four main layers above the forest floor are the emergent layer, the upper canopy, the lower canopy, and the understory. The top layer is called the **emergent layer.** This layer consists of the tallest trees, which reach heights of 60 to 70 m. The trunks of trees this tall can measure up to 5 m around. Trees in the emergent layer grow and emerge into direct sunlight. Animals such as eagles, bats, monkeys, and snakes live in the emergent layer.

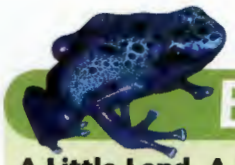
The next layer, considered the primary layer of the rain forest, is called the **canopy.** Trees in the canopy can grow more than 30 m tall. The tall trees form a dense layer that absorbs up to 95 percent of the sunlight. The canopy can be split into an upper canopy and a lower canopy. The lower canopy receives less light than the upper canopy does. Plants called **epiphytes,** such as the orchid in **Figure 8,** use the entire surface of a tree as a place to live. Epiphytes grow on tall trees for support and grow high in the canopy, where their leaves can reach the sunlight needed for photosynthesis. Growing on tall trees also allows them to absorb the water and nutrients that run down the tree after it rains. Most animals that live in the rain forest live in the canopy because they depend on the abundant flowers and fruits that grow there.

Below the canopy, very little light reaches the next layer, called the **understory.** Trees and shrubs adapted to shade grow in the understory. Most plants in the understory do not grow more than 3.5 m tall. Herbs with large, flat leaves that grow on the forest floor capture the small amount of sunlight that penetrates the understory. These plants must be able to grow in the darker spots. When fallen trees create an opening in the canopy, tree seedlings that are adapted to grow quickly compete with other seedlings on the forest floor for sunlight.

Connection to Chemistry

Medicines from Plants Many of the medicines we use come from plants native to tropical rain forests. Chemists extract and test chemicals found in plants to determine if the chemicals can cure or fight diseases. Rosy periwinkle, a plant that grows in the tropical rain forests of Madagascar, is the source of two medicines, vinblastine and vincristine. Vinblastine is used to treat Hodgkin's disease, a type of cancer, and vincristine is used to treat childhood leukemia.

Species Diversity in Rain Forests The tropical rain forest is the biome with the greatest amount of species diversity. The diversity of rain-forest vegetation has led to the evolution of a diverse community of animals. Most rain-forest animals are specialists that use specific resources in particular ways to avoid competition. Some rain-forest animals have amazing adaptations for capturing prey, and other animals have adaptations that they use to escape predators. For example, the collared anteater in **Figure 8** uses its long tongue to reach insects in small cracks and holes where other animals cannot reach. The wreathed hornbill (shown below) uses its strong, curved beak to crack open nutshells. Insects, such as the Costa Rican mantis in **Figure 8**, use camouflage to avoid predators and may be shaped like leaves or twigs.



Ecofact

A Little Land, A Lot of Species
Tropical rain forests cover less than 7 percent of Earth's land surface but contain at least 50 percent of all the plant and animal species in the world.

Figure 8 ▶ Examples of plant and animal adaptations in the tropical rain forest include ❶ the long tongue of a collared anteater, ❷ the strong, curved beak of a wreathed hornbill, ❸ the shape of a Costa Rican mantis, and ❹ an orchid attached to a tall tree.

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Threats to Rain Forests Tropical rain forests once covered about 20 percent of Earth's surface. Today, they cover only about 7 percent. Every minute of every day, 100 acres of tropical rain forest are cleared for logging operations, agriculture, or oil exploration. *Habitat destruction* occurs when land inhabited by an organism is destroyed or altered. If the habitat that an organism depends on is destroyed, the organism is at risk of disappearing.

Animals and plants are not the only organisms that live in rain forests. An estimated 50 million native peoples live in tropical rain forests. These native peoples are also threatened by habitat destruction. Because they obtain nearly everything they need from the forest, the loss of their habitat could be devastating. This loss of habitat may force them to leave their homes and move into cities. This drastic change of lifestyle may also cause the native peoples to lose their culture and traditions along the way.

Plants and animals that live in rain forests are also threatened by trading. Many plant species found only in tropical rain forests are valuable and marketable to industries. Animals are threatened by exotic-pet trading. Some exotic-pet traders illegally trap animals, such as parrots, and sell them in pet stores at high prices.

CASE STUDY

Deforestation, Climate, and Floods

A plant absorbs water from the soil through its roots and transports the water to its stems and leaves. Water then evaporates from pores in plant leaves into the atmosphere through a process called *transpiration*. A large tree may transpire as much as five tons of water on a hot day. Water absorbs heat when it evaporates. Therefore, the temperature is much cooler under a tree on a hot day than under a wood or brick shelter. Trees that provide shade around homes keep homes much cooler in the summer.

When rain falls on a forest, much of the rain is absorbed by plant roots and transpired into the air as water vapor. Water vapor forms rain clouds. Much of this water will fall as rain somewhere downwind from the forest. Because of the role trees play in transpiration, *deforestation*, the clearing of trees, can change the climate. If a forest is cut down or replaced by smaller plants, much of the rainfall is not absorbed by plants. Instead, the rain runs off the soil and causes flooding as well as soil erosion. So, the climate downwind from the forest becomes drier.

Deforestation led to the disastrous flooding of the Yangtze River in China in 1998. More than 2,000 people died in the floods, and at least 13 million people had to leave their homes. When the Yangtze River flooded, the water poured into a flood plain where over 400 million people lived. It is estimated that 85 percent of the forest in the Yangtze River basin has been cut down. The millions of tons of water that these trees once absorbed now flows freely down the river and spreads across fields and into towns during the seasonal monsoon rains.

▶ A man makes his way past flooded buildings in his street on a makeshift raft after the Yangtze River flooded in July 1998. Water of the Yangtze River reached record-high levels.

Deforestation has also caused terrible floods in places such as Bangladesh. The Ganges River rises high in the Himalaya Mountains and flows through Bangladesh. Deforestation of the Himalaya

Temperate Forests

Temperate rain forest occurs in North America, Australia, and New Zealand. Temperate rain forests have large amounts of precipitation, high humidity, and moderate temperatures. The Pacific Northwest shown in **Figure 9**, houses North America's only temperate rain forest, where tree branches are draped with mosses and tree trunks are covered in lichens. The forest floor is blanketed with lush ferns. Evergreen trees that are 90 m tall, such as the Sitka spruce and the Douglas fir, dominate the forest. Other large trees, such as western hemlock, Pacific silver fir, and redwood, can also be found in temperate rain forests.

Even though the temperate rain forest of the Pacific Northwest is located north of most other rain forests, it still maintains a moderate temperature year-round. The temperate rain forest also rarely freezes because the nearby Pacific Ocean waters keep temperatures mild by blowing cool ocean wind over the forest. As this ocean wind meets the coastal Olympic Mountains, a large amount of rainfall is produced. This rainfall keeps the temperate rain forest cool and moist.

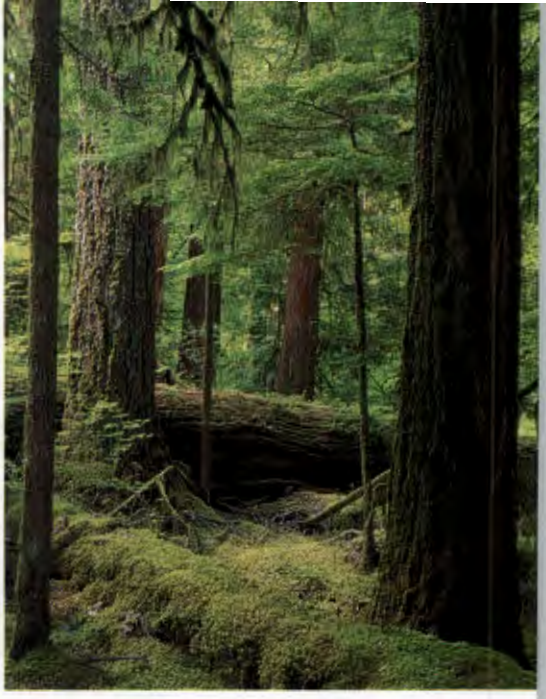


Figure 9 ▶ The only temperate rain forest in North America is located in the Pacific Northwest, as shown above in Olympic National Park in Washington State.

▶ Deforestation reduces the amount of water that is absorbed by plants after it rains. The more trees that are cleared from a forest, the more likely a flood will occur in that area.

Mountains left few trees to stop the water flowing down the mountain. So, most of the water flows into the river when it rains. Heavy rains have eroded and carried away so much soil from the slopes of the mountains that the soil has formed a new island in the Bay of Bengal, which is off the coast of Bangladesh.

People are beginning to understand the connection between deforestation and floods. People held protests in northern Italy in 2000 after floods covered a town that had never been flooded before. The townspeople claimed that authorities had permitted developers to cover the hills with homes. These developers cut down most of the trees and covered much of the land with asphalt. After heavy rains, the water was no longer absorbed by trees and soil, so the water flowed down the hills and flooded the town.

CRITICAL THINKING

1. Identifying Relationships
How might deforestation in China and other countries affect the overall climate of the Earth?

2. Analyzing a Viewpoint
Imagine that you are a city council member and must vote on whether to clear a forest so that a mall can be built. List the pros and cons of each viewpoint. After reviewing your list, how would you vote? Explain your answer.

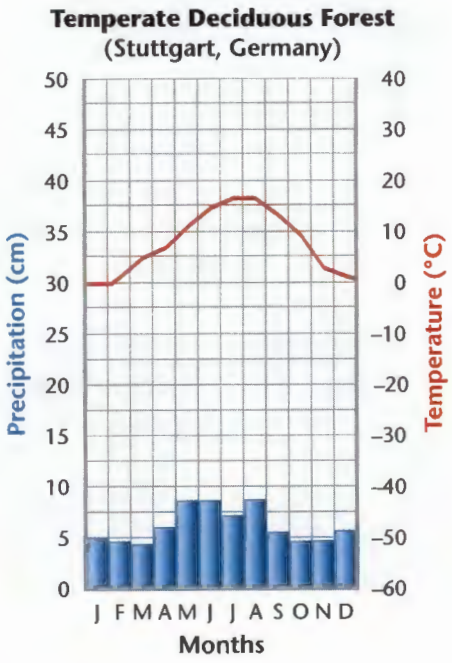


Figure 10 ▶ The difference between summer and winter temperatures in temperate deciduous forests is extreme.

Temperate Deciduous Forests

If you walk through a North American deciduous forest in the fall, you will immerse yourself in color. Leaves in every shade of orange, red, and yellow crackle beneath your feet. Most birds have flown south. The forest is quieter than it was in the summer. You see mostly chipmunks and squirrels gathering and storing the food they will need during the long, cold winter.

In temperate deciduous forests, trees drop their broad, flat leaves each fall. These forests once dominated vast regions of the Earth, including parts of North America, Europe, and Asia. Today, temperate deciduous forests are generally located between 30° and 50° north latitude, as shown in **Figure 10.** The range of temperatures in a temperate deciduous forest can be extreme, and the growing season lasts for only four to six months. Summer temperatures can soar to 35°C. Winter temperatures often fall below freezing, so little water is available for plants. Temperatures vary due to a change of seasons, as shown in **Figure 11.** Temperate deciduous forests are moist. They receive 75 to 125 cm of precipitation annually. The rain and snow help decompose dead organic matter, such as fallen leaves, which in turn contributes to the rich, deep soils of temperate deciduous forests.

Plants of Temperate Deciduous Forests Like the plants of tropical rain forests, the plants in deciduous forests grow in layers. Tall trees, such as maple, oak, and birch, dominate the forest canopy. Small trees and shrubs cover the understory. Because the forest floor in a deciduous forest gets more light than that of a rain forest does, more plants such as ferns, herbs, and mosses grow in a deciduous forest.

Figure 11 ▶ The change of seasons in a temperate deciduous forest in Michigan is shown below.

Temperate-forest plants are adapted to survive seasonal changes. In the fall, most deciduous trees begin to shed their leaves. In the winter, moisture in the soil changes to ice, which causes the remaining leaves to fall to the ground. Also, herb seeds, bulbs, and rhizomes, which are underground stems, become dormant in the ground and are insulated by the soil, leaf litter, and snow. In the spring, when sunlight increases and temperatures rise, trees grow new leaves, seeds germinate, and rhizomes and roots grow new shoots and stems.

Animals of Temperate Deciduous Forests The animals of temperate deciduous forests are adapted to use the forest plants for food and shelter. Squirrels eat the nuts, seeds, and fruits in the treetops. Bears feast on the leaves and berries of forest plants. Grasshoppers, such as the one shown in **Figure 12**, eat almost all types of vegetation found throughout the forest, while deer and other herbivores nibble leaves from trees and shrubs.

Many birds nest in the relative safety of the canopy. Most of these birds are migratory. Because the birds cannot survive the harsh winters, each fall they fly south for warmer weather and for more available food. Each spring, they return north to nest and feed. Animals that do not migrate use various strategies for surviving the winter. For example, mammals and insects reduce their activity so that they do not need as much food for energy.

Figure 12 ▶ Grasshoppers, woodpeckers, and deer are among many animals that live in the temperate deciduous forest.

Taiga

The taiga is the northern coniferous forest that stretches in a broad band across the Northern Hemisphere just below the Arctic Circle. As shown in **Figure 13**, winters are long (6 to 10 months) and have average temperatures that are below freezing and that often fall to –20°C. In the taiga, the forest floor is dark and has little vegetation. Many trees seem like straight, dead shafts of bark and wood—until you look up and see their green tops. The growing season in the taiga may be as short as 50 days depending on latitude. Plant growth is most abundant during the summer months because of nearly constant daylight and larger amounts of precipitation.

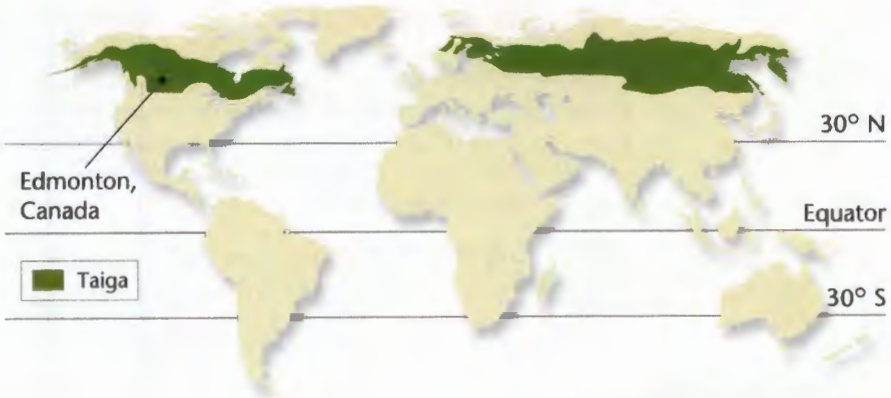
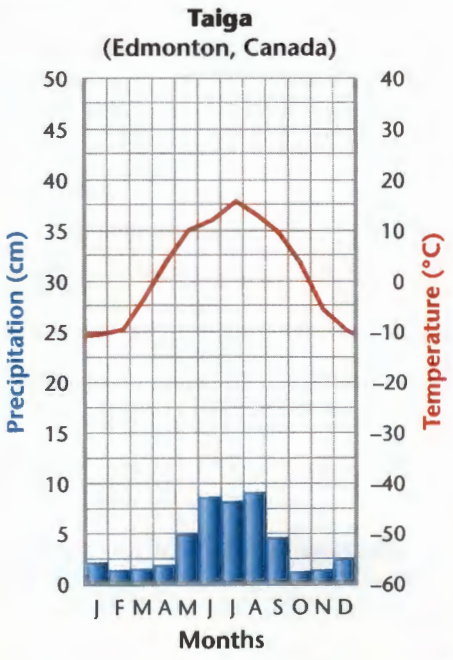


Figure 13 ▶ The taiga has long, cold winters and small amounts of precipitation, as shown in the climatogram below.



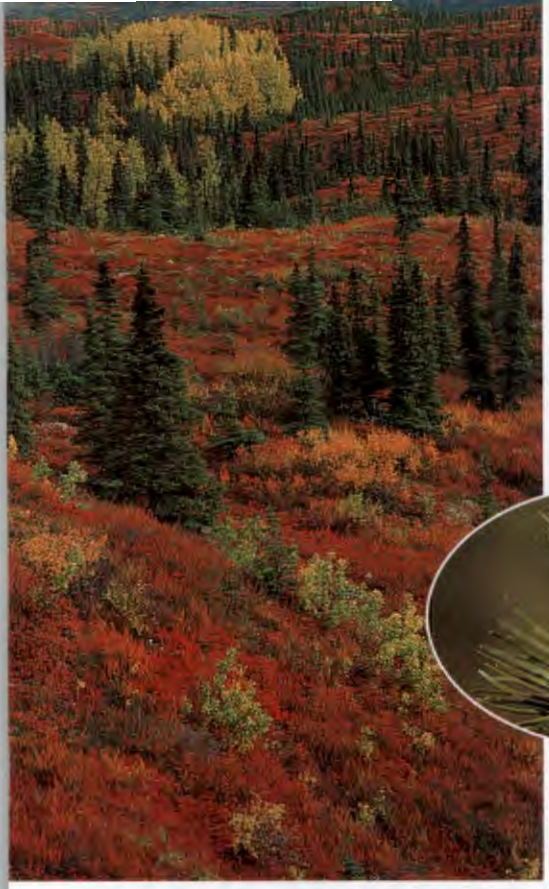


Figure 14 ▶ The taiga has cold winter temperatures, a small amount of annual precipitation, and coniferous trees. The seeds of conifers are protected inside tough cones like the one above. Also, the narrow shape and waxy coating of conifer needles help the tree retain water.

Plants of the Taiga A *conifer* is a tree that has seeds that develop in cones. Most conifers do not shed their needle-shaped leaves, which help them survive harsh winters. The leaves' narrow shape and waxy coating retain water for the tree when the moisture in the ground is frozen. As shown in **Figure 14,** a conifer's pointed shape also helps the tree shed snow to the ground so that it does not become weighed down.

Conifer needles contain substances that make the soil acidic when the needles fall to the ground. Most plants cannot grow in acidic soil, which is one reason the forest floor of the taiga has few plants. In addition, soil forms slowly in the taiga because the climate and acidity of the fallen leaves slow decomposition.

Animals of the Taiga The taiga has many lakes and swamps that in summer attract birds that feed on insects, fish, or other aquatic organisms. Many birds migrate south to avoid winter in the taiga. Some year-round residents, such as shrews and rodents, may burrow underground during the winter, because the deep snow cover insulates the ground. Moose and snowshoe hares eat any vegetation they can find. As shown in **Figure 15,** some animals, such as snowshoe hares, have adapted to avoid predation by lynxes, wolves, and foxes by shedding their brown summer fur and growing white fur that camouflages them in the winter snow.

Figure 15 ▶ In the taiga, a snowshoe hare's fur changes color according to the seasons to help camouflage the animal from predators.

SECTION 2 Review

1. **List** three characteristics of tropical rain forests.
2. **Name** the main layers of a tropical rain forest. What kinds of plants grow in each layer?
3. **Describe** two ways in which tropical rain forests of the world are being threatened.
4. **Describe** how a plant survives the change of seasons in a temperate deciduous forest. Write a short paragraph to explain your answer. WRITING SKILLS

CRITICAL THINKING

5. **Evaluating Information** Which would be better suited for agricultural development: the soil of a tropical rain forest or the soil of a temperate deciduous forest? Explain your answer.
6. **Identifying Relationships** How does a snowshoe hare avoid predation by other animals during the winter in a taiga biome? How might this affect the animal that depends on the snowshoe hare for food?

SECTION 3

Grassland, Desert, and Tundra Biomes

In climates that have less rainfall, forest biomes are replaced by savanna, grassland, and chaparral biomes. As less rain falls in these biomes, they change into desert and tundra biomes. As precipitation decreases in an area, the diversity of the species in the area also decreases. But while the number of different species is often smaller in areas that have less precipitation, the number of individuals of each species present may be very large.

Objectives

- Describe the difference between tropical and temperate grasslands.
- Describe the climate in a chaparral biome.
- Describe two desert animals and the adaptations that help them survive.
- Describe one threat to the tundra biome.

Key Terms

savanna
temperate grassland
chaparral
desert
tundra
permafrost

Savannas

Parts of Africa, western India, northern Australia, and some parts of South America are covered by grassland called *savanna*. Savannas are located in tropical and subtropical areas near the equator and between tropical rain forest and desert biomes. Because savannas are full of grasses, scattered trees, and shrubs, savannas contain a large variety of grazing animals and the predators that hunt them. As shown in **Figure 16**, savannas receive little precipitation throughout the year. Savannas have a wet season and a dry season. Many animals of the savanna are active only during the wet season. Grass fires sweep across the savanna during the dry season and help restore nutrients to the soil.

Plants of the Savanna Because most of the rain falls during the wet season, plants must be able to survive prolonged periods without water. Therefore, some trees and grasses have large horizontal root systems by which they obtain water during the dry season. These root systems also enable plants to quickly grow again after a fire. The coarse savanna grasses have vertical leaves that expose less of their surface area to the hot sun to further help the grasses conserve water. Some trees of the savanna also lose their leaves during the dry season to conserve water. Trees and shrubs often have thorns or sharp leaves that keep hungry herbivores away.

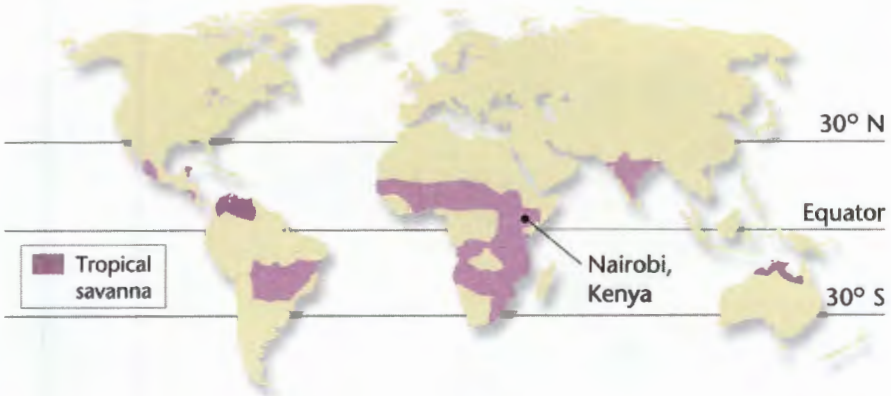


Figure 16 ▶ Savannas have periods of heavy rainfall followed by periods of drought.

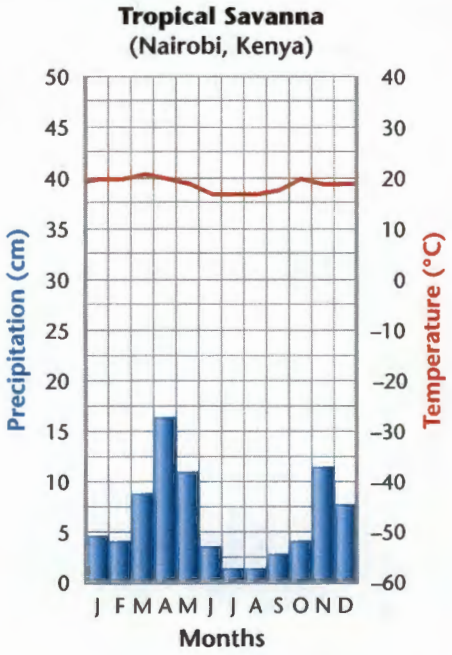


Figure 17 ▶ Herbivores of the savanna reduce their competition for food by feeding on vegetation located at different heights. Elephants feed on tree leaves, while impala graze on grasses.

Geofact

Deep Soil Gravel or sand becomes fertile soil when decomposers slowly break down organic matter such as dead leaves. Decomposers work most effectively in hot, wet weather. As a result, the world's deepest soil is in grasslands. In grassland biomes, winters are cold and summers are dry, which causes leaves to break down slowly. So, organic matter builds up over time. Some North American prairies had more than 2 m of topsoil when the first farmers arrived.

Animals of the Savanna Grazing herbivores such as the elephants shown in **Figure 17,** have adopted a migratory way of life. They follow the rains to areas of newly sprouted grass and watering holes. Some predators follow and stalk the migratory animals for food. Many savanna animals give birth only during the rainy season, when food is most abundant and the young are more likely to survive. Also, some species of herbivores reduce competition for food by eating vegetation at different heights than other species do. For example, small gazelles graze on grasses, black rhinos browse on shrubs, and giraffes feed on tree leaves.

Temperate Grasslands

A **temperate grassland** is a biome that is dominated by grasses and that has very few trees. Most temperate grasslands have hot summers and cold winters. The amount of rainfall that a temperate grassland receives is moderate compared to the amount a forest receives. On average, a temperate grassland can receive 50 to 88 cm of precipitation per year, as shown in **Figure 18.** Although temperate grasslands may seem harsh and dry, they have the most fertile soil of any biome. So, many grassland biomes have been replaced with crops such as corn, soybeans, and wheat. Few natural temperate grasslands remain because many have been replaced by farms and grazing areas.

Figure 18 ▶ Temperate grasslands are characterized by small amounts of rainfall, periodic droughts, and high temperatures in the summer.

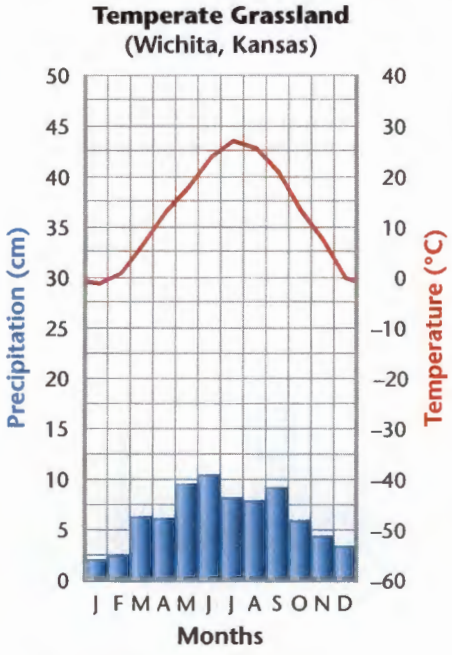


Figure 19 ▶ Temperate grasslands can be named according to the vegetation that grows there. Steppes (left), have shorter grasses and are located in Europe and Asia. Pampas (right), are made up of clusters of feathery grasses and are located in South America.

Temperate grasslands are located on the interiors of continents where too little rain falls for trees to grow. Grassland biomes include the prairies of North America, the steppes of Russia and Ukraine, and the pampas of South America, as shown in **Figure 19.** Mountains often play a crucial role in maintaining grasslands. For example, in North America, rain clouds from the west are blocked by the Rocky Mountains, so the shortgrass prairie east of the mountains receives only about 25 cm of rain a year. Rainfall increases as you move eastward, so taller grasses and some shrubs can grow in areas where more rain falls. Heavy precipitation is rare in the grasslands, so sizzling temperatures in the summer make the grasslands susceptible to fires, which are common in grassland biomes.

Plants of Temperate Grasslands Prairie grasses and wildflowers are perennials, plants that survive from year to year. The root systems of prairie grasses form dense layers that survive drought and fire as well as hold the soil in place. The amount of rainfall in an area determines the types of plants that will grow in that area. **Figure 20** shows how root depth and grass height vary depending on the amount of rainfall. Few trees survive on the grasslands because of the lack of rainfall, fire, and the constant winds.

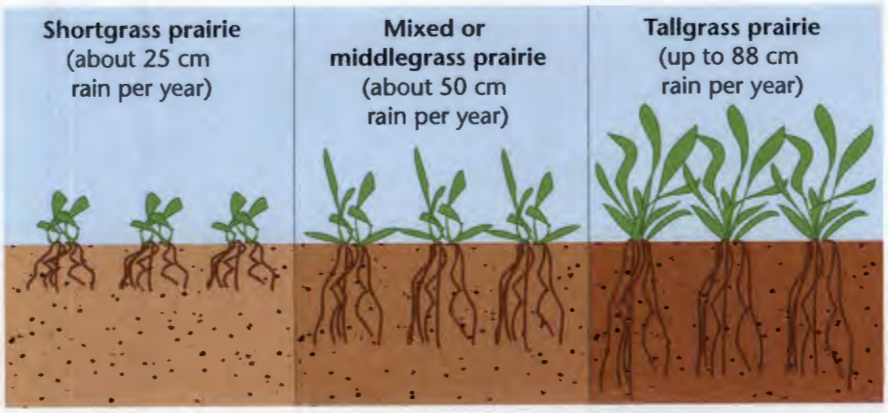


Figure 20 ▶ The height of grassland plants and the depth of their roots depend on the amount of rainfall that the grasslands receive.

Connection to History

The State of Bison More than 60 million bison once roamed the temperate grasslands of North America. But these large grass-eating mammals were almost brought to extinction by the late 1800s because of hunting by western settlers. By 1889, fewer than 1,100 bison remained in North America! The first bill to save the bison was introduced by Congress in 1874. In 1903, President Theodore Roosevelt started the National Wildlife Refuge System to provide protected areas for bison and other animals. Today, North America has more than 200,000 bison.

Figure 21 ▶ Prairie dogs, such as those shown here, live in temperate grasslands. Prairie dogs live in colonies and burrow in the ground to build mounds, holes, and tunnels.

Animals of Temperate Grasslands Grazing animals, such as pronghorn antelope and bison, have large, flat back teeth for chewing the coarse prairie grasses. Other grassland animals, such as badgers, prairie dogs, and owls, live protected in underground burrows as shown in **Figure 21.** The burrows shield the animals from fire and weather and protect them from predators on the open grasslands.

Threats to Temperate Grasslands Farming and overgrazing have changed the grasslands. Grain crops cannot hold the soil in place as well as native grasses can because the roots of crops are shallow, so soil erosion eventually occurs. Erosion is also caused by overgrazing. When grasses are constantly eaten and trampled, the grasses cannot regenerate or hold the soil. This constant use can change fruitful grasslands into less productive, desertlike biomes.

QuickLAB

Sponging It Up

Procedure

1. Completely saturate **two small sponges** with **water** and allow the excess water to drain off.
2. Measure each sponge's mass by using an **electric balance.** Record the mass.
3. Using **plastic wrap,** completely cover one of the sponges.
4. Place the sponges outside in a sunny place for 10 to 15 minutes.
5. Measure each sponge's mass after removing it from outside. Record the mass.

Analysis

1. Which sponge lost the most mass? Why?
2. How was the covering you created for the sponge similar to the adaptations of the plants in the chaparral biome?

Chaparral

Plants that have leathery leaves are commonly found in temperate woodland biomes. Temperate woodland biomes have fairly dry climates but receive enough rainfall to support more plants than a desert does. Temperate woodlands consist of scattered tree communities made up of coniferous trees such as piñon pines and junipers, as shown in **Figure 22.**

Chaparral is a type of temperate woodland biome that is dominated by more broad-leafed evergreen shrubs than by evergreen trees. Look at the famous white letters that spell Hollywood

Figure 22 ▶ Temperate woodlands are usually too dry to support a forest, but they receive sufficient precipitation to support vegetation that grows in bunches, such as the piñon and juniper trees shown here.

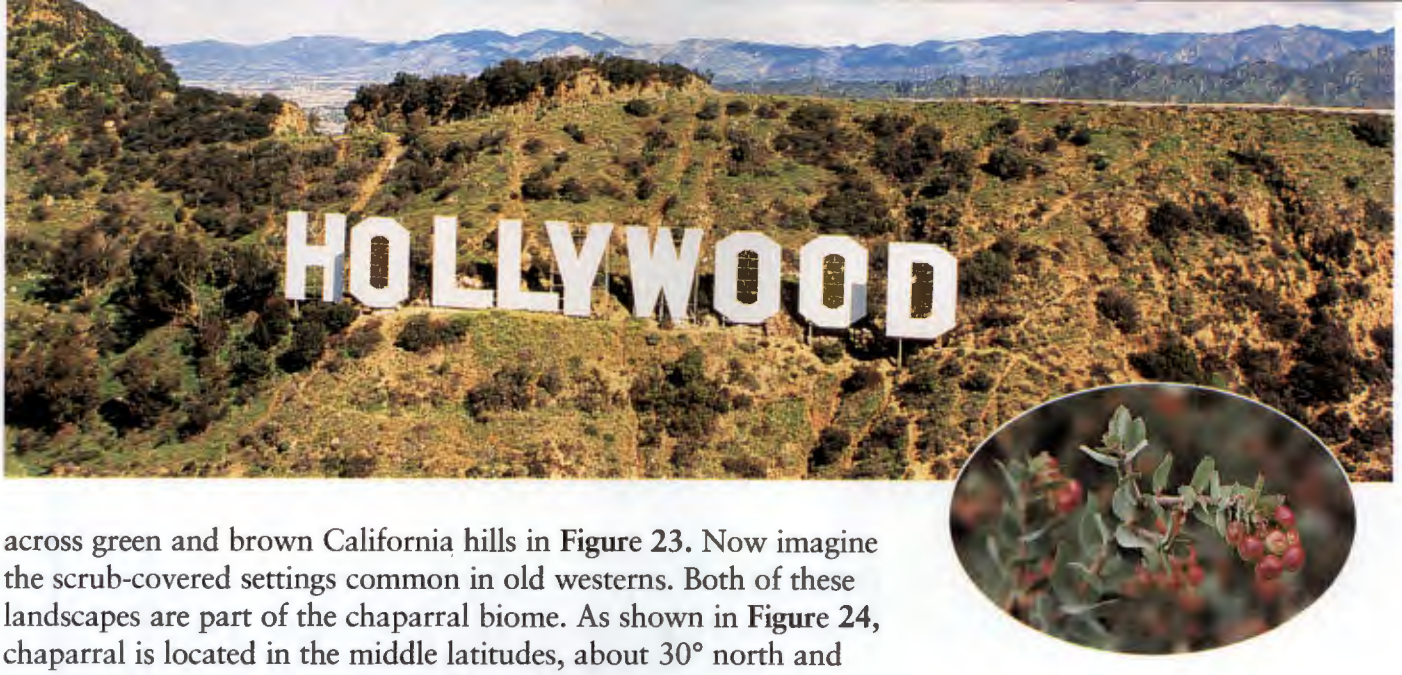


Figure 23 ▶ The chaparral biome in the Hollywood hills is home to plants such as the manzanita, which is shown above.

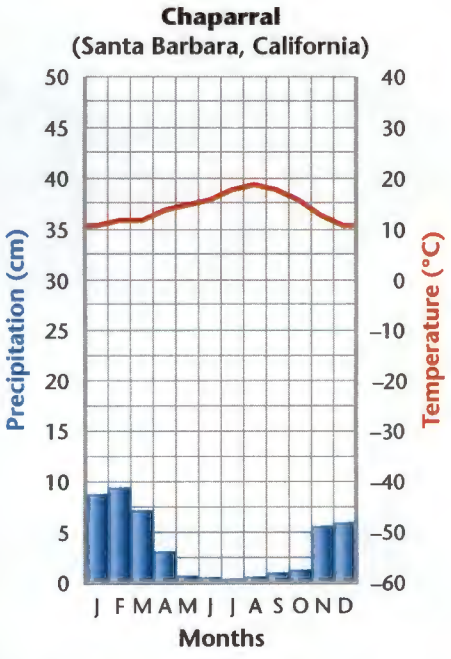
across green and brown California hills in **Figure 23.** Now imagine the scrub-covered settings common in old westerns. Both of these landscapes are part of the chaparral biome. As shown in **Figure 24,** chaparral is located in the middle latitudes, about 30° north and south of the equator. Chaparral is located primarily in coastal areas that have Mediterranean climates. Chaparral biomes typically have warm, dry summers and mild, wet winters.

Plants of the Chaparral Most chaparral plants are low-lying, evergreen shrubs and small trees that tend to grow in dense patches. Common chaparral plants include chamise, manzanita, scrub oak, olive trees, and herbs, such as sage and bay. These plants have small, leathery leaves that retain water. The leaves also contain oils that promote burning, which is an advantage because natural fires destroy trees that might compete with chaparral plants for light and space. Chaparral plants are so well adapted to fire that they can resprout from small bits of surviving plant tissue. The flammable oils give plants such as sage their characteristic taste and smell.

Animals of the Chaparral A common adaptation of chaparral animals is camouflage, shape or coloring that allows an animal to blend into its environment. Animals such as quail, lizards, chipmunks, and mule deer have a brownish gray coloring that lets them move through the brush without being noticed.

Threats to the Chaparral Worldwide, the greatest threat to chaparral is human development. Because chaparral biomes get a lot of sun, are near the oceans, and a have a mild climate year-round, humans tend to develop land for commercial and residential use.

Figure 24 ▶ Chaparral biomes are located in areas that have Mediterranean climates.



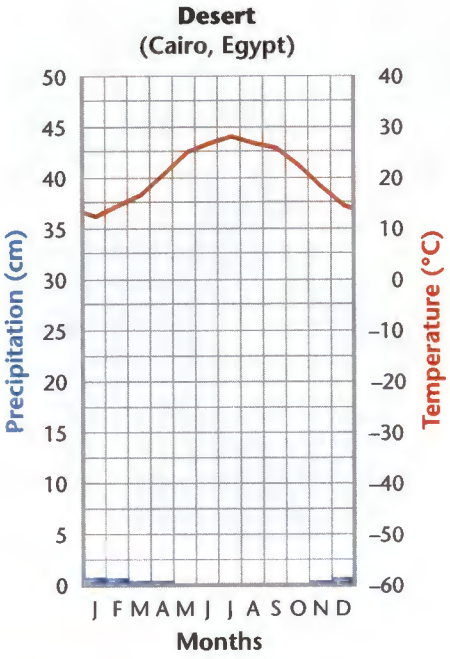
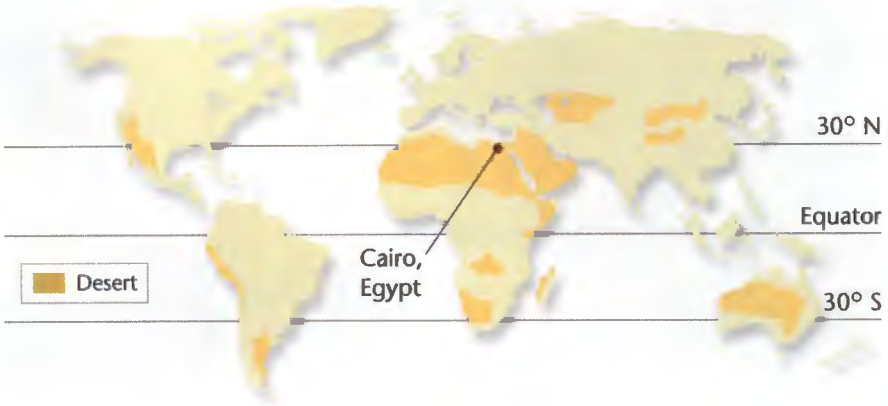


Figure 25 ▶ Deserts are the driest places on Earth. They typically receive less than 25 cm of precipitation a year.



Deserts

When some people think of a desert, they think of the hot sand that surrounds the Egyptian pyramids. Other people picture the Sonoran Desert and its mighty saguaro cactuses, or the magnificent rock formations of Monument Valley in Arizona and Utah. Many kinds of deserts are located throughout the world, but one characteristic that they share is that they are the driest places on Earth.

Deserts are areas that receive less than 25 cm of precipitation a year and have little or no vegetation. Deserts, as shown in **Figure 25**, also have extreme temperatures. Hot deserts, such as Arizona's Sonoran Desert and the Sahara in Africa, are closer to the equator than are cold deserts, such as the Gobi Desert in China and the Great Basin of the western United States. Deserts are often located in areas near large mountain ranges because mountains can block the passage of moisture-filled clouds, which limits precipitation.

▶ The flapnecked chameleon lives in the deserts of Botswana.

▶ The plants of the Sonoran Desert in Arizona collect and retain water after rain showers to survive the hot desert temperatures.

Plants of the Desert All desert plants have adaptations for obtaining and conserving water, which allows the plants to live in dry, desert conditions. Plants called *succulents*, such as cactuses, have thick, fleshy stems and leaves that store water. Their leaves also have a waxy coating that prevents water loss. Sharp spines on cactuses keep thirsty animals from devouring the plant's juicy flesh. Rainfall rarely penetrates deeply into the soil, so many plants' roots spread out just under the surface of the soil to absorb as much rain as possible.

Instead of living in dry conditions, some desert plants are adapted to survive for long periods of time without water. When conditions are too dry, some plants die and drop seeds that stay dormant in the soil until the next rainfall. Then, new plants quickly germinate, grow, and bloom before the soil becomes dry again. Some desert plants have adapted so that they can survive even if their water content drops to as low as 30 percent of their mass. Water levels below 50 to 75 percent are fatal for most plants.

Animals of the Desert Reptiles, such as Gila monsters and rattlesnakes, have thick, scaly skin that prevents water loss. Amphibians, such as the spadefoot toad, survive scorching desert summers by *estivating*—burying themselves in the ground and sleeping through the dry season. Some animals, such as the elf owl shown in **Figure 26,** nest in cactuses to avoid predators. Desert insects and spiders are covered with body armor that helps them retain water. In addition, most desert animals are nocturnal, which means they are active mainly at night or at dusk, when the air is cooler.

FIELD ACTIVITY

Miniature Desert Create a miniature desert by growing a small cactus garden. Purchase two or three small cactus plants, or take several cuttings from a large cactus. To take cuttings, carefully break off the shoots growing at the base of the parent cactus. Place the plants in rocky or sandy soil similar to the soil in a desert. Keep the cactuses in bright sunlight, and do not water them frequently. Record your observations of your cactus garden in your ***Ecolog***.

Figure 26 ▶ Desert plants survive harsh conditions by growing deep roots to reach groundwater and by having specialized structures that limit the loss of water. Desert animals bury themselves underground or burrow in cactuses to avoid extreme temperatures and predators.

▶ Elf owls burrow in cactuses to avoid hot temperatures during the day.

▶ This sidewinder has a unique way of moving so that only small portions of its body are in contact with the hot sands at any one time.

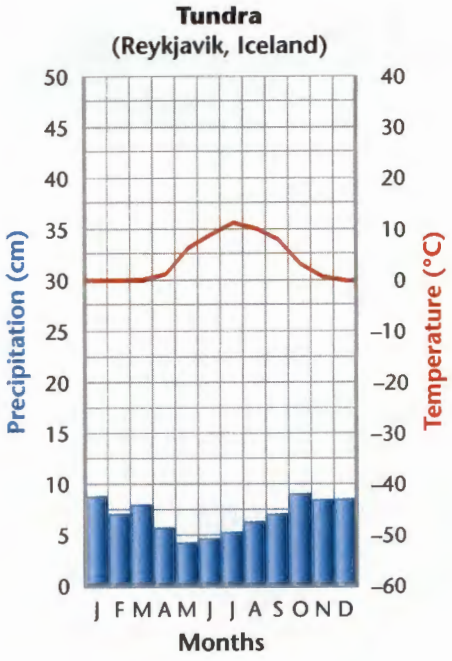


Figure 27 ▶ The precipitation that the tundra biome receives remains frozen much of the year.

Tundra

Tundra is a biome that is dominated by grasses, lichens, and herbs and that is located primarily north of the Arctic Circle, as shown in **Figure 27.** The tundra soil supports mostly tough grasses and shrubs. Summers are short in the tundra, so only the top few centimeters of soil thaw. Plants flower in the summer, as shown in **Figure 28.** Underneath the topsoil is a layer of soil called **permafrost,** which is permanently frozen soil. The tundra becomes dotted with bogs and swamps when the top layer of soil thaws. In summer, these wet areas are ideal breeding grounds for huge numbers of swarming insects, such as mosquitoes and blackflies, and for the many birds that feed on the insects.

Vegetation of the Tundra Mosses and lichens, which can grow without soil, cover vast areas of rocks in the tundra. The soil is thin, so plants have wide, shallow roots to help anchor them against the icy winds. Most flowering plants of the tundra, such as campion and gentian, are short. Growing close to the ground keeps the plants out of the wind and helps them absorb heat from the sunlit soil. Woody plants and perennials such as willow and juniper have evolved dwarf forms and grow flat or grow along the ground.

Graphic Organizer

Venn Diagram Create the **Graphic Organizer** entitled "Venn Diagram" described in the Appendix. Label the circles with "Tundra" and "Desert." Then, fill in the diagram with characteristics that each biome shares with the other.

Figure 28 ▶ During its brief summer, the Alaskan tundra is covered by flowering plants and lichens.

Figure 29 ▶ Many migratory animals, such as geese (left) and caribou (below), return to the tundra each year to breed.

Animals of the Tundra Millions of migratory birds fly to the tundra to breed in the summer. Food is abundant in the form of plants, mollusks, worms, and especially insects. Caribou, as shown in **Figure 29,** migrate throughout the tundra in search of food and water. Hunters such as wolves roam the tundra and prey on caribou, deer, moose, and smaller animals, such as lemmings, mice, and rabbits. These rodents burrow underground during the winter but they are still active. Many animals that live in the tundra year-round, such as arctic foxes, lose their brown fur and grow white fur that camouflages them with the winter snow. These animals are also extremely well insulated.

Threats to the Tundra The tundra is one of the most fragile biomes on the planet. The food chains are relatively simple, so they are easily disrupted. Because conditions are so extreme, the land is easily damaged and slow to recover. Until recently, these areas were undisturbed by humans. But oil has been located in some tundra regions, such as Prudhoe Bay in northern Alaska. Oil exploration, extraction, and transport has disrupted the habitats of the plants and animals in many parts of the tundra. Pollution caused by spills or leaks of oil and other toxic materials may also poison the food and water sources of the organisms that live in the tundra.

MATHPRACTICE

U.S. Oil Production On average, the United States produces an estimated 8.1 million barrels of oil per day. How many millions of barrels of oil does the United States produce in 1 year? If all of the oil-producing countries of the world produce an estimated 74.13 million barrels of oil per day, what percentage of worldwide oil does the United States produce?

SECTION 3 Review

1. **Describe** two desert animals and the adaptations that help them survive.
2. **Describe** how tropical grasslands differ from temperate grasslands.
3. **Compare** the plants that live in deserts with the plants that live in the tundra biome.
4. **Describe** one threat to the tundra biome.

CRITICAL THINKING

5. **Making Inferences** Former grasslands are among the most productive farming regions. Read the description of temperate grasslands in this section and explain why this statement is true. READING SKILLS
6. **Analyzing Relationships** Explain why elephants and caribou, which live in very different biomes, both migrate.

CHAPTER 6

Highlights

1 What Is a Biome?

Key Terms

biome, 143
climate, 144
latitude, 145
altitude, 145

Main Ideas

- Scientists classify the ecosystems of the world into large areas called *biomes*.
- Biomes are described by their plant life because the plants that grow in an area determine what other organisms live there.
- Temperature, precipitation, latitude, and altitude are factors that affect climate, which determines the types of the plants that can grow in an area.

2 Forest Biomes

tropical rain forest, 146
emergent layer, 148
canopy, 148
epiphyte, 148
understory, 148
temperate rain forest, 151
temperate deciduous forest, 152
taiga, 153

- The major forest biomes include tropical rain forests, temperate rain forests, temperate deciduous forests, and taiga.
- Tropical rain forests receive heavy rains and high temperatures throughout the year. They receive about 200 to 450 cm of rainfall a year. They are the most diverse of all biomes.
- Temperate deciduous forests experience seasonal variations in temperature and precipitation. They receive 75 to 125 cm of precipitation a year.
- Forest biomes are threatened by deforestation through logging, ranching, and farming.

3 Grassland, Desert, and Tundra Biomes

savanna, 155
temperate grassland, 156
chaparral, 158
desert, 160
tundra, 162
permafrost, 162

- Savannas are located north and south of tropical rain forests and have distinct wet seasons. Savannas receive 90 to 150 cm of precipitation a year.
- Temperate grasslands get too little rainfall to support trees. Grasslands are dominated mostly by different types of grasses and flowering plants. Shortgrass prairies receive about 25 cm of precipitation a year.
- Deserts are the driest biomes on Earth. Deserts receive less than 25 cm of precipitation a year.
- Plants and animals found in each biome adapt to the environment in which they live.

CHAPTER 6 Review

Using Key Terms

Use each of the following terms in a separate sentence.

1. *biome*
2. *climate*
3. *epiphyte*
4. *tundra*
5. *permafrost*

For each pair of terms, explain how the meanings of the terms differ.

6. *understory* and *canopy*
7. *latitude* and *altitude*
8. *chaparral* and *desert*
9. *tropical rain forest* and *temperate deciduous forest*

STUDY TIP

Concept Maps Remembering words and understanding concepts are easier when information is organized in a way that you recognize. For example, you can use key terms and key concepts to create a concept map that links them together in a pattern you will understand and remember.

Understanding Key Ideas

10. Approximately what percentage of the Earth's species do tropical rain forests contain?
    a. 7 percent
    b. 20 percent
    c. 40 percent
    d. 50 percent
11. Animal species of the tropical rain forest
    a. compete more for available resources than species native to other biomes do.
    b. have adaptations to use resources and avoid competition.
    c. have adaptations to cope with extreme variations in climate.
    d. are never camouflaged.
12. Migration of animals in the savanna is mostly a response to
    a. predation.
    b. altitude.
    c. rainfall.
    d. temperature.
13. Spadefoot toads survive the dry conditions of the desert by
    a. migrating to seasonal watering holes.
    b. finding underground springs.
    c. burying themselves in the ground.
    d. drinking cactus juice.
14. The tundra is most suitable to a vertebrate that
    a. requires nesting sites in tall trees.
    b. is coldblooded.
    c. has a green outer skin for camouflage.
    d. can migrate hundreds of kilometers each summer.
15. A biome that has a large amount of rainfall, high temperature, and poor soil is a
    a. temperate woodland.
    b. temperate rain forest.
    c. tropical rain forest.
    d. savanna.
16. The two main factors that determine where organisms live are
    a. soil type and precipitation.
    b. temperature and precipitation.
    c. altitude and precipitation.
    d. temperature and latitude.
17. Which of the following biomes contains large trees?
    a. savanna
    b. temperate rain forest
    c. chaparral
    d. desert
18. The most common types of plants in the taiga biome are
    a. deciduous trees.
    b. short shrubs.
    c. coniferous trees.
    d. grasses.

CHAPTER 6 Review

Short Answer

19. Unlike the jungles you see in movies, the floor of an undisturbed tropical rain forest usually lacks much vegetation. Explain why it lacks vegetation.

20. What is the relationship between root systems and erosion in a grassland ecosystem?

21. How might a mountain affect where particular types of biomes are located?

22. Well-preserved mammoths have been found buried in the tundra. Explain why the tundra preserves animal remains well.

23. How does deforestation contribute to a change in climate and increase the chance of floods in a biome?

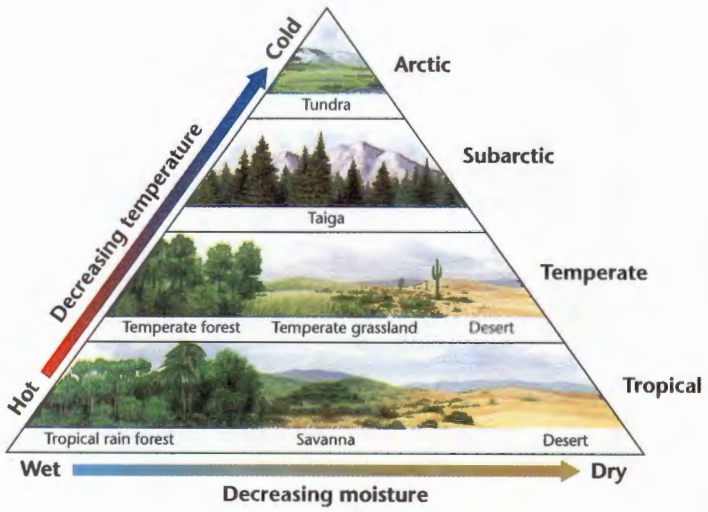
Interpreting Graphics

Use the diagram below to answer questions 24–26.

24. Why are tall trees found in taiga biomes but not in tundra biomes?

25. As moisture decreases, what happens to the amount of vegetation in an area?

26. What does the diagram tell you about the temperature of and precipitation in temperate grasslands?



Concept Mapping

27. Use the following terms to create a concept map: *threats to an ecosystem, erosion, overgrazing, logging, grasslands, rain forests, tundra, deserts, oil extraction,* and *irrigation.*

Critical Thinking

28. Comparing Processes American prairies and Asian steppes contain different plant species but are dominated by grasses. Write a short paragraph that explains why the two grasslands contain different species but the same types of plants. WRITING SKILLS

29. Classifying Information Read the description of tropical rain forests in this chapter, and list two factors that are responsible for the biodiversity of this biome. Describe two reasons for the decline of tropical rain forests, and discuss actions that some countries have taken to protect tropical rain forests. READING SKILLS

30. Analyzing Relationships If you took a population of squirrels from the southeastern United States and introduced them into a Central American rain forest, they would probably not survive. Why do you think the squirrels would not survive even though they are naturally adapted to life in a forest?

31. Making Inferences How might prairie fires set from natural and human causes have affected the evolution of fire resistance in prairie grasses?

Cross-Disciplinary Connection

32. Geography Use a world map to find locations of the various biomes. Then, make a poster that contains photos or illustrations of plants and animals native to each biome.

Portfolio Project

33. Food Webs in Your Community Do a special project on the ecosystems in your community. Use field guides of your area to find out what plants and animals live in your community. Then, draw a food web that shows how organisms in each ecosystem could be related.

MATH SKILLS

Use the table below to answer quesions 34–35.

Amount of Tropical Rainforest		
Country	Amount of tropical rain forest (km^2)	Amount of annual deforestation (km^2/y)
A	1,800,000	50,000
B	55,000	3,300
C	22,000	6,000
D	530,000	12,000
E	80,000	700

34. Making Calculations What percentage of tropical rain forest is being destroyed each year in country A? in country D?

35. Interpreting Statistics According to the table, which country's tropical rain forest will be completely destroyed first? Which country's rain forest will be completely destroyed last?

WRITING SKILLS

36. Communicating Main Ideas Describe the importance of conserving the biomes of the world. What can you do to help conserve the world's biomes?

37. Writing From Research Choose one biome and research the threats that exist against it. Write a short essay that describes the threats and any actions that are being taken to help save the biome.

STANDARDIZED TEST PREP

For extra practice with questions formatted to represent the standardized test you may be asked to take at the end of your school year, turn to the sample test for this chapter in the Appendix.

READING SKILLS

Read the passage below, and then answer the questions that follow.

The Tropics and other regions of high biodiversity include some of the economically poorest countries on Earth. These countries are trying to use their natural resources to build their economies and to raise the standard of living for their citizens. Several conservation strategies offer ways for developing countries to benefit economically from preserving their biodiversity.

For example, in a *debt-for-nature swap*, richer countries or private conservation organizations will sometimes pay some of the debts of a developing country. In exchange, the developing country agrees to take steps to protect its biodiversity, such as setting up a preserve or launching an education program for its citizens. Another idea to help local people make money from intact ecosystems is to set up a national park to attract tourists. People who want to see the ecosystem and its unique organisms will pay money for nature guides, food, and lodging. This idea is called *ecotourism*.

1. The main objective of both *debt-for-nature swap* and *ecotourism* is
- **a.** economic gain.
- **b.** education of citizens.
- **c.** preservation of biodiversity.
- **d.** Both (a) and (c)

2. According to the passage, which of the following statements is true?
- **a.** Regions of high biodiversity are not worth saving.
- **b.** Intact ecosystems are those ecosystems that are most developed.
- **c.** Debt-for-nature swap is an example of international compromise.
- **d.** Launching education programs for citizens does not help protect ecosystems.

CHAPTER 6

Exploration Lab: FIELD ACTIVITY

Objectives

- **Collect** information from international, national, and local resources about the biome in which you live.
- **USING SCIENTIFIC METHODS** **Perform** field observations to identify the name of the biome in which you live.

Materials

binoculars (optional)
field guide to local flora and fauna
globe or atlas
graph paper (optional)
notebook
pencil or pen
ruler

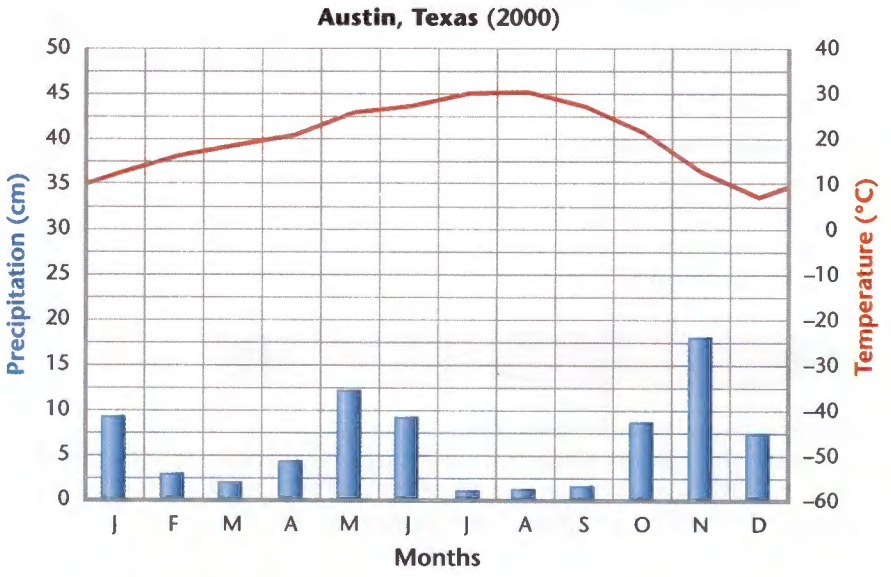
Identify Your Local Biome

In what biome do you live? Do you live in a temperate deciduous forest, a desert, or a temperate grassland, such as a prairie or savanna? In this lab, you will explore certain characteristics of the biome in which you live. With the information you gather, you will be able to identify which biome you live in.

Procedure

1. Use a globe or atlas to determine the latitude at which you live. Record this information.
2. Consider the topography of the place where you live. Study the contour lines on a map or surface variations on a globe. What clues do you find that might help identify your biome? For example, is your area located in near a mountain or an ocean? Record your findings.
3. Prepare a climatogram of your local area. A climatogram is a graph that shows average monthly values for two factors: temperature and precipitation. Temperature is expressed in degrees Celsius and is plotted as a smooth curve. Precipitation values are given in centimeters and are plotted as a histogram.

   To make a climatogram of your area, obtain monthly averages for one year of precipitation and temperature from your local TV or radio weather station. Make a data table, and record these values. Next, draw the vertical and horizontal axes of your climatogram in your notebook or on graph paper. Then, show the temperature scale along the vertical axis on the right side of the graph and the precipitation scale along the vertical axis on the left side of the graph. Show months of the year along the horizontal axis. Finally, plot your data.



Climatograms The temperature and precipitation for Austin, Texas is shown in this climatogram.

4. Go outside to observe the plants growing in your area. Bring a field guide, and respond to the following items in your notebook.
   - **a.** Sketch or describe as many plants that are common in the area as you can. Use your field guide to identify each of these species.
   - **b.** Describe three or more adaptations of each plant to the local climate.
   - **c.** Which of the plants that you observed are native to your area? Which have been introduced by humans? Which of the introduced plants can survive on their own in local conditions? Which of the introduced plants require extensive human care to remain alive?
   - **d.** Look for evidence that animals have left behind—footprints, nests, dens or burrows, hair or feathers, scratches, or urine markings. Sketch or describe as many different animal species as possible. Identify each species by using your field guide.
   - **e.** Describe three or more adaptations that each animal has developed in order to survive in local climatic conditions.

Analysis

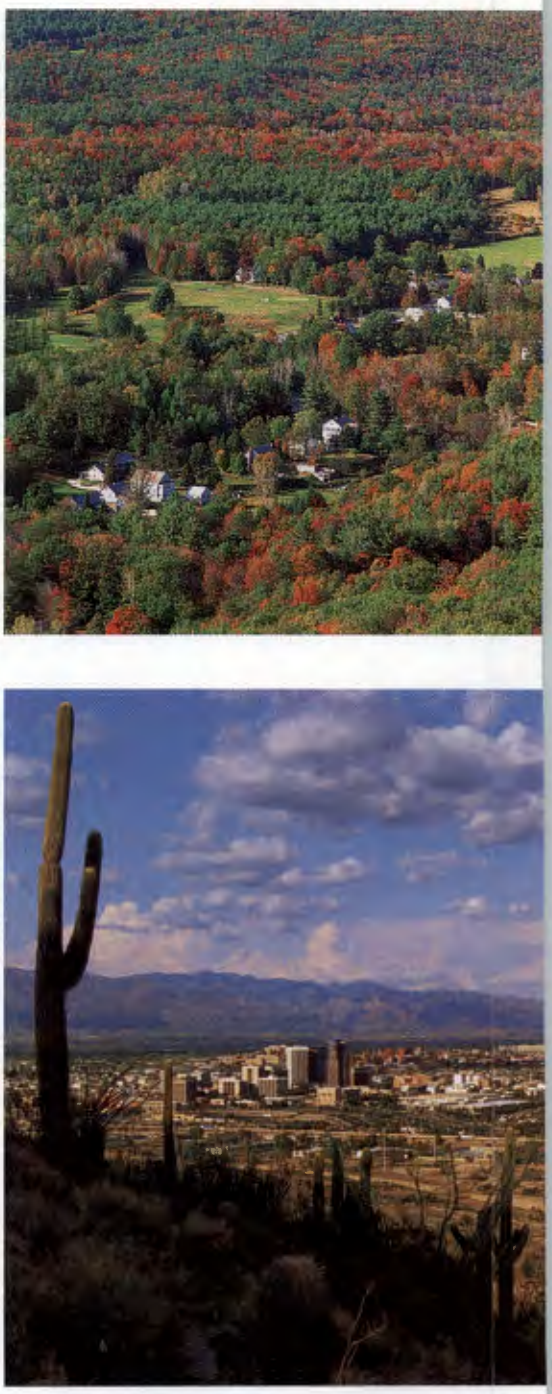
1. **Analyzing Data** Compare your local climatogram to the biome climatograms shown in this chapter. Which biome has a climatogram most similar to your climatogram?
2. **Analyzing Results** Consider your latitude, topographical findings, and observations of local plants and animals. Combine this information with your climatogram, and determine which biome best matches the area in which you live.

Conclusions

3. **Evaluating Results** Does your local climatogram match any of the seven major terrestrial climatograms shown in the chapter? Explain how any differences between your local biome and the biome in the chapter that your local biome most clearly matches might influence the adaptations of local animals and plants.
4. **Applying Conclusions** Organisms create features of the biome in which they live. What features of your biome are created by the organisms that live there?

Extension

1. **Classifying Information** Name three adaptations you observed in the plants that grow naturally in your area. Name at least three adaptations you observed in local animals. Explain in detail how each of these adaptations meets the conditions of your biome.



▶ **Biomes** These two cities are located in two different biomes. Stamford, Vermont (top) is located in a temperate deciduous forest, and Tucson, Arizona (bottom) is located in a desert.

POINTS of view

THE FUTURE OF THE ARCTIC NATIONAL WILDLIFE REFUGE

During the 1970s, Congress passed the Alaska National Interests Land Conservation Act. The legislation gave Congress the responsibility for determining how Alaska's lands will be used. Included in this responsibility is the fate of the Arctic National Wildlife Refuge (ANWR). Oil company geologists believe that oil reserves are under several areas of the northern Alaska coast, including the refuge. Debate has raged about whether Congress should maintain ANWR as a wildlife refuge or open it to oil exploration. Advocates of the refuge feel that the environmental cost of oil exploration would be too high. But those who favor oil exploration in the refuge believe the oil reserves must be tapped to meet U.S. oil needs and to maintain economic security.

▶ A small group of muskoxen huddles on the arctic tundra of the Arctic National Wildlife Refuge.

Protect the Refuge

Conservationists and ecologists are concerned about the impact that oil exploration would have on animals that live in the refuge. Oil exploration would occur within the 1.5 million acre coastal plain of the ANWR. This area includes the breeding ground and grazing area for one of the last great herds of caribou in North America. Biologists think that forcing the herd into other areas of the refuge would deprive the caribou of their main food source and would expose calves to increased predation.

In addition, migratory birds from all over the world travel to the refuge's tundra to nest and raise their young during the short arctic summers. Scientists believe that oil exploration would disrupt the nesting and feeding of these birds so much that the birds would be unable to finish rearing their young before the first freeze of early September.

The ANWR is also a habitat for more than 7,000 native peoples. Some of these people depend on the caribou of the ANWR for food, clothing, and tools. Oil exploration and drilling could displace the caribou population, which would drastically affect the culture and way of life for these people.

Opponents of oil exploration in the refuge also point to the environmental damage that has already been done in nearby Prudhoe Bay. When oil was found there, oil companies joined forces to extract the oil and built a pipeline across the state to reach tankers on the southern Alaska coast. Advocates of the refuge say that the use of this pipeline has exposed the fragile tundra ecosystem to toxic chemicals and destroyed natural habitats. They fear the same fate for the refuge if oil exploration is permitted there.

Advocates of protecting the refuge also point out that no one knows how much oil is available in the refuge. They also point out that even if all of the oil that could possibly be in the refuge were extracted, the oil would supply the United States for only nine months.

Conservationists contend that the development and use of renewable energy resources, such as wind and fuel cells, could reduce the dependence on oil. Laws that require stricter energy conservation measures could also reduce the need for oil in the United States.

▶ Migratory birds, such as the Canada geese below, nest and raise their young on the refuge's tundra.

▶ The pipeline shown above carries oil across the entire state of Alaska.

Open the Refuge

Advocates of oil exploration in the ANWR believe that the current U.S. demand for oil cannot be met by energy conservation alone. Advocates insist that the United States must utilize every domestic source of oil available, including the ANWR. The advocates also point out that the United States depends too much on oil from other countries that control its price and availability. A significant amount of our oil is imported from the Middle East, a politically unstable area. If those countries restrict sales of oil to the United States, our economy could be seriously affected. Those who favor exploration think economic security should take priority over environmental concerns.

Advocates of oil exploration in the refuge also stress that much of the oil in the Prudhoe Bay area has already been extracted and that oil production will soon begin to decline. The industrial complex that is already in place for the production of oil in Prudhoe Bay could be used for the production of oil from the nearby refuge. New construction in the area would be limited.

Because of the decline of oil in Prudhoe Bay, advocates support oil drilling in the ANWR for economic reasons. The oil industry supports two-thirds of Alaska's economy and employs 1 percent of the population. If the refuge were open for drilling, oil companies would profit and more jobs might be available for the people of Alaska.

Government studies indicate a 19 to 46 percent chance of finding oil in the refuge, which is a percentage that the oil industry believes justifies exploration. People who favor exploration also suggest that oil companies can now extract oil with less environmental damage than was caused in Prudhoe Bay.

People who oppose the protection of the wildlife refuge believe the economic benefits of oil exploration in this area outweigh any remaining risks of environmental damage.

▶ Exploration for oil would occur in the northern coastal plain of the Arctic National Wildlife Refuge.

What Do You Think?

Oil exploration in ANWR could have a negative impact on the animals and people living in and around the refuge, but oil in the refuge may help the U.S. meet its future energy needs. Without knowing what the consequences or benefits will be, do you think that the U.S. should permanently protect the ANWR or open it for oil exploration? Explain.