Overview
Tell students that the purpose of this chapter is to help them understand the different terrestrial biomes found throughout the world. Biomes are described by their vegetation, temperature, and precipitation. The terrestrial biomes of the world include tropical rain forest, temperate forest, taiga, temperate grassland, desert, tundra, chaparral, and savanna. Threats to habitats in each biome are also described.

Using the Figure
Animals such as this thorny devil have adapted to the desert’s high temperatures and low precipitation. Ask students to identify adaptations of the thorny devil in the photograph. (Sample answers: the colors of the thorny devil’s skin help it blend in with the desert environment, it has pointy spikes on its rough skin to help it ward off predators. And its thick skin helps retain water in the hot, dry climate.) Ask students to think of other desert animals and explain how each has adapted to living in a hot, dry place. (Sample answer: Armadillos have thick skin and are nocturnal.)

Chapter Correlations
LS 3a Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring. (Section 2 and Section 3)
LS 4c Organisms both cooperate and compete in ecosystems. The interrelationships and interdependencies of these organisms may generate ecosystems that are stable for hundreds or thousands of years. (Section 2 and Section 3)
LS 4d Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. This fundamental tension has profound effects on the interactions between organisms. (Section 2 and Section 3)
LS 6b Organisms have behavioral responses to internal changes and to external stimuli. Responses to external stimuli can result from interactions with the organism’s own species and others, as well as environmental changes; these responses either can be innate or learned. The broad patterns of behavior exhibited by animals have evolved to ensure reproductive success. Animals often live in unpredictable environments, and so their behavior must be flexible enough to deal with uncertainty and change. Plants also respond to stimuli. (Section 2 and Section 3)
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. 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 of the organisms to their very different environments.

### Biomes and Vegetation

Biomes are described by their vegetation because the plants that grow in a certain region are the most noticeable characteristics of that region. The plants, in turn, determine the other organisms that can live there. For example, mahogany trees grow in tropical rain forests because they cannot survive cold, dry weather. Organisms that depend on mahogany trees live where trees grow.

Plants in a particular biome have these adaptations that enable them to survive there. 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. Desert plants, such as cacti, do not have leaves. Instead, cacti have specialized structures to conserve and retain water.

**Reading Check** How are ecosystems related to biomes? (See the Appendix for answers to Reading Checks.)

### Objectives
- Describe why vegetation is used to name 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**

### Motivate

#### Bellringer

Have small groups of students look at a world map. Ask students to find the latitudes of their city or town, and then find a large city in Finland, Argentina, Vermont, and Cameroon. Have them compare these latitudes to the map in Figure 1 in order to find the biomes associated with these cities. Ask students to think about why the biomes might be different in each of these locations. (Finland has taiga, Argentina has grasslands, Vermont has temperate deciduous forest, and Cameroon has tropical rain forests. Different biomes have developed at different latitudes because of the different climatic conditions.)

#### Visual

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

- **Polar ice**
- **Tropical rain forest**
- **Temperate forest**
- **Taiga**
- **Tropical savanna**
- **Temperate grassland**
- **Chaparral**
- **Desert**
- **Tundra**
- **Mountains**

### Chapter Resource File

- **Lesson Plan**
- **Active Reading**
- **Section Quiz**
- **Transparencies**

#### Transparencies
- TT Bellringer
- TT Biomes of the World
- TT Temperature Vs. Precipitation

### Answer to Reading Check

Biomes are composed of many different ecosystems.
Teach

Using the Figure — General

**Climatograms** Ask students to trace or draw Figure 3 in their EcoLog. Students do not need to draw all of the vegetation accurately; they should just sketch a few key plants. Have students leave space near the name of each biome. Then have students find the climatograms (the graphs that give monthly averages of the temperature and precipitation for each biome) throughout the rest of the chapter. On their sketch, ask them to record the range of temperature and the approximate annual precipitation for each biome from the climatograms. (You might want to review how to read a climatogram with students before they do this.) Have them discuss whether or not the climatograms match the general trends indicated in Figure 3. (they should match approximately) Ask students to figure out where chaparral fits into the figure. (It should fit between temperate grassland and desert.) **Visual**

**Homework** — General

**Plants and Animals** Ask students to research two of their favorite plants or animals to find out which biome each organism lives in. Have students write a short paragraph about each organism that details its maximum and minimum temperature and precipitation needs, its typical biome, and some of the adaptations that allow it to survive in that biome. Have them include a picture of the organism above the descriptive paragraph. Encourage students to add these paragraphs to their Portfolio. **Intrapersonal**

**Answer to Reading Check**

Plants can live within only a certain range of temperatures, and they are affected by the length of the growing season.

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**Career**

**Meteorologist** A meteorologist is a scientist who studies atmospheric phenomena, such as pressure fronts and humidity, often in order to predict weather. Meteorologists use sophisticated machinery, such as Doppler radar, to read cloud patterns and pressure systems within the layers of the atmosphere. They also predict severe weather, such as tornadoes and hurricanes, in order to save lives and minimize property damage. Contact a local news station to see if you can set up a tour of the weather prediction facility, or have the meteorologist visit the class to give a presentation on weather and climate in your area. **Intrapersonal**

**Paired Summarizing** Have students form pairs. Then ask students to quiz each other on the temperature and precipitation traits of each biome by using Figure 3. Have each student within the pair switch off and work together until both of them can name all the traits without looking at the figure. **Auditory**

**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** Most organisms are adapted to live within a certain range of temperatures and will not survive at temperatures too far outside of their range. Plants are also affected by the length of the growing season, as shown in Figure 2.

Precipitation also limits the organisms that are found in a biome. All organisms need water. 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 mostly made up of cactuses and desert shrubs. 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.

**Reading Check** Why does temperature limit which plants can grow in a certain biome?
Latitude and Altitude  

Biomes 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, between about 30° and 60° north latitudes and 30° and 60° south latitudes, is where most of the food in the world is grown. This region includes biomes such as temperate forests and grasslands, which usually have the moderate temperatures and fertile soil that are 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.
6. **Analyzing Relationships** Look at Figure 1, and locate the equator and 30° north latitude. Which biomes are located between these two lines?

**Answers to Section Review**

1. Scientists name biomes after their vegetation because the plants that grow in an area determine what other organisms can live there.
2. Plants are adapted to a particular range of temperature and can usually survive only in a climate with that particular range.
3. Plants are adapted to a particular level of precipitation. In general, the larger a plant is, the more water it needs.
4. Latitude is the distance north or south of the equator. Altitude is the height of an object above sea level. Both latitude and altitude determine the temperature and precipitation of a biome. Therefore, if an organism lives in a biome that is close to the equator and at a low altitude, the organism must be able to survive in a very warm, moist environment.
5. Sample answer: Part of the Andes Mountains is located in Ecuador. The resulting wide range of altitudes in Ecuador creates the wide range of climates.
6. Desert, chaparral, tropical savanna, temperate grassland, temperate forest, and tropical rain forest are the biomes that are located between the equator and 30° north latitude.

**Close**

**Reteaching** **BASIC**

**Mountains** Have students discuss how altitude is related to precipitation and temperature. (The higher the altitude, the colder the temperature. Colder temperatures limit the amount of available moisture in an area.) Ask students, “Are all mountains like Figure 4?” (No, mountains located in the temperate region are more like deserts at the top.)

**Logical**

**Quiz** **GENERAL**

1. Why is it hard for trees to survive at the tops of very high mountains? (The conditions at high altitudes are too cold, dry, and windy for trees.)
2. Which biome would you expect to find in warm to hot conditions with a large amount of moisture? (Tropical rain forest)
3. Coniferous trees can be found in both the subarctic taiga and in warm chaparral regions. What kind of conditions have these trees in these areas adapted to? (A lack of moisture.)

**Alternative Assessment** **ADVANCED**

**World Biomes** Have students look at Figure 1 and write down at least three biomes that do not seem to fit the latitude and altitude model presented in Figure 4. Ask them to decide why the biomes do not fit and to write their reasons in a short essay. (The biomes may be influenced by oceans, which would provide cooler temperatures and more moisture. Mountains may also block moisture from the deserts.)

**Logical**

**Transparencies**

**TT** Latitude Vs. Altitude
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 are home to the greatest diversity of plants, animals, and other organisms. Trees need a lot of water, so forests exist where precipitation is plentiful. Tropical forests, temperate forests, and taiga are the main forest biomes.

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 m²) of temperate forest usually contains a few species of trees, the same area of tropical rain forest may contain more than 100 species.
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. Organic matter decays quickly in hot, wet conditions. Decomposers on the rain-forest floor break down organic matter and return the nutrients to the soil, but plants quickly absorb the nutrients. Some trees in a tropical rain forest support fungi that feed on dead organic matter on the rain-forest floor. In this relationship, the fungi transfer the nutrients from the dead organic matter directly to the tree.

The nutrients are removed so efficiently from the soil in a tropical rain forest that water running out of the soil may be as clear 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 the trees with extra support in the thin soil.

Tropical Rain Forests  The tropical rain forests in the Andes mountains in Ecuador are among the wettest places on Earth.

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

Figure 5  The world's tropical rain forests have heavy rainfall during much of the year and fairly constant, high temperatures.

Figure 6  Species of Tropical Rain Forests  These mountain gorillas live in the rain forests of Rwanda.

BRAIN FOOD

Limiting Factors  Every organism in an ecosystem needs certain resources, both biotic and abiotic. When a resource is in such short supply that it limits the growth of a population, it is called a limiting factor. Abiotic factors such as temperature, water, light, and nutrients in soil are usually the most limiting. As you proceed through the chapter, have students identify the limiting factors for each biome.
In tropical rain forests, different types of plants use the entire surface of a tree as a place to grow. Epiphytes, such as bromeliads, are carnivorous—they trap and digest insects to get nutrients. Many rain forest plants and animals have yielded chemicals used to create powerful new drugs. Many rain forest plants and animals have yielded chemicals used to create powerful new drugs. Have each student research one of these medicinal plants or animals (besides the rosy periwinkle). Ask them to identify the active ingredient in each of these organisms, the drug that it helped to create, and what the drug helps to cure. Have students find the chemical structure of the active ingredient, if possible. Encourage students to write up their findings to include in their Portfolio.

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.

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. Trees in the emergent layer grow and emerge into direct sunlight.

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 grow. Epiphytes grow on tall trees for support. Some 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 that are adapted to shade grow here. Most plants in the understory do not grow more than 3.5 m tall. Herbs with large, flat leaves grow on the forest floor. These plants capture the small amount of sunlight that penetrates the understory. Most of our house plants are native to tropical rain-forest floors. Because they are adapted to low levels of light, they are able to grow indoors.

Reading Check  In which layer of the rain forest is most of the animal life found?

Answer to Reading Check
Most of the animals that live in the rain forest live in the canopy.

Notable Quotes

“There is more information of a higher order and complexity stored in a few square kilometers of forest than there is in all the libraries of mankind.”
—Eugene Odum, Ecologist.

Have students discuss the types of information one could gather from a forest. (relationships among species, genetic information, evolutionary history, chemical formulas, artistic forms, perfumes, different tastes)
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. 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. These insects may be shaped like leaves or twigs.

Figure 8  Examples of plant and animal adaptations in the tropical rain forest include 1 the long tongue of a collared anteater, 2 the strong, curved beak of a wreathed hornbill, 3 the shape of a Costa Rican mantis, and 4 an orchid attached to a tall tree.

Biodiversity  Scientists have long debated the reason for the great biodiversity in tropical rain forests. One theory suggests that it is a combination of energy (in the form of sunlight), available area, and stability of the climate. Ask students, “Why would the stability of the climate promote the evolution of biodiversity?” (In temperate and polar regions, organisms have to be adapted to a wide range of seasonal variations in temperature and nutrient availability, so they need to have more flexible adaptations. The environment is less predictable, so specialization is more difficult. In contrast, in the relatively stable climate in the tropics, organisms can count on specific foods being available all or most of the time.)
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 5 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. 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 flow freely down the river and spread across fields and into towns during the seasonal monsoon rains. Deforestation has also caused terrible floods in places such as Bangladesh. The Ganges River starts high in the Himalaya Mountains and flows through Bangladesh. Deforestation of the Himalaya land as ecological reserves may not be politically or economically realistic. Ask students, “Why would a poverty-stricken country be less likely to follow the Costa Rican example?” (An increase in population and poverty would force people to use whatever resources were available.) Ask students, “What can we as residents in a developed nation, do to help less developed nations follow the Costa Rican example?” (Answers may vary. Suggestions include offering grants, increasing ecotourism, or buying the land from the country.)

Reading Check
What are two main threats to the organisms that live in tropical rain forests?
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 mountains, a lot 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.

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.

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.

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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.

Case Study

Deforestation, Climate, and Floods

Have students research the major floods in history. Have students research how and why these floods occurred and the amount of damage that each flood caused. Have them share their research. Discuss with students the importance of preserving areas to prevent flooding.

Answers to Critical Thinking

1. Deforestation may affect the overall climate of the Earth because deforestation releases carbon into the atmosphere and removes the trees that would normally take up carbon. Carbon dioxide can contribute to global warming.

2. Answers may vary. Students should determine whether forests are plentiful locally and whether the removal of the forest would cause other problems, such as flooding, erosion, or species loss.

Group Activity

Pacific Northwest Food Web

In the past, the northern spotted owl has received a great deal of attention in a battle between loggers and environmentalists over the fate of old-growth forests in the Pacific Northwest. Students may not realize that the spotted owl is part of a complicated food web that also contains martens, flying squirrels, red-backed voles, Douglas firs, pseudoscorpions, termites, and black and yellow mycorrhizal fungi. Have students form teams, and have each team investigate the ecological role of one of these organisms. Then have students work together to make a bulletin board display. At the center of the display, place an illustration or photograph of a tree from an old-growth forest. Groups should add a picture of their organism to the display along with a written description of its niche and interaction with the tree.

Logical Co-op Learning

EARTH SCIENCE CONNECTION

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

Figure 9

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.

Logical Co-op Learning

Inclusion Strategies

- Attention Deficit Disorder
- Learning Disabled
- Developmentally Delayed

To help students understand the concept of habitat destruction, ask them to write a story from the perspective of an animal living on land that has been destroyed or altered. The story should include how the animal will adapt or move as a result of the habitat destruction. The story can be word processed or dictated into a tape recorder. Drawings of the land before and after the destruction can be added.

CASE STUDY

Deforestation, Climate, and Floods

Have students research the major floods in history. Have students research how and why these floods occurred and the amount of damage that each flood caused. Have them share their research. Discuss with students the importance of preserving areas to prevent flooding.

Answers to Critical Thinking

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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 latitudes, 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. Just as temperatures change with the seasons, so does the vegetation, as shown in Figure 11. Although there is enough moisture for decomposition, temperatures are low during the winter. As a result, organic matter decomposes fairly slowly. This means that the soil contains more organic matter and nutrients than the soil in a tropical rain forest.

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 floor of a deciduous forest gets more light than the floor of a rain forest does, more plants such as ferns, herbs, and mosses grow in a deciduous forest.

HISTORY

The Father of Forests John Muir (1838–1914) was an American naturalist, explorer, and writer. His conservation efforts included helping persuade Congress to establish both Yosemite and Sequoia National Parks in 1890 and establishing the Sierra Club in 1892. He traveled to many parts of the world and is known for his work explaining Yosemite’s glacial origins, as well as for his discovery of a glacier in Muir Woods, a redwood forest near San Francisco which was named after him in 1908. His books include The Mountains of California (1894), Our National Parks (1901), and The Yosemite (1912). Have students research and report on John Muir, or another American naturalist, such as Aldo Leopold or John James Audobon.
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. Herb seeds, bulbs, and rhizomes (underground stems) become dormant in the ground and are insulated by the soil, leaf litter, and snow. In the spring, when the sunlight increases and the temperature rises, 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 the forest plants. Grasshoppers, such as the one shown in Figure 12, eat almost all types of vegetation found throughout the forest. 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 many birds cannot survive harsh winters, each fall they fly south for warmer weather and 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, some mammals reduce their activity so that they do not need as much food for energy.

**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 often fall to −20°C. Many trees seem like straight, dead shafts of bark and wood—until you look up and see their green tops. Plant growth is most abundant during the summer months because of nearly constant daylight and larger amounts of precipitation.

**Concept Mapping** Have students create a concept map using the animals of the temperate deciduous forest mentioned on this page. Ask them to map the animals by what they eat, where they might live, and whether or not they leave in winter. After they are finished with their maps, ask students to pair up to discuss how they created the connections on their maps. Also have students include their map in their Portfolio.

**Activity**

**Group Activity** Organize students into four groups, and provide each group with a large sheet of poster board or butcher paper. Each sheet should be labeled with a type of forest biome discussed in this section. Ask students to illustrate in light colors the vegetation that grows in the listed forest biome. Then have the groups switch posters and use darker colors to add the appropriate animals for the biome. Encourage students to also include decomposers, such as insects, fungi, and bacteria. Have students switch illustrations once again, this time describing the interrelationships between the organisms shown. Finally, students can switch posters again to label and describe some of the organisms’ adaptations. Display these posters in your room.

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**Notable Quotes**

“Humanity is cutting down its forests, apparently oblivious to the fact that we may not be able to live without them.”

—Isaac Asimov, Science Fiction Writer.

Have students discuss the great variety of services and products provided by forests. Ask them to identify some of the most important services or products. (oxygen production, temperature mediation, flood and erosion prevention, carbon storage, habitat, and wood products.)
**Close**

**Reteaching**

**News Flashes** Some students may have trouble distinguishing between the different forest biomes. Ask volunteers to prepare a three to five minute news report featuring the characteristics of, the location of, and the threats facing the different forest biomes. Then have students present their news flashes to the class. Ask all students to take notes and include them in their Portfolio.

**Quiz**

1. Do animals of the tropical rain forest generally migrate? Explain your answer. (No. The climate is stable year-round, so a reliable food source is available year-round.)

2. How do small mammals survive winter in the taiga? (They may burrow to stay warm.)

3. Most rain forest animals are food generalists, true or false? (False. Because the plants provide a stable, consistently available food source, animals in the tropics are mainly specialists.)

**Alternative Assessment**

**Detailing a Biome** Organize the class into groups of five or six students. Give each group a detailed picture of a forest biome, and ask them to describe the characteristics of the biome. (Answers should include a description of where the biome is located, what types of animal and plant species live there, and what special adaptations help those organisms to survive in the biome.)

**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.

**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?

**Answers to Section Review**

1. Tropical rain forests are typically humid and warm, receive 200 to 450 cm of rain per year, and have nutrient-poor soil.
2. The main layers of a tropical rain forest are the emergent layer, the upper and lower canopies, and the understory. The emergent layer consists of the tallest trees. The upper and lower canopies consist of tall trees and epiphytes. Trees and shrubs that are adapted to shade, grow in the understory.
3. Answers may vary, but should include two of the following: logging, farming, ranching, oil exploration, and trading.
4. Sample answer: In order to survive the change of seasons in the temperate deciduous forest, a plant loses its leaves during the fall and winter and remains dormant until spring.
5. Temperate deciduous forest: Organic matter decays slowly in the temperate forest, and forms a deep, rich soil that would be better suited for agriculture.
6. A snowshoe hare avoids predation by shedding its brown summer fur and growing white fur that camouflages it in the winter snow. Predators will have a difficult time finding a snowshoe hare during the winter.
In areas with too little precipitation for large trees to survive, the biomes are dominated by smaller plants. Where there is almost no rainfall at all, few plants can grow and we find desert. Thus, warm areas with little precipitation are characterized by savanna and desert biomes. Temperate areas have grassland, chaparral, and desert biomes, and cold areas have tundra and desert biomes.

**Savannas**

Parts of Africa, western India, northern Australia, and some parts of South America are covered by grassland called savanna. A savanna is a tropical biome dominated by grasses, shrubs, and small trees. As Figure 16 shows, rain falls mainly during the wet season, which lasts for only a few months of the year. This is the only time that plants can grow. The plants support an amazing variety of herbivores, such as antelopes, giraffes, and elephants, as well as the predators that hunt them—cheetahs, lions, and hyenas, for example.

**Plants of the Savanna**

Because most of the rain falls during the wet season, plants must be able to survive prolonged periods of time without water. During the dry season, plants lose their leaves or die down to the ground. When the rain returns, they start to grow again. Many plants have large, horizontal root systems so they can draw water from as large an area as possible. 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.

### Reading Check

Name two herbivores and two predators that savanna plants support.

### Answer to Reading Check

Sample answer: Savanna plants support herbivores such as antelopes and giraffes, as well as predators such as cheetahs and lions, which hunt the herbivores.
Herbivores of the savanna, such as the elephants shown here, range widely in search of food.

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 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 eat 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

Temperate grassland covers large areas of the interior of continents, where there is moderate rainfall, but still too little for trees to grow. The prairies in North America, the steppes in Asia, the veldt in South Africa, and the pampas in South America are temperate grasslands. Their locations are shown in Figure 18. Two examples of temperate grasslands are shown in Figure 19. Mountains often play a crucial role in maintaining grasslands. For example, in North America, rain clouds moving from the west release most of their moisture as they pass over the Rocky Mountains. As a result, the shortgrass prairie just east of the Rockies receives so little rain that it looks almost like a desert.

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 temperate 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.

Discussion

Introducing Grazers When cattle or other nonnative species are introduced to grasslands, the result is often degradation of the environment. Ask students to discuss the following question: “Why would grazers native to a grassland biome have less of an impact on the area than newly-introduced grazers?” (When a community has remained stable for a long period of time, the animals and plants that comprise it are generally well adapted to each other’s presence. For example, a native grass will be adapted to survive the amount of grazing that is normal for the region’s native herbivores. When a new species is introduced, different consumption patterns might be too severe for a native grass to withstand, and it may die out. The loss of the grass species could then affect the entire ecosystem.)

BRAIN FOOD

Giraffes The giraffe is a resident of the savanna, and occupies a special niche. Because of its long neck, it can reach tree leaves 2 to 5.5 m from the ground. Its tongue can stretch up to 17 inches, so it can reach even taller leaves. Males and females forage differently; males stretch up to reach vegetation, and females eat lower vegetation. This probably eliminates food competition between the sexes. Giraffes live in groups, whose sizes are dictated by the amount of food in the area. A male establishes dominance in a group by pushing at another male’s neck, or by hitting the other male’s neck and head with his horns. Giraffe reproduction is slow; gestation takes about a year and a half, and produces one offspring. Offspring are very vulnerable to predation.
The amount of rain increases as you move east, which permits the growth of taller grasses and some shrubs. Grassland plants dry out in the summer, so lightning strikes often start fires.

**Plants of Temperate Grasslands**  Temperate grassland vegetation consists of grasses and wildflowers. Although there is only a single layer of vegetation, many species may be present. Shrubs and trees grow only where the soil contains extra water, usually on the banks of streams.

The root systems of grassland plants form dense layers that survive drought and fire. Figure 20 shows how the heights of grasses and the depths of their roots vary.

Grasslands are highly productive because of their fertile soil. The summer is hot and the winter is cold, so the plants die back to their roots in the winter. Low temperatures in the winter slow decomposition. As a result, the rate at which dead plants decay is slower than the rate at which new vegetation is added each year. Over time, organic matter accumulates in the soil. This means that grasslands have the most fertile soil in the world. Most grasslands have been converted to farmland for growing crops such as wheat and corn.

**Figure 19** The steppes in Asia (left) and the pampas in South America (right) are dominated by grasses and other plants that are adapted to temperate grasslands.

**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.

**Group Activity**

**Plant a Prairie!** If your climate is appropriate, get permission to plant a prairie garden on your school grounds. Many sources of native prairie seeds exist, and seed suppliers can help your students learn how to prepare the ground and tend the garden properly. With proper maintenance, which includes periodic burning, this garden will thrive with a wide variety of grass and flower species. Your pocket prairie will also attract butterflies and other interesting insects, and can be a great educational resource.

**Homework**

**Bison Today** Have students research and write a report on the status of bison in North America today. Ask them to find out where the bison are, how and if they are being managed, where the largest herds are, if they are conflicting with cattle and other animals on the grasslands, and how bison products are used by humans. If you are in an area where bison are ratched, ask to interview a rancher.

**LANGUAGE ARTS**

**PrairyErth** Students who are interested in the American prairie may enjoy the book *PrairyErth (A Deep Map): An Epic History of the Tallgrass Prairie Country* by William Least Heat-Moon. In this unique work, the author explores the plants, animals, and people that molded the history and ecology of a tallgrass prairie remnant in central Kansas. Encourage students who read this book to write a book report for their Portfolio, linking information from this chapter to details in the book.

**Activity**

**Grass Roots** Gather some trowels and plastic bags, and take students out to a weedy grassland on or near the school grounds. Have students dig out clumps of grass, being careful to try to dig out all of the root system as well. Since grass roots spread horizontally and vertically quite extensively, students will find that it is difficult to get the whole system out without breaking some of the roots. Ask students to try to shake as much soil off of the roots as possible. Then have them put the grass and root systems into plastic bags, and bring them back to the classroom for further study. Carefully rinse each specimen, and ask students to measure both above ground and below ground components of the grass. Students will find that the below ground component, with all its branching, is much longer. Ask them why the root system is so large. (Large root systems help grasses to survive drought, fire, and grazing in a grassland ecosystem, by allowing them to store water and nutrients below ground. Shoots also form along spreading roots, which helps the grass to cover more area and reproduce asexually.)

**Kinesthetic**
The sponge that was not completely saturated in plastic wrap lost the most mass because the water evaporated more quickly from that sponge.

1. Complete 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. Place the sponges outside in a sunny place for 10 to 15 minutes.
4. 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?

**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.

**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 burrowing 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 and the soil is ploughed regularly, 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.

**Chaparral**

Temperate woodland biomes have fairly dry climates but receive enough rainfall to support more plants than a desert does. One type of temperate woodlands consists of scattered tree communities made up of coniferous trees such as piñon pines and junipers, as shown in Figure 22.

**The chaparral** is a temperate shrubland biome that is found in all five parts of the world with a Mediterranean climate. These areas have moderately dry, coastal climates, with little or no rainfall.

**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.

**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.

**HISTORY**

**The American Dust Bowl**

In the 1930s, extreme weather conditions and poor farming practices created a “Dust Bowl” in the formerly rich agricultural areas of the Great Plains. Beginning in 1930, a drought early in the year prevented planting seeds and continued for four years. Wind blowing across abandoned fields kicked up incredible dust storms across the region. Heat followed the drought of the first four years, killing people as well as causing more dust storms. On a Sunday in 1935, an epic dust storm roared across the land at 60 mph. This day was called “Black Sunday” by those who witnessed the storm. Drought and dust storms continued through the decade, blowing away the precious, nutrient-rich topsoil that had been formed over centuries by the decay of the prairie grasses. Fortunately, the United States learned from the Dust Bowl years, and began a soil conservation service to spread information about soil management practices. Have students search the Internet for information about the Dust Bowl and soil conservation methods.

**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.
no rain in the summer. Look at the famous white letters that spell Hollywood across the 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.

**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.

**Animals of the Chaparral** A common adaptation of chaparral animals is camouflage, which is 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 have a mild climate year-round, humans tend to develop the land for commercial and residential use.

### Reading Check

How does camouflage help chaparral animals?
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 have widely scattered vegetation and receive very little rain. In extreme cases, it never rains and there is no vegetation. The distribution of Earth's deserts is shown in Figure 25.

Even in hot deserts near the equator, there is so little insulating moisture in the air that the temperature changes rapidly during a 24-hour period. The temperature may go from 40°C (104°F) during the day to near-freezing at night. Deserts are often located near mountain ranges, which block the passage of rain clouds.

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

Deserts

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The flapnecked chameleon lives in the deserts of Botswana.

The Sonoran Desert in Arizona appears lush with plant life just after the winter rains.

The flapnecked chameleon lives in the deserts of Botswana.

The Sonoran Desert in Arizona appears lush with plant life just after the winter rains.

Cultural Awareness

People of the Desert Just as plants and animals are adapted to desert life, people have also found a way to survive there. Have students research groups of people who live in the world’s deserts, such as the San of the Kalahari, the Tuareg of the Sahara, or the Native Americans of the Southwest. Have students report their findings to the class and include their report in their Portfolio. Interpersonal

ARTS

Home, Home on the Biome Ask students to find a song or poem that was inspired by one of the biomes in this chapter. Have students try to find at least one selection for each type of biome. Have students list, highlight, or pantomime the unique aspects of the biomes that are mentioned within the selections. Auditory
Plants of the Desert  All desert plants have adaptations for obtaining and conserving water, which allow 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.

Many desert shrubs drop their leaves during dry periods and grow new leaves when it rains again. 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.

Debate
ATVs in the Desert  Encourage students to debate the use of all-terrain vehicles in a desert ecosystem. First, have students brainstorm or research the possible negative effects of driving all-terrain vehicles in desert ecosystems. (Effects could include crushed vegetation, the destruction of bird eggs laid on the ground, pollution from leaking motor oil, and discarded trash.) Then have them find or think of reasons why these vehicles should be restricted to designated trails in the desert. (If some areas were designated as trails, this would keep all-terrain vehicles out of the more sensitive areas of deserts.) Finally, ask students to debate whether all-terrain vehicles should be used at all in the desert.

Activity
Animal Adaptations to Heat
Animals that live in extremely hot and dry conditions have developed many adaptations that allow them to retain water and stay cool. Some of these adaptations are listed in the Student Edition, but many more exist. Have students research the cavernous sinus system, which keeps mammal brains cool even in intense heat. In this system of heat exchange, blood from the veins is cooled in the nose by the evaporation of water in the nasal passages. This cooler blood then moves through the veins up into the cavernous sinus in the head. In the cavernous sinus, veins and arteries come into contact with each other, and the warmer arterial blood is cooled before it reaches the animal’s brain. Have students sketch a diagram of the cavernous sinus system to include in their Portfolio.

Internet Activity
Xeriscaping  As urban and suburban desert areas become more populous and water in those areas becomes more scarce, some people have begun to landscape their yards using native plants instead of typical grass. This method of landscaping, called xeriscaping, can be an interesting way to learn about native ecosystems while conserving water resources. Have students use the Internet to research the species of plants used to xeriscape areas in a desert region. Ask groups to create a landscape plan for a home in an urban desert area.

REAL-LIFE CONNECTION
Waxy Resistance  To help students understand how wax helps a plant retain water, bring in some hand lotion that contains beeswax, and have students put some on their hands. Explain that the waxy barrier keeps the skin on their hands from absorbing or excreting water. Then, have them dunk their hands in water, to observe how water beads on their skin.
Tundra Creatures Review with students the characteristics of the tundra. (Extreme cold, low precipitation, limited winter sunlight, permafrost, large numbers of insects in the summer, small plants with shallow roots) Based on these conditions, have students invent a hypothetical organism that could thrive in the Arctic tundra. Have them write an essay about their creature and its adaptations. (Students should describe the creature’s appearance, size, color, skin covering, defense mechanisms, diet, and reproductive strategy.) Encourage students to draw a sketch to accompany their essay and share the new creatures with other class members. Have students add their work to their Portfolio. 

Group Activity Advanced Arctic Science Experiments to determine how global warming will affect arctic areas are being coordinated by the Arctic System Science (ARCSS) Data Coordination Center, through the International Tundra Experiment (ITEX) project. Have students locate information from ARCSS about predicted tundra thaw depths, vegetation changes, snow melt, methane flux from warming tundra, and other possible effects of global warming. Have them create a short news announcement that explains this information, and encourage them to share this with the rest of the school.

Student Opportunities Toolik Field Station One of the designated long-term ecological research (LTER) sites in North America is located above the treeline in arctic Alaska. The Toolik Field Station is managed by the Institute of Arctic Biology at the University of Alaska, Fairbanks. At the station, researchers focus on ecological projects related to the tundra environment. Sample projects have examined freeze avoidance in hibernating ground squirrels, changes in tundra plants and soil due to artificial warming (as a model for global warming), fish community structure and vertical migration of zooplankton in arctic lakes, changes in rivers due to artificial fertilization, and the hydrology of tundra wetlands. Students who are interested in studying biology as undergraduates may want to explore research opportunities at the Toolik Station. Encourage those who are interested to find the Toolik Web site on the Internet, and to contact the University of Alaska for more information.

Tundra The tundra biome is located in northern arctic regions, as shown in Figure 27. The winter is too cold and dry to permit the growth of trees in this biome. In many areas of the tundra, the deeper layers of soil, called permafrost, are permanently frozen throughout the year. As a result, the topsoil is very thin. In the summer, when the thin topsoil layer thaws, the tundra landscape becomes quite moist and spongy and is dotted with bogs. These wet areas are ideal breeding grounds for enormous numbers of swarming insects, such as mosquitoes and black flies, and for the many birds that feed on the insects.

Vegetation of the Tundra Figure 28 shows the Alaskan tundra in the summer. 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 during the brief summer. Woody plants and perennials such as willow and birch have evolved dwarf forms and grow flat or grow along the ground.

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

[Graph: Tundra (Reykjavik, Iceland)]

[Graph: Venn Diagram]

[Graph: Venn Diagram]

[Image of tundra landscape]
**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, shown in Figure 29, migrate throughout the tundra in search of food and water. Wolves roam the tundra and prey on caribou, moose, and smaller animals, such as lemmings, mice, and hares. These animals 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. Its 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, the tundra was undisturbed by humans. But oil has been located in some tundra regions, such as 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.

**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.
6. Analyzing Relationships  Explain why elephants and caribou, which live in very different biomes, both migrate.

**Answers to Section Review**

1. Sample answer: Elf owls burrow in cactuses to avoid hot daytime temperatures. Sidewinders move so that only small areas of their bodies contact the hot sand at a given time.

2. Tropical grasslands are located in tropical and subtropical areas near the equator, and they are full of grasses, scattered trees, and shrubs. Temperate grasslands are located farther from the equator and are dominated by grasses. They have extremely fertile soil.

3. Plants that grow in deserts and plants native to tundra are adapted to low moisture and extreme temperatures. Both desert and tundra plants grow and flower quickly in the short growing season. Desert plants have special structures that allow them to trap and store water. Tundra plants grow low to the ground to stay out of the cold and dry wind.

4. Oil exploration is a threat to the tundra.

5. Moderate to warm temperatures, consistent rain during the growing season, and fertile soils make for productive farming regions.

6. Large herbivores migrate due to the cycles of rain and drought in temperate grasslands. Migratory herbivores follow the rains to find newly sprouted grass and water.
What do the biomes have in common?

Scientists classify the ecosystems of the world into large areas called biomes.

Biomes are described by their plant life because specific climate conditions support the growth of specific types of vegetation.

Climate determines which plants can grow in an area. Latitude and altitude affect climate in similar ways.

Major forest biomes include tropical rain forest, temperate rain forest, temperate deciduous forest, temperate evergreen forest, and taiga.

Tropical rain forests have high rainfall and high temperatures throughout the year. They are the most diverse of all biomes.

Temperate forests experience seasonal variations in precipitation and temperature. Their vegetation is adapted to surviving these changes.

Forest biomes are threatened by deforestation through logging, ranching, and farming.

Savannas are located north and south of tropical rain forests and have distinct wet seasons.

Temperate grasslands get too little rainfall to support trees. Grasslands are dominated mostly by different types of grasses and flowering plants.

Deserts are the driest biomes on Earth.

Plants and animals found in each biome adapt to the environment in which they live.
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 that minimize 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 temperatures, 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. latitude 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.

Assignment Guide
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Understanding Key Ideas

Using Key Terms
1. Sample answer: A biome is a large region characterized by a specific type of climate and certain types of plant and animal communities.
2. Sample answer: Climate refers to weather conditions in an area over a long period of time.
3. Sample answer: Epiphytes grow on tall trees in the canopy for support.
4. Sample answer: Tundra is a biome dominated by grasses, lichens, and herbs and is primarily located north of the Arctic Circle.
5. Sample answer: Permafrost is a layer of soil beneath topsoil that is permanently frozen.
6. The canopy is the main layer of trees in a forest. The understory is below the canopy and extends to shorter plants and shrubs on the ground.
7. Latitude is the distance from the equator. Altitude is the height above sea level.
8. Chaparral has moderately warm temperatures all year and is dry. The desert is drier and is hotter in the summer.
9. Tropical rain forests are located near the equator and maintain a relatively constant warm temperature year-round. Temperate deciduous forests are generally located between 30° and 50° north latitude and have extreme ranges of temperatures.
Short Answer
19. The rain forest floor lacks vegetation because the soil is poor in nutrients and receives very little sunlight.
20. Large root systems hold soil in place and prevent erosion.
21. Biomes vary in climate, and the climate gets colder with increasing altitude. So, different biomes are located in different altitudes across a mountain.
22. Permafrost in the tundra can preserve organisms such as a mammoth because the cold temperatures and frozen ground prevent and slow bacterial activity. Therefore, a mammoth would not decompose quickly if buried in the tundra.
23. A decrease in the number of trees will cause less carbon to be absorbed and stored. This will lead to an increase in carbon dioxide, a greenhouse gas that can cause warmer temperatures. A decrease in the number of trees also leads to flooding because the trees are no longer there to absorb and store water.

Interpreting Graphics
24. Cold temperatures and limited precipitation exclude most trees from tundra.
25. The amount of vegetation decreases.
26. Temperate grasslands have moderate temperature and precipitation.

Concept Mapping
27. Answers to the concept mapping questions are on pp. 715–720.

Critical Thinking
28. Similar environments led to the evolution of similar organisms with similar characteristics and strategies, even though the species live in different locations.
29. Answers may vary. Two factors that are responsible for the biodiversity of this biome are constant warm temperatures and large amounts of annual rainfall. Deforestation caused by logging and agricultural operations contributes to the decline of tropical rain forests.
30. The squirrels are not adapted to the rain forest, so they may not be able to eat or compete for the food that is available. The displaced squirrels are also not adapted to constant high temperatures, high humidity, and high precipitation.
31. Frequent fires may have increased the evolutionary pressure for prairie grasses to evolve fire resistance.

Cross-Disciplinary Connection
32. Answers may vary.

Portfolio Project
33. Answers may vary.
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 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 a 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 ecosystems that are most developed.  
   c. A debt-for-nature swap is an example of international compromise.  
   d. Launching education programs for citizens does not help protect ecosystems.

Reading Skills
1. d  
2. c

Writing Skills
36. Each biome represents a wealth of adaptations and biological variety. Losing any biome would rob the world of that evolutionary history and diversity. Biomes can be conserved in part by the development of sustainable forestry and agriculture and by setting aside areas for preservation. Support of international conservation and human rights organizations can also help to preserve biomes.

37. Answers may vary.

Reading Skills
1. d  
2. c

Math Skills
34. \( \frac{50,000}{1,800,000} \times 100\% = 2.8\% \) in country A; \( \frac{12,000}{530,000} \times 100\% = 2.3\% \) in country D

35. The tropical rain forest in country C will be completely destroyed first. The tropical rain forest in country E will be completely destroyed last.

Writing Skills
36. Each biome represents a wealth of adaptations and biological variety. Losing any biome would rob the world of that evolutionary history and diversity. Biomes can be conserved in part by the development of sustainable forestry and agriculture and by setting aside areas for preservation. Support of international conservation and human rights organizations can also help to preserve biomes.

37. Answers may vary.
CHAPTER 6

Understanding Concepts
Directions (1–4): For each question, write on a separate sheet of paper the letter of the correct answer.

1. Which of the following describes a biome?
   A. all the areas on Earth that are life-supporting
   B. weather conditions in an area for a specific time period
   C. a region characterized by specific climate and organism communities
   D. an area where the animal population interacts with its abiotic environment
   Answer: C

2. What type of forest has the greatest biodiversity?
   F. taiga forest
   G. temperate deciduous forest
   H. temperate rain forest
   I. tropical rain forest
   Answer: I

3. What is the diversity of the species in an area dependent on?
   A. plant life
   B. rainfall
   C. sunlight
   D. temperature
   Answer: D

4. What are the main factors that determine weather?
   F. altitude, latitude, precipitation, temperature
   G. altitude, latitude, precipitation, vegetation
   H. air currents, altitude, temperature, vegetation
   I. air currents, precipitation, temperature, vegetation
   Answer: H

Reading Skills
Directions (7–8): Read the passage below. Then answer the questions.

When rain falls on a forest, much of the rain is absorbed by plant roots and transpired into the air as water vapor. The water vapor forms rain clouds. Much of the water in the clouds will fall as rain somewhere downwind from the forest. Clearing the trees results in deforestation, which can change the climate.

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. It is estimated that 85 percent of the forest in the Yangtze River basin has been cut down. So the millions of tons of water these trees once absorbed now flows freely down the river and spreads across the fields into towns during the seasonal monsoon rains.

7. How could future flooding on the Yangtze River be avoided?
   A. replanting crops
   B. rebuilding homes
   C. replanting trees
   D. rebuilding walls
   Answer: C

8. Examine the climate change produced by deforestation.
   Directions (5–6): For each question, write a short response.

   5. A temperate grassland is a biome that is dominated by grasses and that has very few trees. How are temperate grasslands threatened by overgrazing?
   6. Compare and contrast the tundra and desert biomes.

   Answers
   1. C
   2. I
   3. B
   4. F
   5. Answers will vary. See Test Doctor for detailed scoring rubric.
   6. Answers will vary. See Test Doctor for detailed scoring rubric.
   7. C
   8. Answers will vary. See Test Doctor for detailed scoring rubric.
   9. The forest floor receives the least sunlight, because the other layers block most of it.
Interpreting Graphics

Directions (10–13): For each question below, record the correct answer on a separate sheet of paper.

Different scientists classify biomes in different ways. The map below shows one way to classify the biomes in Africa. Use this map to answer questions 10 through 13.

**Biomes of Africa**

10. What can be inferred about the biomes of Africa?
   F. Africa has a large concentration of tropical rain forests.
   G. Africa has a limited number of plant and animal communities.
   H. Africa has all types of plant life because of the many diverse biomes.
   I. Africa has large desert areas that get less than 25.0 cm of precipitation a year.

11. Which biome covers the most surface area in Africa?
   A. desert  C. Mediterranean
   B. highland  D. steppe

12. According to the map, which of the following determines the characteristics of a biome?
   F. geographic borders  H. longitude
   G. latitude  I. the Indian ocean

13. What geographic features are near 10°N, 40°E?
   A. mountains  C. rivers
   B. plains  D. volcanoes

**Test TIP**
When several questions refer to the same graph, table or map, answer the questions you are most sure of first.
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 it is.

**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 near a mountain or an ocean? Record your findings.
3. **Prepare a climatogram of your 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 of precipitation and temperature for one year 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.

**Tips and Tricks**

If you are near a university or college, contact the biology department, and ask if a professor or student would be willing to help your students identify the local flora and fauna. Climatograms will probably be influenced by human habitations and roads. These structures can elevate ambient temperature. Therefore, students’ climatograms may not match any in the chapter. Have students identify organisms living in natural vegetation as well as those living in human habitation. Have them record the differences in their lab write-up.
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 your 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 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 climatogram match any of the seven major terrestrial climatograms shown in the chapter? Explain how any differences between your biome and the biome in the chapter that your 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 the three plant adaptations and the three animal adaptations that you observed. Explain in detail how each of these adaptations meets the conditions of your biome.

Answers to Analysis
1. Answers may vary.
2. Answers may vary.

Answers to Conclusions
3. Answers may vary.
4. Answers may vary but may include dams, dens, burrows, or other features.

Answers to Extension
1. Answers may vary.

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.
A LITTLE PIECE OF CAJUN PRAIRIE

Background

The original human inhabitants of the prairie in southwest Louisiana were the nomadic Attakapas peoples. In the second half of the 18th century, Acadians arrived in Louisiana. The Acadians were French settlers who were forced to leave Nova Scotia by the colonial British government because of their religion and culture. Some of the exiled Acadians returned to France. Those who settled in Louisiana became known as Cajuns.

The Cajuns lived in relative isolation in Louisiana for about 100 years. During this time, other parts of Louisiana developed quickly. By the mid-1800s, the population of New Orleans was increasing quickly and the food supply could not keep up. At the time, agricultural goods had to be transported by boats through lakes, swamps, and rivers.

Transporting food became easier when a railroad was built between Texas and Louisiana. After the railroad was built in the 1880s, developers began to buy the prairie lands and build towns, including Eunice, Louisiana. Many farmers from the prairies in the Mid-west relocated to grow rice on the Cajun prairie. They brought with them new, more intensive agricultural practices and technologies, which led to the destruction of the prairie biome.

Cajun prairie is a distinct grassland, named for the settlers who lived there. It once covered more than 2.5 million acres of southwest Louisiana. Today, only about 100 acres of Cajun prairie remain. If the work of two biologists and many volunteers pays off, however, a little piece of Cajun prairie will always exist in Louisiana.

“I think that saving Cajun prairie is important because once it is gone, you cannot bring it back,” says Charles Allen, a retired professor from the University of Louisiana and the botanist for Louisiana’s Fort Polk. “There are plants and animals there that have never been tested for uses by humans. We could be losing a plant that would cure cancer, or provide food or fiber,” he says.

Allen and biologist Malcolm Vidrine, a professor of biology at Louisiana State University in Eunice, have been working for almost two decades to restore Cajun prairie.

Although Cajun prairie and the tallgrass prairies of the Mid-west both belong to the temperate grassland biome, Cajun prairie soil has unique characteristics. It is made of tight, heavy clays that formed as a result of coastal flooding and rains. This soil, combined with frequent lightning fires, makes it difficult for trees to grow but easy for prairie plants to flourish.

Settling on the Prairie

In the mid-1700s, many French Acadians, also known as Cajuns, arrived in Louisiana from Nova Scotia, Canada. They sustained themselves for over 100 years by fishing, hunting, and some farming. They also sustained their environment because their lifestyle caused little damage to the prairie.

The establishment of the railroad in the late 1800s brought new settlers to farm the rich land. These settlers brought with them new, more intensive agricultural practices and established herds of cattle that overgrazed the vegetation. By the early 20th century, most of the Cajun prairie had disappeared.

Today, the Cajun prairie ecosystem is labelled as “imperiled globally” by the Nature Conservancy, an organization dedicated to preserving natural communities. There are now fewer than 100 acres of Cajun prairie left in Louisiana. The railroad led to the near disappearance of the prairie, but it has also played an important role
in saving the last remaining pieces of prairie. The remaining prairie is mostly in remnants of small, narrow strips along railroad right-of-ways. Because the railroad owned these pieces of land, they were never farmed.

The Eunice Cajun Prairie Restoration Project

In the late 1980s, Allen and Vidrine located as many remnant strips as they could. They chose 10 of the strips and studied them carefully. They found almost 500 species of plants in the 10 strips.

The Eunice Cajun Prairie Restoration Project began in the summer of 1988. Its goal was to restore and preserve a small Cajun prairie in the city of Eunice, Louisiana. A 10-acre site in Eunice was mowed, and herbicide was used to destroy the nonnative vegetation. Volunteers from local elementary and high schools collected bags of seeds from Cajun prairie plants growing in the remnant strips. That winter, controlled burns were used to prepare the site. On a designated planting day, the students spread the seeds they had collected. The site was then lightly tilled. Sod was removed from the remnant strips and replanted at the Eunice site during the next three seasons.

Restoration is an ongoing effort. Yearly controlled burns maintain the habitat. The fires destroy shrubs and trees, but do not kill most of the prairie plants. Spot herbicides are used on the more pervasive non-native species, such as the Chinese tallow tree, the most threatening nonnative species for the prairie. The seeds of this tree are easily spread when birds eat the seeds and deposit them in droppings.

Today, nearly 300 native Cajun prairie species, including little blue-stem, Eastern gama grass, blazing stars, and hairy sunflower, have been reestablished at the site. As well, the rare wild coco orchid (Eulophia ecrista) has been found at the site. This is a very positive sign because few of these orchids have been found in the remnant strips or in Louisiana. Much of the Eunice site is now almost completely Cajun prairie.

To maintain the habitat, volunteers remove nonnative vegetation such as this vasey grass.

Answers to What Do You Think?

Are there threatened habitats in your area? What factors do you think led to the loss of these habitats? Is it possible for people to settle in a habitat without having a negative impact? How were the Cajuns able to sustain themselves on the prairie without destroying the habitat?

Students Opportunities

The Native Prairie Bank

Prairie lands once covered millions of acres of North America. For example, in the state of Minnesota, there were once 18 million acres of prairie. Today, less than one percent of Minnesota’s tallgrass prairie exists. Across the United States, there are ongoing efforts to protect prairie remnants.

To encourage such efforts, the state legislature created the Native Prairie Bank program in 1987. This program helps landowners protect native prairie located on their properties. Prairie has survived on some farms in areas where the land is too rocky or hilly to plow. Landowners with such remnants on their farms can register their properties in the Native Prairie Bank and receive payment for preserving their native prairies, while continuing to own their properties. The program protects the land from development or farming.

Have students find out more about the Native Prairie Bank. Do similar programs exist for threatened habitats in their state? Challenge students to come up with a way to raise awareness about these programs.